U.S. Army Engineer District, Alaska

FINAL REPORT

FEASIBILITY STUDY
FORMER YAKUTAT AIR FORCE BASE
YAKUTAT, ALASKA

July 2010

Prepared for:

U.S. Army Engineers District, Alaska
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EXECUTIVE SUMMARY

This report presents the results of our Feasibility Study for the former Yakutat Air Force Base (AFB), Yakutat, Alaska. The Feasibility Study was conducted by Shannon & Wilson, Inc. (Shannon & Wilson) under Hazardous, Toxic, and Radioactive Waste (HTRW) Contract W911KB-08-D-0005, Task Order 0003. The project consisted of reviewing existing government furnished materials (GFM) to identify Areas of Concern (AOCs) to be included in the Feasibility Study. Following identification of the AOCs, the Feasibility Study consisted of an analysis of potential remedial technologies and actions that may satisfy the project's preliminary remediation goals (PRGs).

Seventeen sites at the former Yakutat AFB potentially contain contamination resulting from previous use during World War II. Based on our review of the GFM documents, a total of 68 AOCs were identified within those 17 sites at the former Yakutat AFB, along with the chemicals of potential concern (COPC), and the affected media. For purposes of this Feasibility Study, a COPC is identified as a contaminant detected in sediment, soil, surface water and/or groundwater during a former investigation. Each AOC was initially screened to determine Formerly Used Defense Sites (FUDS) eligibility and those AOCs requiring further action. AOCs that had soil, sediment, surface water and/or groundwater containing chemicals of concern (COC) were identified as requiring further action. For the purposes of this Feasibility Study, a COC is identified as chemicals that were detected at concentrations that exceed the Appropriate, Relevant, and Applicable Requirements (ARARs) established for this project.

Based on previous investigations and site histories, 28 AOCs at the former Yakutat AFB were identified for inclusion in the feasibility study. Fifteen AOCs were initially selected by the U.S. Army Corps of Engineers (USACE) for inclusion in the FS. These comprise AOCs C2, C4, C6, D-AST1, D-AST2, D-AST3, D-AST4, D-AST5, D-AST6, D-AST7, D-AST8, E1 (Northwest Drum Dump), G4, M2, and the Rifle Range. During a meeting held on November 14, 2008 with representatives from the U.S. Army Corps of Engineers (USACE), the Alaska Department of Environmental Conservation (ADEC), and Shannon & Wilson, an additional seven AOCs including AOCs K1, L1 (South Drum Dump), L3 (Tanks 1, 7, 8, and 14), and L4 were identified. After review of the available Yakutat soil data, the USACE performed a statistical analysis and established background concentrations for arsenic and chromium. As a result, three additional AOCs (C1, C7, and O1) were added to the FS based solely on elevated concentrations of arsenic and chromium. The soil and groundwater cleanup standards listed in 18 AAC 75 were revised on October 9, 2008, affecting several COPCs detected at the AOCs (e.g., benzene, pentachlorophenol, benzo(a)pyrene, etc.). As a result, two additional sites (AOC L3 Tanks 3 and 11) were included in the FS. Based on our detailed review of the GFM, one additional AOC, the Drainage Ditch at AOC E1, was identified as a separate AOC from the Northwest Drum Dump. Note that AOC N1 is not considered in this FS due to access restrictions by the present property owner.

Media affected by COCs include surface soil, subsurface soil, sediment, surface water, and groundwater. The most common COCs identified are petroleum hydrocarbon constituents and include gasoline range organics (GRO), diesel range organics (DRO), benzene, toluene, 2-methylnaphthalene, chrysene, phenanthrene, pyrene, benzo(a)pyrene, and benzo(a)anthracene. Petroleum hydrocarbon COCs were identified in surface soil, subsurface soil, sediment, surface water, and/or groundwater. The metals arsenic, cadmium, chromium, lead, mercury, and silver were also identified as COCs in surface soil, subsurface soil, sediment, and/or surface water. Pentachlorophenol was identified as a COC in surface soil and sediment. PCBs were identified as a COC at one AOC in surface water. Bis(2-ethylhexyl)phthalate was also identified as a COC but is also a common laboratory contaminant generated by overheating lab ware.

Volume of impacted media was calculated for the 28 AOCs selected for the FS evaluation. The combined volume of petroleum contaminated soil is estimated at 80,000 cubic yards. The combined volume of metal contaminated soil and sediment is estimated at 500 cubic yards. The combined volume of multiple COC type contaminated soil and sediment is estimated at 7,500 cubic yards. At sites where COCs were encountered in surface water, the aerial extent of impacted surface water cannot be estimated based on available data. For the purpose of this FS, the aerial extent of impacted surface water is uncertain. The aerial extent of the groundwater plumes is estimated at 57,000 square feet.

The project's remedial action objectives (RAOs) are to protect human health and the environment by addressing the COC exposure pathways. RAOs may be accomplished through use of engineering and/or institutional controls, reducing the concentrations of COCs to levels below ARARs, and/or eliminating non-viable exposure pathways. The ARARs, used to identify COCs, were developed based on risk to human health and the environment, and comprise promulgated and recommended standards published by the ADEC, US Environmental Protection Agency (EPA) and/or National Oceanic and Atmospheric Administration (NOAA). ARARs for arsenic and chromium in soil are background concentrations established by the USACE.

Remedial technologies were identified by evaluating COCs and affected media at each of the AOCs identified for the Feasibility Study. The technologies were initially screened based on consideration of effectiveness, implementability and cost. Based on this evaluation, a decision was made as to whether the remedial technology would be incorporated into a remedial alternative that would be included in the Feasibility Study detailed analysis.

Many of the AOCs have the same media affected by similar type COCs; therefore, remedial alternatives were developed for each medium and for each COC type that are common to more than one AOC. Ten specific media and COC type scenarios were identified for the 28 AOCs and include:

- Petroleum COCs in Surface Soil (<2 feet bgs)

- Petroleum COCs in Subsurface Soil (<15 feet bgs)
- Petroleum COCs in Subsurface Soil (>15 feet bgs)
- Petroleum COCs in Sediment
- Metals in Soil and Sediment
- Lead in Soil
- Multiple COC Types in Soil and Sediment
- Multiple COC Types in Landfill Cover Material
- COCs in Surface Water
- Petroleum COCs in Groundwater

Thirteen remedial alternatives were identified to address these ten scenarios. These alternatives include:

- Alternative 1 - No Action
- Alternative 2 - Institutional Controls
- Alternative 3 - Monitored Natural Attenuation
- Alternative 4 - In-Situ Fenton's Reagent Oxidation
- Alternative 5 - In-Situ Soil Heating
- Alternative 6 - Bioventing
- Alternative 7 - Passive Bioventing
- Alternative 8 - Biopiles
- Alternative 9 - Excavation and On-Site Low-Temperature Thermal Desorption
- Alternative 10 - Excavation and Off-Site Disposal
- Alternative 11 - Excavation and Soil Washing
- Alternative 12 - Capping
- Alternative 13 - Air Sparging/Soil Vapor Extraction

Criteria used for detailed evaluation of the selected thirteen alternatives are those defined in the US Environmental Protection Agency (EPA) document *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final,* EPA/540/G-89/004, OSWER Directive 9355.3-01, October 1988. The criteria are:

- Overall Protection of Human Health and the Environment;
- Compliance with ARARs;
- Long-Term Effectiveness and Permanence;
- Reduction of Toxicity, Mobility, or Volume Through Treatment;
- Short-Term Effectiveness;
- Implementability; and
- Cost.

Two additional criteria, State Acceptance and Community Acceptance, will be evaluated following review of this document by the USACE, the ADEC, and the public. A comparative analysis of the remedial alternatives applicable for each of the ten scenarios was conducted to identify the relative advantages and disadvantages of each. Finally, site-specific considerations are provided to identify limitations for selecting remedial alternatives.

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ACRONYMS AND ABBREVIATIONS LIST

°F	Degrees Fahrenheit
AAC	Alaska Administrative Code
ACOR	Air Corps Operations Reserve
ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish and Game
AFB	Air Force Base
AGRA	AGRA Earth & Environmental, Inc.
AK	State of Alaska
AMSL	Above Mean Sea Level
AOC	Area of Concern
ARARs	Applicable or Relevant and Appropriate Requirements
AST	Aboveground Storage Tank
ATSDR	Agency for Toxic Substances and Disease Registry
AvGas	Aviation Gasoline
AWFC	Air Warning Filter Center
AWQS	Alaska Water Quality Standards
AWS	Air Warning System
B	Benzene
BC-J	BC Contractors - Jacobs Joint Venture
bgs	Below Ground Surface
BLM	Bureau of Land Management
BNA	Base/Neutral and Acid Extractable Organic Compounds
CAA	Civil Aeronautic Administration
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cy	Cubic Yards
COC	Chemical of Concern
COPC	Chemical of Potential Concern
Cr3+	Trivalent Chromium
Cr6+	Hexavalent Chromium
DERP	Defense Environmental Restoration Program
DDD	Dichlorodiphenyldichloroethane
DDT	Dichlorodiphenyltrichloroethane
DoD	Department of Defense
DRO	Diesel Range Organics
E&E	Ecology & Environment, Inc.
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FRTR	Federal Remediation Technology Roundtable
FS	Feasibility Study
sf	Square Feet
FUDS	Formerly Used Defense Sites
GC/MS	Gas Chromatography/Mass Spectroscopy
GFM	Government Furnished Materials
GOCO	Government-owned, contractor-operated
gpm	Gallons per Minute

ACRONYMS AND ABBREVIATIONS LIST (CONTINUED)

GRO	Gasoline Range Organics
GW	Groundwater
hp	Horsepower
HTRW	Hazardous, Toxic, and Radioactive Waste
IC	Institutional Controls
LIF	Laser-Induced Fluorescence
LTTD	Low-Temperature Thermal Desorption
Malaspina	Malaspina Investments
MCL	Maximum Contaminant Level
mm	Millimeter
mg/kg	Milligrams per Kilogram
mg/L	Milligrams per Liter
MNA	Monitored Natural Attenuation
MSL	Mean Sea Level
NA	Not Applicable
NOAA	National Oceanic and Atmospheric Administration
OCRR	Ocean Cape Radio Relay
O&M	Operation and Maintenance
OSC	Oil Spill Consultants
OSWER	Office of Solid Waste and Emergency Response
PA	Preliminary Assessment
PAH	Polynuclear Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PCDDs	Polychlorinated Dibenzo-P-Dioxins
PCDFs	Polychlorinated Dibenzo-Furans
PCP	Pentachlorophenol
POL	Petroleum, Oil, and Lubricants
PPE	Personal Protective Equipment
ppm	Parts per Million
ppt	Parts per Trillion
PQL	Practical Quantitation Limit
PRG	Preliminary Remediation Goal
PVC	Polyvinyl Chloride
QA	Quality Assurance
QC	Quality Control
RA	Remedial Actions
RAO	Remedial Action Objectives
RBC	Risk-Based Concentration
RCA	Radio Corporation of America
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RNCL	Regional Native Corporation Lands
ROM	Rough Order of Magnitude
ROST	Rapid Optical Screening Tool
RRO	Residual Range Organics
S	Sub-surface Soil

ACRONYMS AND ABBREVIATIONS LIST (Continued)

Sd	Sediment
SI	Site Investigation
SQuiRT	Screening Quick Reference Tables
SS	Surface Soil
SVE	Soil Vapor Extraction
SVOC	Semi-Volatile Organic Compound
SW	Surface Water
TAH	Total aromatic hydrocarbons
TAqH	Total Aqueous Hydrocarbons
TCDD	2,3,7,8-Tetrachlorodibenzo-p-dioxin
TCDF	2,3,7,8-Tetrachlorodibenzo-p-furan
TCLP	Toxicity Characteristic Leaching Procedure
TEF	Toxic Equivalency Factor
TEQ	Toxic Equivalency Quotient
TRPH	Total Recoverable Petroleum Hydrocarbon
US	United States
USACE	U.S. Army Corps of Engineers
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
UST	Underground Storage Tank
VOC	Volatile Organic Compound
WACS	White Alice Communications System
WHO	World Health Organization
WWII	World War II

FEASIBILITY STUDY
FORMER YAKUTAT AIR FORCE BASE
YAKUTAT, ALASKA

1.0 INTRODUCTION

This report presents the results of our Feasibility Study (FS) for the former Yakutat Air Force Base (AFB), Yakutat, Alaska. This FS was conducted by Shannon & Wilson, Inc. (Shannon & Wilson) under Hazardous, Toxic, and Radioactive Waste (HTRW) Contract W911KB-08-D-0005, Task Order 0003. Authorization to proceed with Task Order 0003 was received from Ms. Anita Dale, U.S. Army Corps of Engineers (USACE) - Alaska District, on September 28, 2008.

1.1 Project Objective

The project objective is to provide a FS for the Formerly Used Defense Sites (FUDS) located at the former Yakutat AFB in Yakutat, Alaska. Results of the FS will be used to prepare a Proposed Plan and Decision Document.

1.2 FS Process Overview

The FS process was initiated by reviewing previous Preliminary Assessment/Site Investigations (PA/SI), Remedial Investigation/Feasibility Studies (RI/FS), and remedial actions (RAs), as described in reports listed as Government Furnished Materials (GFM). Based on review of the GFM, Areas of Concern (AOCs) were identified at the former Yakutat AFB. A vicinity map showing the approximate locations of the AOCs is provided as Figure 1.2-1.

An initial screening of the identified AOCs was conducted to determine which AOCs require full analysis and development of remedial alternatives using the FS process. Chemicals of potential concern (COPC) were identified for each AOC and each contaminated medium. For purposes of this FS, a COPC is identified as a contaminant detected in sediment, soil, surface water and/or groundwater during a former investigation. COPCs identified for each AOC and each contaminated medium were compared with applicable or relevant and appropriate requirements (ARARs). Contaminants which exceed ARARs were identified as chemicals of concern (COCs) to be addressed in the FS process. Based on the initial screening, each of the AOCs was documented as either:

- Not FUDS eligible,
- Included in the FS (with one or more alternatives),
- Not included in the FS (with the no further action alternative).

For the FS, potential remedial technologies were identified and screened. After initial screening, selected remedial technologies were incorporated/integrated into media-specific alternatives to be analyzed in detail for specific scenarios applicable to the AOCs. Many of the AOCs have the same media affected by similar type COCs; therefore, the remedial alternatives were considered in context of each medium and for each COC type that are common to at least one or more AOC. Alternatives were individually evaluated using the criteria stated in *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final EPA/540/G-89/004*, OSWER Directive 9355.3-01, October 1988 (EPA 1988). A comparative analysis of the remedial alternatives was also conducted to identify the relative advantages and disadvantages.

1.3 Report Format and Organization

The FS report has been prepared in general accordance with the following documents, as applicable:

- USACE August 19, 2008 Scope of Work (USACE 2008);
- Shannon & Wilson's September 20, 2008 proposal (S&W 2008);
- USACE "Document Guidelines" (USACE 2003);
- US Environmental Protection Agency (EPA) RI/FS Guidance Document (EPA 1988);
- EPA and USACE Guide to Developing and Documenting Cost Estimates During the Feasibility Study (EPA 2000).

The main text body is composed of Sections 1.0 through 8.0, with each section followed by the associated support tables and figures. The appendices are presented at the end of the main text body.

Section 1.0 specifies the project objective and introduces the overall project approach for the FS and this report organization summary.

Section 2.0 presents the environmental setting for the project including a discussion of the historical development and land use of the area as an air force base and various other military operations.

Section 3.0 presents a brief history, previous investigations conducted, remedial actions performed, and COPCs present for each of the AOCs identified at the former Yakutat AFB. AOCs are evaluated and selected for inclusion in the FS based on COPCs and applicable ARARs. Estimates of the area and volume of impacted media are presented for each AOC to be included in the FS.

Section 4.0 presents the identification and initial screening of technologies to develop a range of appropriate remedial alternatives for the AOCs at the former Yakutat AFB that will be analyzed more fully in the detailed analysis. Each technology is evaluated for implementability, effectiveness and cost based on EPA guidance document criteria.

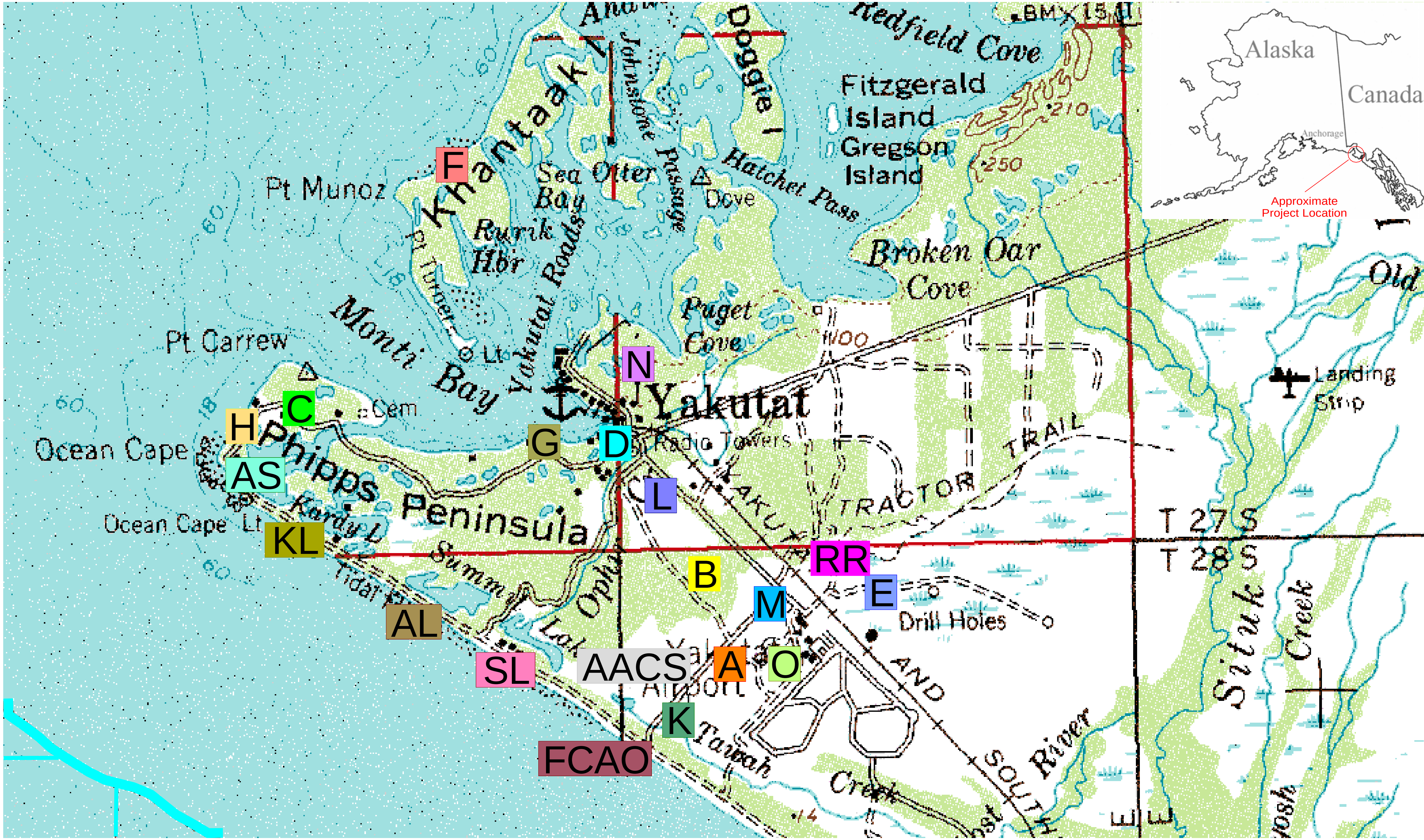
Section 5.0 presents the remedial alternatives selected during the identification and initial screening process for specific site scenarios. As many of the AOCs have the same media affected by similar type COCs, remedial alternatives were developed for each medium and for each COC type that are common to more than one AOC.

Section 6.0 contains the detailed analyses of the selected remedial alternatives. The technology/process of each alternative is evaluated using seven of the nine criteria recommended in *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final EPA/540/G-89/004*, OSWER Directive 9355.3-01, October 1988 (EPA 1988). Two additional criteria, State Acceptance and Community Acceptance, will be evaluated following review of this document by the USACE, the ADEC, and the public. As part of the detailed analysis, a comparison analysis of the selected remedial alternatives is presented to identify the advantages and disadvantages of each alternative relative to one another. Following the comparison analysis, site specific considerations are presented which provide additional information regarding circumstances at specific AOCs.

Section 7.0 presents the limitations on the data presented in this FS document.

Section 8.0 lists the references used in the development of the FS.

Appendix A provides historical maps of the Yakutat AFB referenced in this FS. Descriptions of potential remedial alternatives evaluated in this FS are provided in Appendix B. Appendix C presents rough order of magnitude (ROM) costs for implementing the remedial alternatives selected for detailed analysis. Appendix D presents comments received during the process of developing this FS, from the USACE, ADEC and the Technical Assistance and Public Participation (TAPP) representative, and responses by Shannon & Wilson.



LEGEND

- A Site A - Air Corps Increase Group No. 2
- B Site B - Air Warning Filter Center
- C Site C - Point Carrew
- D Site D - Army Dock Area
- E Site E - NW Drum Dump/Quartermaster Loop Area
- F Site F - Khantaak Island
- G Site G - Seaplane Base
- H Site H - Ocean Cape Radio Relay Station (OCRR)
- K Site K - Solid Waste Disposal Dump No. 4 Area
- L Site L - Air Corps Operations Reserve Tank Farm
- M Site M - Post Powerhouse
- N Site N - Air Warning System Powerhouse
- O Site O - Air Corps Warehouse Group No. 2
- RR Rifle Range
- KL Kardy Lake
- AL Aka Lake
- SL Summit Lake
- AACS AACS Transmitter Station Powerhouse
- FCAO Former Coast Artillery Outpost
- AS Ankau Slough

0 0.5 1 2
APPROXIMATE SCALE IN MILES

Taken from Yakutat C-5 and B-5
U.S. Geological Survey Quadrangles

N

Former Yakutat Air Force Base
Yakutat, Alaska

VICINITY MAP

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Geotechnical & Environmental Consultants

Fig. 1.2-1
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2.0 ENVIRONMENTAL SETTING

This section describes the regional environmental setting for the Yakutat area, including a description of the former Yakutat AFB. Information for this section was primarily obtained from ENSR's February 2003 RI/FS report (ENSR 2003a) with modifications made based on our 2004 and 2005 Focused RI findings (S&W 2006a, 2006b).

2.1 Former Yakutat Air Force Base

United States (US) Military interest in Yakutat began by Executive Order in 1929, with the creation of the Yakutat Bay Naval Reservation. However, occupation was not set in motion until 1939 with a proposal by the Civil Aeronautic Administration (CAA) to develop a landing field. Runway construction began in 1940 for an "Auxiliary Landing Field and Staging Area" (also known as the Yakutat Air Base). With the arrival of the first troops in October of that year, the Yakutat Landing Field was activated. A dock and wharf facilities were built on Monti Bay in support of the air base. Natural resources of timber and aggregate were used in bridge and foundation construction. The Yakutat Naval Base was established as a "Naval Air Facility" in September 1942, and was redesigned as a "Naval Auxiliary Air Facility" in February 1943. The air base was completed in June 1943. An additional 42,437 acres, known as Tract B, which included the city of Yakutat and the active Yakutat airport, were obtained from the U.S. Department of the Interior in September 1943, making the total area approximately 46,080 acres.

The air base was placed on caretaker status in April 1944, declared surplus in December 1945, and ceased operations in 1946. Tract B was relinquished to the U.S. Department of the Interior, Bureau of Land Management (BLM) in two portions in 1946 and 1947. Another section, Tract C, containing 147 acres, was retransferred to the CAA in 1948, while the remaining 3,499 acres, Tract A, were relinquished and retransferred to the Department of the Navy in 1949. The Yakutat Bay Naval Reservation was revoked in 1953, and all but 266 acres were designated as part of the Tongass National Forest. The remaining land was placed in federal land holding for the CAA (now known as the Federal Aviation Administration [FAA]). The USACE carried out cleanup operations around Yakutat in 1984. Remaining Department of Defense (DoD) facilities were slated to be removed. Although no project report is available, it appears that most of the infrastructure was removed at that time.

In 1960, the U.S. Air Force acquired 78.6 acres of land from the U.S. Forest Service and 96.96 acres of tidelands from the State of Alaska Division of Lands to construct a radio link between Cape Yakataga and Hoonah. The Ocean Cape Radio Relay (OCRR) Station facility served as a tropospheric communications station as part of the Ballistic Missile Early Warning System under the White Alice Communications System (WACS). An additional 69.2 acres were obtained from the BLM in 1967 and 1968 for gravel removal. The site, located on the Phipps Peninsula at the end of Point Carrew Road, approximately 5 miles west of the city of Yakutat, included industrial buildings, support facilities, water and fuel storage tanks, pipelines, billboard antennae, a bridge, roads, and utility lines. The facilities were leased to Recording Company America Alaska Communications, Inc. between 1974 and 1976. The OCRR Station was declared excess by the U.S. Air Force in June 1976. This land was relinquished to the BLM in 1977, and conveyed to the Yakutat Tlingit Tribe in 1983. Property ownership is presently listed under Yak-Tat Kwaan, Inc., a corporate entity of the Yakutat Tlingit Tribe. The four tropospheric dishes, industrial buildings, and associated equipment were removed during the 1984 USACE cleanup activities. Sewer manholes were filled with gravel. A 130,000-gallon tank; a petroleum, oil, and lubricants pump house; a heavy equipment maintenance shop; and a water tower remain on site.

2.2 Geographic Setting and Topography

Yakutat, located at the mouth of Yakutat Bay, is approximately 225 miles northwest of Juneau and 220 miles southeast of Cordova at 59° 33’ N Latitude, 139° 44’ W Longitude (Section 30, Township 27 South, Range 34 East, Copper River Meridian). Geographically, the town is bordered by Yakutat Bay and the Wrangell-Saint Elias Mountains to the north, by the Saint Elias Mountains and Tongass National Forest to the south and east, and by the Gulf of Alaska to the west. The elevation of most of the Yakutat forelands lies between 0 and 65 feet above mean sea level (MSL).

2.3 Demographics and Land Use

According to the Alaska Department of Commerce, Community and Economic Development, the population of the Yakutat Borough, incorporated in 1992, is 590 (certified 2008). Approximately half of the population consists of Alaskan Natives. Yakutat’s economy is dependent on commercial and sport fishing, fish processing, and government employment. Approximately 25 percent of Yakutat’s residents hold commercial fishing permits (ADCC 2009).

The public water system is derived from four community wells, and is piped to 191 homes in the community and to the schools. A public sewer system serves most of the households. The majority of homes are heated using fuel oil and kerosene, with 8.7 percent using alternative methods, mainly wood or electricity, in 2000. Refuse is collected by a private firm and deposited in the Borough-operated landfill. Electricity is produced by four diesel-fueled generators operated by Yakutat Power, Inc. (ADCC 2009).

2.4 Geology

The following summary of the surficial geology of the Yakutat area is taken largely from U.S. Geological Survey (USGS) papers published in 1909 and 1979 (USGS 1909, 1979).

According to the USGS, "Within the Yakutat region are some of the tallest mountains, some of the heaviest snowfalls, and one of the largest glaciers (Malaspina) in North America. Between the abrupt mountain front and the Gulf of Alaska lies a very gently sloping plain of outwash derived from repeated cycles of advance and retreat of glaciers during the Quaternary Period."

The city of Yakutat is located on the Yakutat foreland, a gently sloping glacial outwash plain between the Saint Elias Mountains and the Gulf of Alaska. Eight dominant surficial deposits have been mapped in the Yakutat area, all of Holocene age. These include artificial fill, organic, eolian, beach, delta-estuarine, alluvial, outwash, and moraine deposits. Artificial fill is mostly present under the airport runways and other areas that were extensively modified during construction, including the civic center of Yakutat. Organic deposits, interpreted from aerial photographs, are divided into two subunits based on underlying material. Where the organic deposits are prevalent, thickness probably ranges from 3 to 6 feet. Eolian sand dune deposits are principally located near the estuary of the Situk River. Beach deposits are subdivided into three subunits based on age, the oldest being timbered ridges inland near Tawah Creek and Lost and Situk Rivers. Four subunits of delta-estuarine deposits, based on age, have been mapped, mostly near Tawah Creek and Lost and Situk Rivers, with some deposits near Ophir Creek. Alluvial deposits are located chiefly near the Situk River.

Two outwash deposits have been mapped, based on grain size. Outwash deposits range from 3 to 40 feet thick, with an average of approximately 21 feet. Cobbly gravel is the major constituent of the outwash close to the moraines. Sands and gravel in the plain become steadily finer toward the Situk River (USGS 1909). The outwash deposits overlie old delta-estuarine sediments, probably some buried moraine deposits, and, locally, coarse-grained outwash.

End- and ground-moraine deposits have not been separated into subunits. Average moraine thickness is approximately 75 feet, with a maximum of approximately 200 feet. The mixture of till that composes the moraines consists mainly of gravel-laden silt and sand, in varying proportions, with lesser amounts of cobbles, clay, and boulders. Rarely, organic material is present within the till. Numerous bogs and ponds are present between moraine ridges. Subordinate alluvial deposits, including kames, eskers, crevasse fillings, and minor outwash, also exist between moraine ridges.

At least 13 earthquakes of magnitude 5 or greater have occurred within 130 kilometers of Yakutat since 1899. Shaking from the September 4, 1899, earthquake, with an estimated magnitude of 8.4, lasted about 2 to 5 minutes. Six days later, two earthquakes shook the area with estimated magnitudes of 7.8 and 8.6. The greatest onshore uplift ever recorded for an earthquake sequence occurred at Bancas Point, about 28 miles north of Yakutat, during the September 1899 earthquakes. An earthquake of magnitude 7.9 hit on July 10, 1958, shaking the ground for 3 to 4.5 minutes, causing several submarine landslides and large waves in Monti Bay. Earth shaking caused by the 1964 Good Friday earthquake lasted 4 to 6 minutes.

Yakutat has had only minor earthquake damage over the years, but has the potential for major earthquake damage. Yakutat lies within a seismic risk zone 4 and is subject to major to severe damage from earthquakes greater than or equal to magnitude 6. Future large earthquakes will continue to affect the Yakutat area and cause ground shaking, liquefaction, ground fracturing and water-sediment ejection, compaction and related subsidence, sub-terrestrial and underwater landslides, and tsunamis and other earthquake-related water waves (USGS 1985).

2.5 Hydrogeology

2.5.1 Groundwater

Glacial moraine and outwash deposits comprise the majority of the regional aquifer. These materials typically exhibit a wide range of hydrogeologic parameters that are based on the depositional history and grain size of the deposits. Moraine deposits vary in thickness up to approximately 200 feet and generally contain poorly sorted, gravel-rich sand and silt, with some clay, cobbles, and boulders. Outwash alluvial deposits begin close to the end moraine near Yakutat Bay and range in thickness from approximately 3 to 40 feet. They are generally well sorted, coarsely grained materials having a higher permeability than moraines and tills. Grain size decreases farther in front of the end moraines (USGS 1998).

Unconfined groundwater in the Yakutat area has been found to range in depth from within the top 10 feet below ground surface (bgs) to greater than 70 feet bgs. This fluctuation appears to be a function of the surface topography, as the piezometric groundwater surface is relatively flat. The groundwater flow direction also appears to be generally dictated by topography, with flow towards the principal surface water bodies, including streams, lakes, the coastline, and constructed drains (USGS 1998).

The Yakutat foreland aquifer is fed by precipitation infiltration and drained by small streams. Recharge can also occur by the streams when the stage of streams is higher than the local water table. Groundwater flows both vertically and horizontally through this unconfined water table.

2.5.2 Surface Water

The primary surface drainage features within the investigation areas are the Ankau Slough, Ophir Creek, and Tawah Creek, shown on Figure 1.2-1. The Ankau Slough is a tidally influenced shallow water system on Point Carrew, connected to Monti Bay through the Ankau Head. Ophir Creek begins in the hummocky glacier moraine terrain between Monti Bay and Redfield Cove, and flows toward the southwest to Summit Lake. Tawah Creek begins at

Summit Lake and flows southeast to Lost River, collecting many small streams and constructed drains originating in the area. Most streams in the Yakutat foreland flow toward the southwest. The southeasterly flow of Tawah Creek is due to the beach deposits creating a topographical barrier along the Gulf of Alaska (USGS 1998).

2.5.3 Drinking Water Supply

Yakutat's public water system is comprised of four city-owned community wells. Two of the four water wells are located in the southern portion of the Army Dock Area (AOC D). These wells are designated "ARCO Well #1" and "ARCO Well #2," and are reportedly constructed of 12-inch diameter casing (ENSR 2003b). According to ENSR's March 2003 report, ARCO Well #1 extends about 174 feet bgs, with static water level measured about 70 feet bgs. A 50-horsepower (hp) pump set at about 96 feet bgs has a maximum output of 725 gallons per minute (gpm). Well #2 extends about 125 feet bgs, with a static water level about 69 feet bgs. A 20-hp pump is set about 96 feet bgs, and is capable of pumping at 375 gpm. The water entry mechanism (open-end pipe and/or perforated casing) was not determined for this document.

2.6 Ecology

Historically, the rich fisheries, wildlife, and plants of the region have been used for subsistence living. The Yakutat area hosts numerous productive habitat types that are generally healthy and affected little by human intervention. The local economy is largely dependent on the natural resources of the area. Most residents still rely at least partly on subsistence hunting and fishing.

Three types of plant communities exist within the coastal area: true forest, grass-sedge meadows, and muskeg. The true forest generally consists of dense old-growth Sitka spruce, some western hemlock, and cottonwood, with skunk cabbage and devil's club for ground cover. Salmonberries, blueberries, and highbush cranberries are found within the forest. The forested areas in and around the Ankau Slough on Point Carrew have historically been used to gather berries.

Grass-sedge meadows often border freshwater ponds and lakes, and are found at the mouth of river deltas. Fireweed, lousewort, paintbrush, lupine, and strawberries exist in this environment. Muskeg are interspersed throughout the forest, containing sedges, deer cabbage, heather, Alaska cotton grass, Arctic iris, yellow pond lily, willow, and Nagoon berry.

Many land animals and birds frequent the Yakutat area. Mammals that may frequent the project sites include moose, deer, wolves, coyote, black bear, brown bear, and numerous smaller fur-bearing and rodent species (BLM 1980). Wolverines, weasels, martens, mink, marmots, and fox are all found on the Yakutat foreland. River otters and beaver occupy the riparian habitats.

Squirrels, voles, shrews, and brown bats can also be found. Some of these animals are important food sources for the local residents. The Cape Phipps Peninsula is an important productive subsistence area (USACE 1984). Many species listed as endangered by the U.S. Fish and Wildlife Service thrive in Alaska. Currently, the Alaska Department of Fish and Game (ADF&G) lists 13 species as endangered. Six of the endangered species have a range that may include the Yakutat area (ADF&G 2009):

- Short-tailed albatross,
- Humpback whales,
- Blue whales,
- Fin whales,
- Sperm whales, and possibly
- Northern right whale

The State of Alaska also administers a list of "Species of Special Concern," last updated in November 1998. Several of the listed species have a habitat range that includes the Yakutat area, such as the American peregrine falcon, the Arctic peregrine falcon, the Stellar's sea lion, and the Townsend's Warbler (USACE 1984).

2.7 Climate

Yakutat's climate is dominated by its proximity to the coast. These maritime conditions often are cloudy and wet. Meteorological data from Yakutat from 1952 to 2000 indicate a yearly average temperature of 39.5 degrees Fahrenheit (^{o}F) with maximum summer temperatures of up to 87^{o}F and winter temperatures down to -24^{o}F. January exhibits the lowest monthly mean temperature at 26^{o}F. The highest monthly mean temperature of 54^{o}F is in July.

The yearly average precipitation is approximately 140 inches, including over 200 inches of snowfall. Precipitation infiltration and runoff both occur during breakup when the winter snowpack melts.

Wind in the Yakutat area is generally toward the east from the Gulf of Alaska. In winter, these winds are more likely to blow east/northeast and in summer east/southeast. Surface wind velocities average 7 miles per hour.

3.0 AOC EVALUATION AND SELECTION

Seventeen sites at the former Yakutat AFB potentially contain contamination resulting from previous use during World War II (WWII). These sites are listed on Table 3.0-1. Their approximate locations are shown on Figure 1.2-1. A total of 68 AOCs have been identified at these 17 sites. Brief histories for each of the 68 AOCs are presented in this section, as well as the COPCs identified at each AOC. The historical information is used to evaluate each AOC for inclusion in the FS and to estimate lateral and vertical extent and volume of impacted media.

3.1 Background Information

The following sections provide background information used in the AOC evaluation process.

3.1.1 Government Furnished Materials (GFM)

Historical information pertaining to the AOCs was obtained from the following GFM:

- March 1997, *Summary Investigation of DoD Activities on Yakutat Tribal Lands, ANA Grant No. 90NM0024/01, Yakutat, Alaska, Volume 1*, prepared by AGRA Earth & Environmental, Inc. (AGRA) for Yakutat Tlingit Tribe.
- March 2007, *Final Former Yakutat Air Force Base Remedial Investigation Report, Yakutat, Alaska*, prepared by BC Contractors-Jacobs Joint Venture (BC-J).
- December 12, 1997, *Yakutat Air Base/Ocean Cape Radio Relay Site Investigation Report, Yakutat, Alaska, Site No. F10AK060600*, prepared by Ecology & Environment, Inc. (E&E). Note that a complete copy of the E&E document was not available for review.
- February 2003, *2000 Remedial Investigation Report - Final - Remedial Investigation/Feasibility Study, Yakutat Area, Alaska*, prepared by ENSR.
- March 2003, *2001 Remedial Investigation Report - Final - Remedial Investigation/Feasibility Study, Yakutat Area, Alaska*, prepared by ENSR.
- January 2005, *Final Feasibility Study, Yakutat Area RI/FS*, prepared by ENSR.
- June 29, 2001, *Revised Final Remedial Action Report for Northwest Airport Drum Dump, Yakutat, Alaska*, prepared by Oil Spill Consultants (OSC).
- April 2006, *2004 Final Focused Remedial Investigation, Former Yakutat Air Force Base, Yakutat, Alaska*, prepared by Shannon & Wilson.
- August 2006, *2005 Final Focused Remedial Investigation, Former Yakutat Air Force Base, Yakutat, Alaska*, prepared by Shannon & Wilson.

- July 1984, *Environmental Restoration Defense Account Debris Cleanup and Site Restoration Design, Yakutat, Alaska Civil*, prepared by Frank Moolin & Associates, Inc. for USACE.
- September 2006, *Final Rapid Optical Screening Tool (ROST)/Laser-Induced Fluorescence (LIF) Focused Remedial Investigation, Former Yakutat Air Force Base, Yakutat, Alaska*, prepared by USACE.
- May 16, 2008, *Military Munitions Response Program CERCLA Preliminary Assessment for the Yakutat Air Base, Yakutat, Alaska*, prepared by USACE.

Our evaluation of the AOCs was limited exclusively to the information provided in the GFM listed above. Data gaps may exist, however, assessing data sufficiency was not part of the scope of the FS.

3.1.2 FUDS Eligibility

In order to be included in this FS, sites must conform to the definition of FUDS as stated in the USACE document *Environmental Quality, Formerly Used Defense Sites (FUDS) Program Policy*, ER 200-3-1, May 10, 2004 (USACE 2004). FUDS are defined as "real property that was under jurisdiction of the Secretary and owned by, leased by, or otherwise possessed by the United States (including governmental entities that are the legal predecessors of DoD or its Components) and those real properties where accountability rested with DoD but where the activities at the property were conducted by contractors (i.e. government-owned, contractor-operated [GOCO] properties) that were transferred from DoD control prior to 17 October 1986."

The AOCs selected for analysis in this FS have been confirmed as FUDS eligible by the USACE, with the following three exceptions:

- Benzene contamination outside the Malaspina Building garage at AOC D - AST1, is assumed to have been caused by operations associated with the garage; therefore, the benzene-impacted area is not considered FUDS eligible.
- Surface staining was observed in the vicinity of several drums within the former Tank AST2 site. According to the USACE project manager, these drums are of non-DoD origin. Surface staining associated with these drums is not FUDS eligible.
- The USACE has also determined that the Aka Lake drum is not of DoD origin; therefore, it is not FUDS eligible.

3.1.3 Applicable or Relevant and Appropriate Requirements (ARARs)

To establish remedial action objectives (RAO), definitive ARARs must first be identified. For this FS, the ARARs are based on both promulgated and recommended standards published by the Alaska Department of Environmental Conservation (ADEC), US Environmental Protection Agency (EPA), and National Oceanic and Atmospheric Administration (NOAA). These include the current 18 Alaska Administrative Code (AAC) 75 cleanup criteria (ADEC 2008b); background concentrations established for the Yakutat area (USACE, 2009); the 18 AAC 70, Water Quality Standards (ADEC 2006); the NOAA screening quick reference tables (SQuiRTs) (NOAA, 2008); and the Resource Conservation and Recovery Act (RCRA) toxicity characteristic criteria for hazardous waste listed in the Code of Federal Regulations (CFR) Title 40, Chapter 261.24. Concentrations of COPCs identified at the AOCs will be compared to the ARARs. COPCs with concentrations that exceed the project ARARs are considered chemicals of concern (COCs) at each AOC included in the FS. Table 3.1-1 presents the ARARs and the chemical constituents in one or more media (surface and subsurface soil, sediment, surface water, and/or groundwater) that exceed the ARARs for the former Yakutat AFB AOCs.

Soil

With the exception of dioxins and select metals, the project ARARs for soil comprise state soil cleanup standards listed in 18 AAC 75, *Oil and Other Hazardous Substances Pollution Control* regulations (ADEC 2008b), and *Cleanup Levels Guidance* (ADEC 2008a). The soil ARARs for this project, with the exception of dioxins, lead, arsenic, and chromium, are the most stringent Method 2 risk-based standards (typically the "migration to groundwater" standard) for the "Over 40 Inches" precipitation zone, as listed in Tables B1 and B2, 18 AAC 75.341. These ARARs are risk-based concentrations calculated using standard default exposure parameters developed by the EPA, conservative representative Alaska-specific soil parameters, and a risk threshold of $1x10^{-5}$ for carcinogens and a hazard index of 1 for toxic compounds (ADEC, 2008a). Note that a groundwater use determination in accordance with 18 AAC 75.350 could be conducted for the Concern D sites and other sites with groundwater issues (i.e. potentially complete migration to groundwater exposure route); such a demonstration could lower applicable soil cleanup levels. For example, if there is no potential for groundwater use, the cleanup level for diesel in soil would be 8,250 mg/Kg.

Dioxins are a group of compounds generally referred to as Polychlorinated Dibenzo-P-Dioxins (PCDDs), but 18 AAC 75, Table B-1 lists a cleanup standard for only one compound, 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). As discussed below, the project-specific ARAR for dioxins in soil is 38 parts per trillion (ppt) toxic equivalency quotient (TEQ), referenced to 2,3,7,8-TCDD.

The ARAR for lead in surface and subsurface soil at the former Rifle Range is 800 milligrams per kilogram (mg/kg). The ADEC has indicated the acceptance of 800 mg/kg due to current and anticipated future land use as industrial/commercial, and limited access to the property due to its location within the restricted area controlled by the Yakutat airport. The EPA maintained statistical software package, ProUCL 4.0, was utilized by the USACE to establish background concentrations of arsenic and chromium in soil for the AOCs. The data set included 200 measured values of arsenic and 201 measured values of chromium in soil samples collected and analyzed from the Yakutat Air Force Base area. The ProUCL 4.0 results indicate a background concentration for arsenic of 11.6 mg/kg and a background concentration for chromium of 37 mg/kg (USACE 2009). Arsenic and/or chromium values exceeding these established background concentrations will be considered COCs.

Sediment

Sediment samples containing concentrations of COPCs, other than dioxins, exceeding the most stringent fresh water level presented in the NOAA screening quick reference tables (SQuiRT) (NOAA 2008) or background concentrations will be considered COCs. NOAA encourages the use of established background concentrations instead of the screening levels presented in the SQuiRT when such background concentrations are available. The established background concentration for chromium, 37 mg/kg, will be used as the ARAR for chromium in sediment (USACE 2009). The established background concentration for arsenic, 11.6 mg/kg, will be used as the ARAR for arsenic in sediment (USACE 2009). The ADEC Method 2 soil cleanup standard, listed in Tables B1 and B2, 18 AAC 75.341, will be used as the ARAR if a SQuiRT value for a COPC is not given. Dioxins are discussed in more detail below.

Surface Water

For surface water samples, the ARAR for a specific COPC will be the most stringent of the following three criteria: (1) the SQuiRT values; (2) the 18 AAC 70.020(b), Water Quality Standards (ADEC 2009), referred to in this document as the Alaska Water Quality Standards (AWQS); and (3) the EPA drinking water primary maximum contaminant levels (MCLs). If a SQuiRT value, AWQS, or EPA MCL for a COPC is not given, the cleanup criteria listed in Table C, 18 AAC 75.345 will be used.

Groundwater

The groundwater ARARs are the cleanup criteria listed in Table C, 18 AAC 75.345.

Dioxins

The dioxin data generated from surface soil, subsurface soil, sediment and surface water sampling activities is evaluated using the TEQ approach. This methodology has been applied by multiple agencies, including the EPA, the World Health Organization (WHO), and the U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry (ATSDR). The TEQ method uses conversion factors, or toxic equivalency factors (TEFs), to express each dioxin and dioxin-like compound as an equivalent concentration of the reference compound 2,3,7,8-TCDD. The sum of the TEF concentrations in a sample yields a TEQ. Although footnote 8 to Tables B1 and B2 of the ADEC Method 2 Soil Cleanup Levels states "dioxin cleanup levels must be determined on a site specific basis," the ADEC has accepted a screening level of 38 parts per trillion (ppt) TEQ for soil and sediment, based on 10-5 risk threshold, as an acceptable criterion for determining the need for additional assessment. Dioxin and dioxin-like compounds in soil or sediment having TEQ values exceeding the screening level of 38 ppt will be considered COCs. For surface water samples, the ARAR for dioxin and dioxin-like compounds will be the SQuiRT value of 0.01 ppt. ADEC has also accepted the EPA drinking water MCL of 0.03 ppt TEQ as a groundwater screening level criterion.

RCRA Considerations

Selected COPCs are also subject to RCRA. Because the presumed contamination source is not an Underground Storage Tank (UST), the resulting contaminated media are not eligible for the UST exemption rule. Note that military records show that three USTs were planned for the Seaplane Base (AOC G); however, two tanks may not have been installed and the third has been removed and the site investigated. No contamination at the Seaplane Base is attributed to USTs. Accordingly, determination of disposal options must consider the RCRA toxicity characteristic criteria for hazardous waste listed in CFR Title 40, Chapter 261.24. The criteria apply directly to the measured analyte concentrations in groundwater, and to the leachable component in soils, as measured using toxicity characteristic leaching procedure (TCLP) testing protocols. The EPA munitions rule may also apply to lead at the Rifle Range.

3.1.4 Assumptions for Estimated Areas and Volumes of Impacted Media

Areas and volumes of impacted media are estimated for the AOCs selected for the FS and are presented in Tables 3.1-2 and 3.1-3. The estimates shown on these tables are rough order of magnitude numbers, should not be interpreted as exact areas or volumes, and have not been rounded. The estimates are based on the sampling data available in the GFM and may differ from previous estimates by others. Due to inconsistencies in data presentation in the various GFM, interpretations of the extent of impacted media may also differ from previous interpretations by others. The lateral and/or vertical extent of the impacted media may not have been determined for each of the AOCs; therefore, since the actual extent of the impacted media is uncertain assumptions regarding the extent of impacted media have been made. The cross sections and contour plans developed for the 2006 ROST/LIF are utilized to estimate both the lateral and vertical extent of impacted media at AOCs addressed in the study. This information is combined with sampling data from other investigations to estimate the boundary of impacted media shown on respective figures.

The approximate and/or interpreted boundary of contaminated surface soil, subsurface soil and/or sediment, representing the estimated lateral extent, is shown for each applicable AOC on site plans included in Section 3. Assumptions made in estimating the lateral and vertical extent of impacted media are discussed below.

A “hotspot” is assumed at locations where a single surface or subsurface soil sample contained a COC. The “hotspot” was assumed to extend over a 20-foot diameter area at sample locations where petroleum COCs were identified. The “hotspot” was assumed to extend over a 10-foot diameter area at sample locations where metals or pentachlorophenol were identified.

The lateral extent of impacted soil or sediment was estimated at locations where the COC was documented in multiple locations by outlining an area encompassing each location where the COC was identified. The boundary was typically extended 10 to 20 feet beyond the COC sampling location. Our boundary interpretations also assume that the lateral distribution of impacted media extends continuously between sampling locations.

The vertical extent of impacted soil was estimated based on the depths of samples containing identified COCs. In surface soil, the vertical extent of impacted soil was assumed to extend from the ground surface to a depth of 2 feet bgs. The depth of 2 feet was selected based on the definition of “surface soil” by ADEC in 18 AAC 75. The depth of impacted subsurface soil was assumed to extend over the interval in which the COC was identified. For example, if two soil samples collected at 15 feet to 17 feet bgs and 25 feet to 27 feet bgs contained a COC, the vertical depth of impacted soil would be estimated from 15 feet bgs to 27 feet bgs. If a second sampling location contained a COC at a deeper interval, such as 35 feet bgs, the vertical extent of impacted soil would be estimated from 15 feet bgs to 35 feet bgs. The estimated vertical extent is assumed to extend continuously throughout the entire estimated lateral area.

Volumes of impacted surface and subsurface soil and sediment are calculated using the estimated lateral and vertical extent. The assumption is made that the impacted media is homogenous, extending throughout the estimated vertical extent over the entire lateral area. The volume of clean overburden requiring removal to physically access impacted subsurface soil is estimated for AOCs where only impacted subsurface soil is present. The assumption is again made that the clean overburden volume is limited to the vertical extent of soil from the site surface to the depth of the impacted soil extending over the lateral extent of impacted subsurface soil. A bulking factor of 15% is applied to the estimated volumes of impacted soil and overburden to reflect actual volumes that, based on our experience, are measured once the material is excavated. The areas and volumes calculated are shown in Table 3.1-2.

At sites where COCs were encountered in surface water, the aerial extent of impacted surface water cannot be estimated based on available data. For the purpose of this FS, the aerial extent of impacted surface water is uncertain. At sites where COCs were encountered in groundwater, the impacted groundwater plume is assumed to be twice the lateral extent of the impacted soil at the AOC. The assumed aerial extent of the groundwater plumes are indicated in Table 3.1-3.

3.2 AOC A1, Air Corps Increase Group No. 2

AOC A1, also referred to as the Air Corps Increase Group No. 2, consists of a building and miscellaneous debris disposal area. AOC A1 is located on the south side of Cannon Beach Road, approximately 1 mile from Engineer's Road (Airport Road). Figure 1.2-1 shows the general location of AOC A1. USACE documents indicate that the buildings and military-generated debris in the area were buried on site during the 1984 to 1985 USACE cleanup effort. The buildings were demolished, buried in excavation pits, and covered with soil (ENSR 2003b).

During RI efforts by ENSR in 1999 and 2000, two separate site walkovers were conducted in the general area of AOC A1. During one walkover, a large (approximately 25 feet by 35 feet) earthen mound was observed on site and is suspected to be the disposal area for 11 military structures formerly in the area. The mound was covered with unstressed vegetation. During the second walkover, an area approximately 800 feet south of AOC A1 was visually evaluated. The location is a suspected drum storage area. No evidence of debris disposal or other environmental concern was found. Based on their findings, ENSR did not recommend additional investigation at AOC A1 (ENSR 2003a, ENSR 2003b, ENSR 2005).

In summary, COCs were not identified at AOC A1, therefore, AOC A1 will not be included in the FS.

3.3 AOC B - Air Warning Filter Center (AWFC)

The AWFC was built and used during World War II to control the information regarding aircraft approaching the base. Power was supplied by a 20-kilowatt generator (Powerhouse No. 1) and a standby 14-kilowatt generator (Auxiliary Powerhouse No. 2). The AWFC had semi-underground 200- to 500-gallon fuel tanks nearby (ENSR 2003b).

3.3.1 AOC B1 - AWFC Powerhouse No. 1

AOC B1, also referred to as Powerhouse No.1, contained power generation equipment (e.g., generators, transformers, etc.) to supply power for the AWFC. A rectangular concrete slab foundation approximately 14 feet by 20 feet and framed by a vertical curb was present in the area (ENSR 2003b). AOC B1 is shown in Figure 3.3-1.

AOC B1 was first sampled as part of the 1997 Yakutat Air Base/OCRR site investigation. Four surface soil samples were collected from AOC B1 and B2. Analytical results indicated diesel range organic (DRO) concentrations in the soil ranging from non-detect to 23 mg/kg (BC-J 2007). The practical quantitation limit (PQL) for each DRO analysis was less than the 230 mg/kg ARAR.

Surface and subsurface soil and groundwater sampling was conducted by ENSR during the 2001 RI field activities. Three locations around the perimeter of the powerhouse foundation were sampled to determine whether surface soil contamination exists. Borings AP-053, AP-054 and AP-055 were advanced at AOC B1. Monitoring Wells AP-053, AP-054 and AP-055 were installed in these borings and sampled (ENSR 2003b).

Arsenic concentrations up to 8.0 mg/kg in surface and subsurface soil samples exceeded the ADEC Method 2 soil cleanup level (ENSR 2003b). However, the detected concentrations of arsenic are below the established background concentration of 11.6 mg/kg. No other metals in surface and subsurface soil exceeded ADEC Method 2 soil cleanup levels. Groundwater sampling was also conducted by ENSR during the 2001 RI field activities at Monitoring Wells AP-053, AP-054 and AP-055. Lead concentrations in groundwater samples collected from Wells AP-053, AP-054 and AP-055 [up to 0.0439 milligrams per liter (mg/L)] exceeded the ADEC groundwater cleanup level of 0.015 mg/L. ENSR concluded that the elevated concentrations were likely due to suspended solids associated with turbidity in the sample resulting from purging and sampling using a bailer. Elevated lead concentrations were not detected in soil at AOC B1. No other metals in groundwater exceeded ADEC groundwater cleanup levels (ENSR 2003b).

The 2001 RI sampling also addressed polychlorinated biphenyls (PCBs) and petroleum contaminants. No evidence of PCB contamination (possibly associated with the former powerhouse) was detected at AOC B1. Evidence of petroleum contamination was detected in trace amounts; however, those concentrations were below applicable ADEC cleanup levels (ENSR 2003b).

In 2004, Shannon & Wilson conducted groundwater sampling at AOC B1 during Focused RI field activities. Well AP-055 was purged using low-flow techniques and sampled for lead. Lead was detected at 0.0041 mg/L in the triplicate sample collected from the well which is less than the ADEC Table C groundwater cleanup criterion of 0.015 mg/L. The project and duplicate sample did not contain detectable concentrations of lead. The PQL for each analyses was 0.00015 mg/L (S&W 2006a).

Additional groundwater sampling was conducted by BC-J during a RI in 2006. Two monitoring wells at AOC B1 (AP-053 and AP-054) were sampled and analyzed for lead by EPA

Method SW6020. Lead was detected in the two samples at 0.00017 and 0.000236 mg/L, which are less than the ADEC Table C groundwater cleanup criterion of 0.015 mg/L (BC-J 2007).

In summary, COCs were not identified at AOC B1, therefore, AOC B1 will not be included in the FS.

3.3.2 AOC B2 - AWFC - Auxiliary Powerhouse No. 2

AOC B2, also referred to as the Auxiliary Powerhouse No. 2, supported the AWFC in the event that an additional or supplemental source of electrical power was necessary. The auxiliary generator was supposed to be located at one end of a Quonset hut storage building. Two rectangular foundations with collapsed Quonset huts were present in this area, roughly aligned in a north-south orientation. The generator was supposed to be located in the southern end of the south building; however, a chimney cap, a faucet, and other piping possibly associated with the generator were found near the north foundation (ENSR 2003b). AOC B2 is shown in Figure 3.3-1.

AOC B2 and adjacent AOC B1 were first sampled as part of the 1997 Yakutat Air Base/OCRR site investigation. Four surface soil samples were collected from AOC B1 and B2. Analytical results indicated DRO concentrations in the soil ranging from non-detect to 23 mg/kg (BC-J 2007). The PQL for each DRO analysis was less than the 230 mg/kg ARAR.

Surface and subsurface soil and groundwater sampling was conducted by ENSR during the 2001 RI field activities. Five locations near the two concrete foundations were sampled to determine whether surface contamination exists. Since both foundations were considered to be potential source areas, four borings were advanced at this AOC (AP-056, AP-057, AP-058, and AP-059). Monitoring Wells AP-056, AP-057, AP-058, and AP-059 were installed in these borings and sampled (ENSR 2003b).

Pentachlorophenol (PCP) was detected in a surface soil sample at a concentration of 0.0223 mg/kg. PCP was not detected in the subsurface soil samples. The concentration of PCP in the surface soil sample does not exceed the current ADEC Method 2 soil cleanup level of 0.047 mg/kg. Arsenic concentrations up to 7.3 mg/kg in surface and subsurface soil samples exceed the ADEC Method 2 soil cleanup level. Arsenic concentrations in surface and subsurface soil samples, however, are below the established background concentration of 11.6 mg/kg. Chromium concentrations in surface soil were below the ADEC Method 2 soil cleanup level. Chromium concentrations up to 31 mg/kg in subsurface soil exceeded the ADEC Method 2 soil cleanup level. Chromium concentrations in subsurface soil, however, are below the established background concentration of 37 mg/kg. No other metals in surface or subsurface soil exceeded ADEC Method 2 soil cleanup levels (ENSR 2003b).

Groundwater sampling was also conducted by ENSR during the 2001 RI field activities. Lead (up to 0.0834 mg/L), arsenic (up to 0.0575 mg/L), and chromium (up to 0.136 mg/L) concentrations in groundwater samples collected from Wells AP-056, AP-057, AP-058 and AP-059 exceeded ADEC groundwater cleanup levels of 0.015 mg/L, 0.01 mg/L, and 0.1 mg/L, respectively. ENSR concluded that the elevated concentrations of these metals were likely due to suspended solids associated with turbidity in the sample resulting from purging and sampling using a bailer. No other analytes in groundwater exceeded ADEC groundwater cleanup levels (ENSR 2003b).

The 2001 RI sampling also addressed PCBs and petroleum contaminants. No evidence of PCB contamination (possibly associated with a former powerhouse) was detected at AOC B2. Evidence of petroleum contamination was detected in trace amounts; however, those concentrations were below applicable ADEC cleanup levels (ENSR 2003b).

In 2004, Shannon & Wilson conducted groundwater sampling at AOC B2 during Focused RI field activities. Well AP-059 was appropriately purged and sampled for lead. Lead was not detected in the groundwater sample. Well AP-056 could not be purged and sampled due to a surge block obstruction and sand present in the well casing (S&W 2006a).

Additional groundwater sampling was conducted by BC-J during a RI in 2006. Two monitoring wells at AOC B2 (AP-057 and AP-058) were sampled and analyzed for lead by EPA Method SW6020. In addition, Well AP-058 was sampled and analyzed for arsenic and chromium by EPA Method SW6020. Concentrations of lead were detected in the two samples at 0.000059 and 0.000207 mg/L, which are less than the ADEC Table C groundwater cleanup criterion of 0.015 mg/L. Both arsenic and chromium were detected in Well AP-058 at concentrations of 0.00019 and 0.0008 mg/L, respectively, which are both less than the corresponding ADEC Table C groundwater cleanup criteria of 0.01 and 0.1 mg/L (BC-J 2007).

In summary, COCs were not identified at AOC B2, therefore, AOC B2 will not be included in the FS.

3.3.3 AOC B3 - AWFC Tank and Associated Piping

According to military records, a concrete storage tank associated with a bathhouse was located at AOC B3. A 15-foot square foundation with vertical curbs was present on a mound approximately 5 feet high north of the Auxiliary Powerhouse No. 2 area (AOC B2). This foundation had several vertical curbs delineating possible internal wall supports and is thought to be the bathhouse. A 4-foot square, concrete storage tank with an opening on top was present approximately 12 feet south of the foundation. A 4-inch pipe extends out to the south side of the tank and angles into the ground. The tank contained what appeared to be rainwater and was presumed to be a cistern associated with the bathhouse (ENSR 2003b). A site plan of AOC B3 is shown on Figure 3.3-1.

In 2001, ENSR performed a geophysical survey and surface and subsurface soil and groundwater sampling. One surface location near the bathhouse foundation was sampled to determine whether surface soil contamination exists. Two borings (AP-060 and AP-061) were advanced at this AOC. Monitoring Wells AP-060 and AP-061 were installed in these borings and sampled. The geophysical survey was conducted at this site prior to sampling activities to delineate the extent of piping associated with the former storage tank. Results of the geophysical survey indicate that piping exists between the foundation and tank and continues to the south approximately 25 feet (ENSR 2003b).

PCP was detected in the surface soil sample collected near the northeast corner of the bathhouse foundation at a concentration of 0.0254 mg/kg. PCP was not detected in subsurface soil or groundwater. The concentration of PCP in the surface soil sample does not exceed the current ADEC Method 2 soil cleanup level of 0.047 mg/kg. Arsenic concentrations in surface and subsurface soil exceeded the ADEC Method 2 soil cleanup level but were below the established background concentration of 11.6 mg/kg. Chromium concentrations in subsurface soil exceeded the ADEC Method 2 soil cleanup level. Chromium concentrations in surface soil were less than the ADEC Method 2 soil cleanup level. No other analytes in soil exceeded ADEC Method 2 soil cleanup levels. Chromium concentrations in subsurface soil are below the established background concentration of 37 mg/kg (ENSR 2003b).

Lead concentrations in groundwater samples collected from Wells AP-060 and AP-061 exceed the ADEC groundwater cleanup level of 0.015 mg/L. The maximum concentration detected was 0.039 mg/L. ENSR concluded that elevated concentrations are likely due to suspended solids associated with turbidity in the sample resulting from purging and sampling using a bailer. Elevated concentrations were not detected in soils at this AOC. Lead in groundwater was considered by ENSR to be a COPC at this AOC B3. No other analytes in groundwater exceeded ADEC groundwater cleanup levels. ENSR recommended follow-on groundwater sampling using a submersible pump or other low-flow sampling technique to better define dissolved lead concentrations (ENSR 2003b).

In 2004, one monitoring well at AOC B3 (AP-061) was sampled and analyzed for lead. Well AP-061 was appropriately purged and sampled for lead. Concentrations of lead were not detected in AP-061. Well AP-060 could not be sampled as the casing had been broken off and the end of the 2-inch pipe was not visible in the ground (S&W 2006a). Based on the sample result from Well AP-061, lead in groundwater at AOC B3 is no longer considered a COPC.

In summary, COCs were not identified at AOC B3, therefore, AOC B3 will not be included in the FS.

3.4 AOC C - Point Carrew

The Point Carrew Garrison facilities were built to support Panama gun emplacements along the west and south coast of Phipps Peninsula during World War II military presence in Yakutat. Infrastructure on the peninsula included petroleum and ammunition storage facilities; 155-millimeter (mm), rigid-mount gun emplacements and housing; a Coast Artillery Garrison; four warehouses; a small dock (on the Ankau Inlet); a plotting room; powerhouses; and a garbage dump. Most of the buildings were removed during the 1985 USACE cleanup efforts. Historically and currently, Point Carrew, the Ankau waters, and Ocean Cape provide a subsistence food source. The entire Phipps Peninsula is used to hunt moose and ducks; collect berries, clams, cockles, and seaweed; and fish for salmon (ENSR 2003a, USACE 2008).

3.4.1 AOC C1 - Ankau Bridge Garbage/Drum Dump

The 1943 Layout Plan (B-90), Yakutat Landing Field, provided in Appendix A, indicates the presence of a garbage dump off the southwest edge of Artillery Road (Point Carrew Road) approximately 1000 feet south of the Ankau Inlet Bridge. This garbage dump area is referred to as AOC C1. Several large, moss-covered, fallen trees between the landfill and road edge were observed in 1999, possibly left there during road construction. This dump site was not evident from the road and had been overgrown by forest. Field observations during the October 1999 site survey located over 20 partially buried, severely rusted drums with miscellaneous garbage (e.g., tires and bottles) at AOC C1. Topography slopes to the south, and the area is well covered with moss, alders, and spruce trees. Point Carrew Road is built up 1 to 6 feet above the original ground surface. There is a small creek at the south end of the site. A site map is presented as Figure 3.4-1. Possible contaminant sources for AOC C1 are the severely rusted 55-gallon drums and other debris partially buried in the dump. Contamination associated with this dump site could have migrated toward the small creek or infiltrated through the subsurface soils to groundwater (ENSR 2003a).

One soil and one water sample were collected in 1996 by AGRA during a summary investigation of US DoD activities on Yakutat tribal lands. The text within the AGRA report labeled both samples as soil; however, the associated data tables reported one sample as soil and one sample as water. The samples were collected from the south side of the Garbage/Drum Dump, in the area of the small creek. For the purpose of AGRA's Qualitative Risk Assessment, a chemical was identified as a COPC if the concentration of that chemical exceeded its EPA Region 3 residential risk-based concentration (RBC). The RBC of a chemical is the concentration of that substance in soil or water above which an adverse toxicological effect would likely result. EPA Region 3 RBCs were used by convention because the EPA Region 10 (including Alaska) recognizes Region 3 RBCs as a valid tool for evaluating risk. Both samples had detectable concentrations of PCDDs and polychlorinated dibenzo-furans (PCDFs). The calculated 2,3,7,8- TCDD equivalents were 0.00 ppt for the soil sample and 0.038 ppt for the water sample. The soil calculated equivalent was below the RBC of 4.5 ppt and the 38 ppt ARAR, showing no quantifiable risk associated with the soil. The water calculated equivalent was greater than the 0.01 ppt ARAR, therefore dioxins are included as a COC in surface water at AOC C1.

A geophysical survey and sampling of the surface soil, subsurface soil and groundwater were conducted by ENSR during the 2000 RI field activities. Ten surface locations within and around the former landfill were sampled to determine whether surface soil contamination exists. Six soil borings (AP-013 through AP-018) were advanced at AOC C1 to determine whether contaminants were present in subsurface soils. Samples were collected from Monitoring Wells AP-013 through AP-016, and AP-018 to determine whether contaminants were leaching into the groundwater. Boring AP-017 was not completed as a monitoring well. The geophysical survey was conducted at this AOC before sampling activities to delineate the extent of remaining drums and debris in the landfill. Results of a geophysical survey indicated that buried metal or surface debris, or both, in the Garbage/Drum Dump cover approximately 12,440 square feet. The boundary of the dump area is generally defined by visible surface debris (ENSR 2003a).

Arsenic and chromium were the only analytes that exceeded ADEC Method 2 soil cleanup levels. Arsenic concentrations up to 9.6 mg/kg were detected in both surface and subsurface soil but did not exceed the established background concentration of 11.6 mg/kg. One surface soil sample collected outside of the dump area was reported to have a chromium concentration of 43 mg/kg, which is above the background concentration of 37 mg/kg. No other surface or subsurface soil samples contained analytes that exceed ADEC Method 2 soil cleanup levels. Arsenic and lead concentrations were detected in the groundwater samples but at concentrations that do not exceed ADEC Method 2 groundwater cleanup levels. There is no indication of a release of any hazardous substances from the Garbage/Drum Dump. ENSR concluded that development of site-specific, risk-based cleanup levels for chromium were considered as possibly appropriate at AOC C1 (ENSR 2003b).

In summary, the chromium concentration in surface soil exceeds the current background concentration of 37 mg/kg and is the only soil COC identified at AOC C1. Note that the chromium concentration in surface soil is assumed to be hexavalent chromium (Cr6+), a known carcinogen. AOC C1 may be retested to determine if the chromium concentration is due to Cr6+ or trivalent chromium (Cr3+). The cleanup level for Cr3+ is 124,000 mg/kg. If it is determined that the chromium concentration in surface soil is actually Cr3+, then there are no soil COCs at AOC C1. The 2,3,7,8-TCDD equivalent in one surface water sample exceeds the ARAR therefore dioxins are considerd a COC in surface water at AOC C1. AOC C1 is included in the detailed FS. Figure 3.4-1 shows the approximate boundary of the impacted surface soil. The impacted area is treated as a hotspot since chromium was detected in a single sample location. The impacted soil is assumed to extend vertically from the ground surface to a depth of 2 feet bgs and laterally over an area of 78 square feet (sf). The estimated volume of impacted soil is approximately 7 cubic yards (cy). The presence of dioxins in surface water should be investigated further to determine if dioxin is still present.

3.4.2 AOC C2, C3, and C4 - Garrison Area

AOC C2, C3, and C4 are in close proximity to each other in the former garrison area on the north side of Point Carrew Road, approximately 1.4 miles east of Ocean Cape. These AOCs, referred to in former documents as AOC C2 (Drum Dump - Point Carrew), AOC C3 (Powerhouse Foundation 1 Potential Release), and AOC C4 (Surface Debris - Garrison), were investigated as a single area. A site plan for AOC C2, C3, and C4 is provided as Figure 3.4-2.

The 1943 Layout Plan (B-90), Yakutat Landing Field, provided in Appendix A, shows an access road leading to a powerhouse near the north side of Point Carrew Road approximately 1.4 miles from Ocean Cape. No landfill is shown on the 1943 drawings in association with the powerhouse. The landfill has been referred to locally as the RCA (Radio Corporation of America) dump, but it is not known when this area was first used as a landfill. A former RCA worker interviewed by AGRA reported that the DoD disposed of "lots of material … at a dump site between the WACS site and the Ankau Inlet bridge", indicating that this area was used as a landfill prior to 1984 (AGRA 1997). Military-generated debris in the area was removed during the 1984 cleanup effort (USACE 1984). Based on historical documentation regarding PCBs in transformer oil, the potential for contamination in the area exists. Petroleum contamination is also considered possible depending on former petroleum handling and storage practices and petroleum tank disposal practices. Surface debris, including tires and engine parts, were visible at the end of the access road during the 1999 site walkover (ENSR 2003a).

In 1984, during an Environmental Restoration Defense Account Debris Cleanup and Site Restoration, one water sample was collected from a submerged, punctured barrel and analyzed by Gas Chromatography/Mass Spectroscopy (GC/MS) (AGRA 1997). No aliphatic hydrocarbons or common organic solvents were detected. During the 1984 cleanup, the powerhouse ruins, an engine block, and trash were removed from the powerhouse site. A debris pile and lots of trash were removed from the landfill, and 55-gallon drums were removed from the debris area. Two medium-sized Quonset huts were also removed from the general area (ENSR 2003a, ENSR 2003b, USACE 1984).

During a 1994 field investigation, one sediment sample was collected near a potentially leaking drum located in the surface debris area (AOC C4). The location of the sediment sample within the surface debris area is not known. Petroleum odor and fuel sheen were generated when adjacent sediment was disturbed. DRO test results from that sample were estimated at 4,700 mg/kg. This DRO concentration in sediment exceeds the ADEC Method 2 soil cleanup level of 230 mg/kg. Total recoverable petroleum hydrocarbon (TRPH) and gasoline range organics

(GRO) were also detected at 9,000 mg/kg and 29 mg/kg, respectively. DRO and TRPH sample results were estimated because the high concentration of fuel in the sample diluted the matrix spike. GRO sample results were estimated because the chromatogram did not match the typical gasoline fingerprint. E&E estimated the area of contaminated sediment associated with the landfill to be 1,000 sf. The depth of contamination was not determined (E&E 1997, ENSR 2003a, ENSR 2003b). Information regarding other analytes detected, if any, was not available for comparison with SQuiRT values.

In 1996, two soil samples were collected from the former powerhouse area, one soil sample was collected near drums south of the powerhouse, and two surface soil samples and one water sample were collected from the landfill area. The specific locations of these samples are not known. The surface water sample, collected from the trench in the landfill, contained detectable concentrations of PCBs (Aroclor 1242 at 0.051 mg/L and Aroclor 1260 at 0.0008 mg/L), bis(2-ethylhexyl)phthalate (0.048 mg/L), 3- and 4-methylphenol (0.022 mg/L), naphthalene (0.004 mg/L and 0.011 mg/L), and 2-methylnaphthalene (0.023 mg/L), 1,4-dichlorobenzene (0.0032 mg/L), ethylbenzene (0.0005 mg/L), xylenes (0.0047 mg/L), 1,2,4-trimethylbenzene (0.003 mg/L), and 1,3,5-trimethylbenzene (0.003 mg/L). These concentrations exceed the SQuiRT values or AWQS of 0.000014 mg/L for PCBs, and 0.0003 mg/L for bis(2-ethylhexyl)phthalate. No volatile organic compounds (VOCs) were detected in the soil samples from the landfill. One sample collected from the landfill was considered by AGRA to have "the highest potential of containing dioxins for their respective locations" and was analyzed by the P450 Reporter Gene Assay test. That sample did not exhibit a level of toxicity consistent with the possible presence of PCDDs and PCDFs. One soil sample from the former powerhouse had detectable concentrations of polynuclear aromatic hydrocarbon (PAHs); however, none of the chemicals exceeded their respective RBC (ENSR 2003a, ENSR 2003b).

During the 1997 E&E Site Investigation, four soil samples were collected: three from the Point Carrew Garrison dump area and one from beneath a collapsed Quonset hut on the other side of Point Carrew Road. The specific locations of these samples are not known. Elevated concentrations of bis(2-ethylhexyl)phthalate, 4,4'-dichlorodiphenyldichloroethane (4,4'-DDD), aldrin, Aroclor 1242, Aroclor 1260, and lead were detected at the drum dump. None of these contaminant concentrations exceeded regulatory guidelines (E&E 1997, ENSR 2003a, ENSR 2003b). The DRO concentrations at the surface debris area (1,500 mg/kg) exceed ADEC cleanup criterion of 230 mg/kg. The surface soil residual range organics (RRO) concentrations at the landfill (1,000 mg/kg) do not exceed the ADEC cleanup criterion of 9,700 mg/kg.

A geophysical survey and sampling of surface soil, subsurface soil, groundwater, sediment, and surface water were conducted by ENSR during the 2000 RI field activities. Eighteen surface locations in the Point Carrew Garrison dump area were sampled to determine whether surface soil contamination exists. Six soil borings (AP-019 through AP-024) were advanced at AOCs C2, C3, and C4 to determine whether contaminants were present in subsurface soils. Samples were collected from Monitoring Wells AP-020, AP-023, and AP-024 to determine whether contaminants were leaching into the groundwater. One surface water and one co-located sediment sample were collected from the boggy area to the south (downgradient) of the landfill to determine whether contaminants were migrating out of the landfill (ENSR 2003a).

The geophysical survey was conducted before sampling activities to delineate the extent of remaining drums and debris in the landfill. Results of the survey indicate five anomalies suggesting several areas where metallic debris is buried. One strong, broad anomaly represents the lateral extent of the drum dump (AOC C2). The drum dump covers an area of approximately 13,000 square feet. A strong, broad anomaly in the area of AOC C3 suggests significant amounts of surface and buried metal associated with the powerhouse foundation. In the surface debris area (AOC C4), a strong, broad anomaly suggests significant amounts of buried metal. The surface debris area covers an area of approximately 830 square feet although nonmetallic debris may cover a larger area. The extent of the dump is generally defined by the surrounding swamp/bog wetlands (ENSR 2003a).

During the ENSR 2000 RI at AOCs C2 and C4, DRO was detected at concentrations above the ADEC Method 2 soil cleanup level of 230 mg/kg in surface soil, subsurface soil, and sediment from six sample locations. The maximum concentration detected was 2,400 mg/kg. Elevated concentrations were detected in samples from the southern edge of the drum dump site (AOC C2) and the surface debris site (AOC C4). The lateral and vertical extent of DRO contamination was not determined. Groundwater samples contained detectable concentrations of DRO which were less than ADEC cleanup levels. Surface water samples contained a DRO concentration estimated at 1.2 mg/L. This surface water sample had concentrations of total aqueous hydrocarbons (TAqH) of 0.00086 mg/L and total aromatic hydrocarbons (TAH) of 0.00053 mg/L which do not exceed the AWQS of 0.015 mg/l and 0.010 mg/l, respectively. DRO was considered by ENSR to be a COPC in surface soil, subsurface soil, and sediment at the drum dump site (AOC C2) and surface debris area (AOC C4) (ENSR 2003a).

Silver was reported in a surface soil sample from the southeast corner of the drum dump site (AOC C2) at 26 mg/kg, exceeding the ADEC Method 2 soil cleanup level of 11.2 mg/kg. Silver in surface soil was considered by ENSR to be a COPC at the drum dump site (AOC C2). Chromium (46 mg/kg and 49 mg/kg) was reported in two surface soil samples from AOC C4, exceeding the current background concentration of 37 mg/kg. Cadmium (3.4 mg/kg) and mercury (0.3 mg/kg) were reported in the sediment sample from AOC C2 at concentrations that exceed the SQuiRT values of 0.583 and 0.174 mg/kg, respectively. Lead (0.013 mg/L) was reported in the surface water sample from AOC C2 at concentrations that exceed the SQuiRT value of 0.0025 mg/L. No PCB or petroleum contamination was found to be associated with the former powerhouse (AOC C3). No COPCs were identified at the former powerhouse location. No other analytes were considered by ENSR to be a COPC at AOC C3 (ENSR 2003a).

In 2005, additional investigation at AOC C2 and C4 was conducted by the USACE. The ROST/LIF results from AOC C2 and C4 indicated the presence of diesel fuel in the near surface soils over a very limited area. Petroleum contamination was limited to the near surface soils (approximately 1 to 3 feet bgs) and did not exceed a depth of 4 feet bgs. The aerial extent of contamination is well defined, and did not extend beyond the known boundaries of AOC C2 and C4 (USACE 2006).

In summary, DRO in surface soil, subsurface soil, and sediment is considered a COC at AOCs C2 and C4. Silver in surface soil is considered a COC at AOC C2. DRO, cadmium and mercury in sediment are considered COCs at AOC C2. PCBs, bis(2-ethylhexyl)phthalate, 2-methylnaphthalene, and lead in surface water are considered COCs at AOC C2. Chromium in surface soil is considered a COC at AOC C4. Note that the chromium concentration in surface soil is assumed to be Cr6+, a known carcinogen. AOC C4 may be retested to determine if the chromium concentration is due to Cr6+ and/or Cr3+. The cleanup level for Cr3+ is 124,000 mg/kg. If it is determined that the chromium concentration in surface soil is actually Cr3+, then there are no soil COCs at AOC C4. AOCs C2 and C4 are included in the detailed FS. COCs were not identified at AOC C3, therefore, AOC C3 will not be included in the FS.

Figure 3.4-2 shows the approximate boundaries of the DRO-impacted surface soil, subsurface soil and sediment, the silver-impacted surface soil, and the DRO, cadmium and mercury-impacted sediment at AOC C2. The DRO-impacted surface and subsurface soil is assumed to extend vertically from 1 to 4 feet bgs and laterally over an area of 10,845 sf. The estimated volume of DRO-impacted soil is 1,386 cy which is overlain by an estimated 462 cy of clean overburden. The DRO-impacted sediment is assumed to extend vertically from 0 to 4 feet bgs and laterally over an area of 470 sf. The estimated volume of DRO-impacted sediment is 80 cy. The silver-impacted area is treated as a hotspot since silver was detected in a single sample location. The silver-impacted surface soil is assumed to extend vertically from the ground surface to a depth of 2 feet bgs and laterally over an area of 78 sf. The DRO, cadmium and mercury-impacted sediment is treated as a hotspot since the combination of COCs was detected in a single sample location. The impacted sediment is assumed to extend vertically from the ground surface to a depth of 2 feet bgs and laterally over an area of 314 sf. The estimated volume of DRO, cadmium and mercury-impacted sediment, is approximately 27 cy. The concentration of PCBs, bis(2-ethylhexyl)phthalate, and lead in surface water should be investigated further to determine if these COCs are still present.

Figure 3.4-2 shows the approximate boundaries of the DRO-impacted surface soil and subsurface soil and the chromium-impacted surface soil at AOC C4. The DRO-impacted soil is assumed to extend vertically from the ground surface to 4 feet bgs and laterally over an area of

1,426 sf. The estimated volume of DRO-impacted soil is 243 cy. Information regarding the location of DRO-impacted sediment at AOC C4 is not known and, therefore, is not shown on Figure 3.4-2. The DRO-impacted sediment is treated as a hotspot and is assumed to extend vertically from 0 to 2 feet bgs and laterally over an area of 314 sf. The two chromium-impacted areas are treated as hotspots. Each hotspot is assumed to extend vertically from the ground surface to a depth of 2 feet bgs and laterally over an area of 78 sf (156 sf total). The estimated volume of chromium-impacted soil is approximately 13 cy.

3.4.3 AOC C5 - Powerhouse No. 1092

Powerhouse No. 1092 supplied power to a group of buildings at Ocean Cape. Little is known of the military presence at the cape during the World War II era. The area was extensively modified during the construction of the Ocean Cape Radio Relay Station. The powerhouse was most likely located to the east of the water storage tank currently on site although the actual location has not been determined. ENSR made an attempt to locate AOC C5 during their 2001 RI/FS field program. The area behind the water tank was covered in thick brush and lead up to a flat-topped hill. This hill was probably cleared and leveled off when a swath was cut for radio transmission from the radar antennas toward the east in the direction of another radio relay station. No evidence was found indicating the location of the powerhouse or contamination associated with it (ENSR 2003b). The general location of AOC C5 is shown in Appendix A on E&E Figure 5-6.

In summary, COPCs were not identified at AOC C5, therefore, AOC C5 will not be included in the FS.

3.4.4 AOC C6 - 50,000-Gallon Fuel Tank

AOC C6 is the former location of an aboveground, 50,000-gallon, wood-stave reserve diesel fuel tank. The site is located on the south side of Point Carrew Road about one-third of a mile west of the Ankau Bridge and approximately 125 feet west of Ankau Inlet. A site plan of AOC C6 is included as Figure 3.4-3. The tank and associated piping were removed at some time in the past. A circular concrete foundation at the site shows where the former AST was once located (ENSR 2003b). No parts of the tank, or associated piping, remain or are evident at the site. However, because fuel was stored in a wood stave tank, there is a high potential for a petroleum release.

The area was initially investigated in 1996, when a single soil sample was analyzed for polynuclear aromatic hydrocarbons. The only positive result was for fluoranthene, with a concentration of 0.009 mg/kg (AGRA 1997). This fluoranthene concentration does not exceed the most stringent ADEC soil cleanup criterion (migration to groundwater) of 1,400 mg/kg.

Three surface soil samples were collected in 1997 as part of the 1997 Yakutat Air Base/OCRR site investigation. Analytical results indicated elevated concentrations of dichlorodiphenyldichloroethane (DDD) and dichlorodiphenyltrichloroethane (DDT) but not of petroleum products (BC-J 2007). These DDD and DDT concentrations do not exceed the most stringent ADEC soil cleanup criteria (migration to groundwater) of 7.2 and 7.3 mg/kg, respectively.

During ENSR's 2001 investigation, a geophysical survey and sampling of surface soil, subsurface soil, and groundwater were conducted at AOC C6. The geophysical survey was conducted at this site prior to sampling activities to delineate buried pipelines associated with the former tank (if present) and to aid in borehole placement. Three locations downslope of the tank foundation were sampled to determine whether any residual fuel contamination exists in the surface soil. Three soil borings (AP-062, AP-063, and AP-064) were advanced to determine whether residual fuel contamination exists in the subsurface soil. Groundwater samples were obtained from Monitoring Wells AP-062 and AP-063 (ENSR 2003b).

DRO was detected in surface soil and subsurface soil at concentrations that exceed the ADEC Method 2 soil cleanup level of 230 mg/kg. Concentrations ranging from 705 mg/kg to 5,800 mg/kg were reported in samples to the south and east of the tank foundation. No other analytes in soil exceeded ADEC Method 2 soil cleanup levels. DRO in groundwater was detected in the sample from Well AP-062 (approximately 75 feet east of the tank foundation) at a concentration (6.84 mg/L) that exceeds the ADEC groundwater cleanup level of 1.5 mg/L. No other analytes in groundwater exceeded ADEC groundwater cleanup levels. ENSR recommended additional investigation to better define the extent of DRO contamination in soil and groundwater at this AOC (ENSR 2003b).

In 2004, two monitoring wells at this site (Wells AP-063 and AP-064) were sampled for RCRA metals. The RCRA metal concentrations were either non-detectable or below the applicable ADEC Method 2 cleanup levels (S&W 2006a).

In 2005, USACE utilized the ROST, with its LIF probe to identify and delineate petroleum, oil, and lubricant (POL) contamination at AOC C6. Twenty-four ROST/LIF probes were pushed at this site, and four correlation soil samples were collected. The ROST/LIF results indicated the presence of diesel fuel contamination in the soil associated with the former tank in discrete zones ranging from 5 to 15 feet bgs. The extent of the contamination was well defined in some areas, but poorly defined in others due to physical constraints (rough terrain, heavy vegetation, etc.). The results did show that the contamination in soil does not extend to Ankau Slough, the nearest environmental receptor. The four correlation soil samples were analyzed for DRO, RRO, and one for GRO. The four DRO results exceed the ADEC Method 2 cleanup level, with the highest concentration at 5,880 mg/kg. RRO and GRO results were below the applicable ADEC Method 2 cleanup levels (USACE 2006).

In 2006, one monitoring well at AOC C6 (AP-062) was sampled and analyzed for DRO by Method AK102 and RCRA metals by EPA Methods SW6020 and SW7470A. Duplicate and triplicate samples were also collected from Well AP-062 and analyzed for DRO only. DRO was detected in the primary, quality control (QC) duplicate, and quality assurance (QA) triplicate samples at concentrations ranging from 1.73 to 2.1 mg/L, each above the ADEC Table C groundwater cleanup criterion of 1.5 mg/L. No other analytes exceeded ADEC Table C groundwater cleanup criteria. Sample results from AOC C6 indicate that DRO concentrations at the site remain above the ADEC Table C groundwater cleanup criterion (BC-J 2007). It is noted that in 2005, six ROST/LIF probes were positioned between Ankau Slough and the soil contaminant plume originating at the tank. The probes were advanced to the depth of groundwater. The ROST/LIF results for the six probes did not indicate that DRO contamination was present. Although these results indicate the DRO contamination does not extend to Ankau Slough, groundwater sampling was not conducted and, therefore, the lateral extent of DRO-impacted groundwater is not known.

In summary, DRO in surface and subsurface soil and groundwater is considered a COC at AOC C6. AOC C6 is included in the detailed FS. Figure 3.4-3 shows the approximate boundary of the DRO-impacted soil. The DRO-impacted soil is assumed to extend vertically from the ground surface to 15 feet bgs and laterally over an area of 19,893 sf. The estimated volume of DRO-impacted soil is 12,709 cy. The lateral extent of DRO-impacted groundwater is not known, however, for the purposes of this FS, the DRO-impacted groundwater plume is assumed to be about twice the lateral extent of the DRO-impacted soil or over an area of approximately 40,000 sf.

3.4.5 AOC C7 - Powerhouse No. 1093

Powerhouse No. 1093 contained a 7.5-kilowatt gasoline-engine generator to provide power to the warehouses in the ammunition storage area of the Point Carrew Garrison. A rectangular concrete slab foundation approximately 12 feet by 18 feet was located on site (ENSR 2003b, ENSR 2005). A site plan of AOC C7 is provided in Figure 3.4-4.

Surface and subsurface soil sampling was conducted by ENSR during the 2001 RI field activities. Arsenic concentrations in surface soil exceeded the ADEC Method 2 soil cleanup level. Arsenic was reported in one surface soil sample collected from a shallow ditch (approximately 50 feet south of the powerhouse foundation) at a concentration (26.3 mg/kg) which exceeds the background concentration of 11.6 mg/kg. However, only the primary sample from this location reported an arsenic concentration above the background concentration. The reported concentration in the associated field QC duplicate sample (8.31 mg/kg) was below the background concentration. The presence of arsenic above the background concentration at this sample location is inconclusive. Associated QA referee sample data was not available for comparison. Arsenic in surface soil is considered a COC at this AOC (ENSR 2003b).

Chromium concentrations in surface soil exceeded the ADEC Method 2 soil cleanup level. Chromium was reported in one surface soil sample from the shallow ditch south of the powerhouse foundation at a concentration (42.7 mg/kg) which exceeds the background concentration of 37 mg/kg. However, only the primary sample from this location reported a chromium concentration above the background concentration. The reported concentration in the associated field QC duplicate sample (18.9 mg/kg) was below the ADEC cleanup level (23 mg/kg) and background concentration. The presence of chromium above the background concentration at this sample location is inconclusive. Associated QA referee sample data was not available for comparison. Chromium in surface soil is considered a COC at this AOC. No other analytes in the surface soil or subsurface soil samples exceeded ADEC Method 2 soil cleanup levels (ENSR 2003b).

Three monitoring wells (Wells AP-065, AP-066, and AP-067) were sampled by ENSR during the 2001 RI field activities. Lead, arsenic, and chromium concentrations in groundwater samples exceeded ADEC groundwater cleanup levels of 0.015 mg/L, 0.05 mg/L, and 0.1 mg/L, respectively. The maximum lead concentration detected was 0.0575 mg/L. The maximum arsenic concentration detected was 0.0587 mg/L. The maximum chromium concentration detected was 0.186 mg/L. ENSR concluded that the elevated concentrations of these metals are likely due to suspended solids associated with turbidity in the sample resulting from purging and sampling using a bailer. Lead, arsenic, and chromium in groundwater were considered COCs at this AOC. No other analytes in groundwater exceeded ADEC groundwater cleanup levels (ENSR 2003b).

No evidence of PCB contamination (possibly associated with the former powerhouse) was detected at this site. Evidence of petroleum contamination was detected in trace amounts; however, the concentrations were below cleanup levels (ENSR 2003b).

In 2004, Shannon & Wilson conducted groundwater sampling at AOC C7 during Focused RI field activities. Wells AP-065, AP-066, and AP-067 were appropriately purged and sampled for arsenic, chromium, and/or lead. Chromium was detected at an estimated concentration of 0.0111 mg/L in Well AP-065 which is less than the ADEC Table C groundwater cleanup criterion of 0.1 mg/L. Concentrations of arsenic and lead in Well AP-065 and lead in Wells AP-066 and AP-067 were not detected (S&W 2006a).

In summary, arsenic and chromium in surface soil are considered COCs at AOC C7. Note that the chromium concentration in surface soil is assumed to be Cr6+, a known carcinogen. AOC C7 may be retested to determine if the chromium concentration is due to Cr6+ and/or Cr3+. The cleanup level for Cr3+ is 124,000 mg/kg. If it is determined that the chromium concentration in surface soil is actually Cr3+, then chromium is not a COC at AOC C7. AOC C7 is included in the detailed FS. Figure 3.4-4 shows the approximate boundary of the impacted surface soil. The impacted area is treated as a hotspot since arsenic and chromium were detected in a single sample location. The impacted soil is assumed to extend vertically from the ground surface to a depth of 2 feet bgs and laterally over an area of 78 sf. The estimated volume of impacted soil is approximately 7 cy.

3.5 AOC D - Army Dock Area Aboveground Storage Tanks (ASTs)

The former tank farm located at AOC D was the primary fuel off-loading site for World War II military activities in Yakutat between 1940 and 1946. Eight ASTs, with tank capacities that ranged from 500 barrels to 2,000 barrels (20,000 to 80,000 gallons), were used to store diesel fuel. AOC D, including the eight ASTs, is shown on Figure 3.5-1. Piping connected the eight ASTs to each other and the Army Dock at Monti Bay. Additional piping transferred truck gasoline and aviation fuel from the dock to tank farms located east and southeast of AOC D. The ASTs were removed prior to August 1963. A cleared gravel pad was constructed to accommodate the current Malaspina Investments (Malaspina) Office and Warehouse, located in the northwest section of AOC D. This facility includes an apartment, office, warehouse, and construction storage yard constructed at the AST1 location (S&W 2006a).

Two public water wells, one water storage tank, and a pump house are currently located in the southern portion of AOC D. These facilities are part of the Yakutat community public drinking water system. The water storage tank is located on the former AST8 tank foundation. In a 1997 Site Investigation, E&E sampled one of the Yakutat city wells, ARCO Well #1, after a 15-minute purge upstream of chlorination and filtration points. Metals were detected, but at concentrations less than the MCLs for drinking water presented in 18 AAC 80. Other analytes were not detected. ARCO Well #2 was not sampled due to mechanical malfunctions (S&W 2006a).

3.5.1 AOC D - Former AST No. 1

Former AST No. 1 (AST1) was located in the northwest corner of AOC D. The area in the vicinity of former AST1, referred to as AOC D - AST1, is an unpaved gravel pad, which is presently occupied by the Malaspina Investment warehouse and apartment building. AOC D - AST1 is shown on Figure 3.5-2. A pond is located approximately 165 feet south of former AST1, and Monti Bay is located approximately 300 feet to the north/northeast. The two Yakutat City water wells are located approximately 570 and 690 feet southeast of AOC D - AST1. The city wells are located upgradient with respect to surface topography and the apparent groundwater flow direction. Visual signs of potential contamination related to the AOC D - AST1 were not observed.

The 2004 Focused RI activities at AOC D - AST1 consisted of collecting surface and subsurface soil samples, and installing, developing, and sampling three groundwater monitoring wells. Results at AOC D - AST1 indicate the presence of DRO at concentrations greater than the

Method 2 migration to groundwater cleanup level in the subsurface soil at concentrations up to 7,900 parts per million (ppm). In addition, DRO was detected in the surface soil and groundwater, but at concentrations less than the ADEC Method 2 soil cleanup criteria and Table C groundwater cleanup levels (S&W 2006a).

The presence of surface stains and an elevated benzene concentration in the surface sample collected adjacent to the garage door of the Malaspina building may indicate a source other than the AOC D - AST1. Benzene was detected in surface soil at an estimated concentration of 0.039 ppm, which is greater than the Method 2 migration to groundwater cleanup level. This potential benzene concern is not considered to be a DoD issue (S&W 2006a).

DRO concentrations were detected in groundwater samples from Wells AST1-1 through AST1-3. The groundwater sample from Well AST1-1 contained the highest concentration of DRO, 0.37 mg/L, which is less than ADEC cleanup level (S&W 2006a).

The 2005 ROST/LIF investigation results delineated the presence of contamination in the soils associated with the AOC D - AST1. Contamination was generally encountered at a depth of at least 7 feet bgs with the exception of one probe (YAK-D-029) where petroleum contamination was located at three depth intervals between 4 feet and 25 feet bgs. The extent of contamination was defined to the north, east, and west (USACE 2006).

Two probes (YAK-D-057 and YAK-D-061) indicated contamination in the subsurface soil between 7 to 16 feet bgs over 100 feet downslope of former AST1. The ROST/LIF report stated that there was not enough evidence to associate this contamination to either former AST1 or AST2 and the contamination is likely related to small localized spills and not from AST1 (USACE 2006). This area is referred to as AOC D - AST1 (downslope).

In summary, DRO in subsurface soil is considered a COC at AOC D - AST1. AOC D - AST1 is included in the detailed FS. Figure 3.5-3 shows the approximate boundaries of the DRO-impacted subsurface soil in the vicinity and downslope of former AST1. The DRO-impacted soil surrounding former AST1 is assumed to extend vertically from approximate 4 feet bgs to groundwater at about 47 feet bgs and laterally over an area of 15,100 sf. The estimated volume of DRO-impacted soil is 27,655 cy overlain by an estimated 2,573 cy of overburden soil. The DRO-impacted soil downslope of former AST1 is assumed to extend vertically from approximate 7 feet bgs to 16 feet bgs and laterally over an area of 11,100 sf. The estimated volume of DRO-impacted soil is 4,255 cy overlain by an estimated 3,309 cy of overburden soil. Note that the volume estimates assume that the impacted media are continuous over the estimated vertical extent. The 2006 ROST/LIF cross sections for AOC D - AST1 indicate the impacted subsurface soil is found in several discrete layers at both locations.

3.5.2 AOC D - Former AST No. 2

Former AST No. 2 (AST2) is located in the northwest corner of AOC D approximately 175 feet east of AOC D - AST1, as shown in Figure 3.5-3. The area in the vicinity of former AST2, referred to as AOC D - AST2, is comprised of a gravel road bounded by trees and shrubs to the east, and the Malaspina Investment warehouse and storage yard to the west. AST2 was likely located on the edge of the current gravel road, although the tank foundation was not identified during the 2004 field activities. The former locations of the truck gasoline pipeline from the tank farm and the diesel fuel pipeline used to fill the tank from the Army Dock loading facility are also shown on Figures 3.5-1 and 3.5-3. Visual signs of potential contamination related to AST2 were not observed. However, surface staining was observed in the vicinity of several drums on site. According to the USACE project manager, there was clear evidence that these drums are of non-DoD origin.

The 2004 Focused RI activities at AOC D - AST2 consisted of collecting surface and subsurface soil samples, and installing, developing, and sampling three groundwater monitoring wells. Elevated DRO concentrations were detected in two of the three analytical surface samples up to 5,800 mg/kg. The DRO concentration at only one of the surface sample locations (04Y-DT2-01-SS) exceeds the Method 2 cleanup level. The reported DRO concentration at the second sample location (04Y-DT2-02-SS) was 230 mg/kg, equal to the Method 2 cleanup level. Benzene was also detected in one surface sample (04Y-DT2-01-SS) at an estimated concentration of 0.026 mg/kg, which is greater than the Method 2 cleanup level. The presence of surface stains in the vicinity of the on-site drums may indicate a source other than the former AST2. The drums do not appear to be vintage WWII drums. DRO concentrations were not detected above cleanup levels in subsurface soil samples or in groundwater samples from Wells AST2-1 (AP-203) through AST2-3 (AP-205) (S&W 2006a).

Results of the 2005 ROST/LIF investigation at former AST2 indicate that the area immediately surrounding the former tank location was not contaminated (USACE 2006).

In summary, DRO and benzene in surface soil are considered COCs at AOC D - AST2. AOC D - AST2 is included in the detailed FS. Figure 3.5-4 shows the approximate boundary of the impacted surface soil. Since COCs were detected at a single location, the contaminated area is treated as a hotspot with a diameter of 20 feet. The impacted soil is assumed to extend vertically from the ground surface to a depth of 2 feet bgs and laterally over an area of 314 sf. The estimated volume of impacted soil is approximately 27 cy. Note that a second surface soil sample contained a concentration of DRO equal to the applicable cleanup level suggesting the lateral extent may be greater than the assumed hotspot location.

3.5.3 AOC D - Former AST No. 3

Former AST No. 3 (AST3) is located in the east-central portion of AOC D, about 225 feet southeast of AOC D - AST2, as shown on Figure 3.5-1. The concrete foundation for AST3 is no longer present at the site, referred to as AOC D - AST3. The area where the tank was formerly located has overgrown with Sitka spruce, devil's club, and alders. Visual signs of potential contamination related to former AST3 were not observed (S&W 2006a).

The 2004 Focused RI activities at AOC D - AST3 consisted of collecting surface and subsurface soil samples, and installing, developing, and sampling one groundwater monitoring well. Results of the Focused RI activities at AOC D - AST3 indicate the presence of DRO and/or benzene in the surface and subsurface soil at concentrations greater than the Method 2 migration to groundwater cleanup levels. DRO was detected in three of the four analytical surface soil samples at concentrations ranging from 120 ppm to 3,100 mg/kg. DRO concentrations up to 6,600 mg/kg were reported in subsurface samples. Benzene was detected in two subsurface samples at 0.025 mg/kg and an estimated 0.035 mg/kg. DRO and benzene were not detected in the groundwater sample collected from Well AST3-1. GRO and toluene were reported in the groundwater samples but at concentrations less than the ADEC cleanup levels (S&W 2006a).

During the 2005 ROST/LIF investigation, diesel fuel was detected in the soil associated with former AST3, but due to physical constraints, the lateral extent of contamination was not defined. Contamination appears limited to a depth of 4 feet bgs, with the exception of two probes (YAK-D-043 and YAK-D-045). YAK-D-043, positioned approximately 90 feet west of the former AST3, detected petroleum in two zones between 4 and 12 feet bgs. YAK-D-045, located just to the south of former tank AST3, identified contamination in a zone from 2 to 7 feet bgs (USACE 2006).

In summary, DRO in surface soil and DRO and benzene in subsurface soil are considered COCs at AOC D - AST3. AOC D - AST3 is included in the detailed FS. Figure 3.5-5 shows the approximate boundary of the impacted surface and subsurface soil. The impacted soil is assumed to extend vertically from the ground surface to 12 feet bgs and laterally over an area of 3,188 sf. The estimated volume of impacted soil is approximately 1,629 cy.

3.5.4 AOC D - Former AST No. 4

Former AST No. 4 (AST4) is located approximately 500 feet southeast of AOC D - AST1 as shown on the site plan provided as Figure 3.5-1. This area is referred to as AOC D - AST4. The former AST4 foundation was not identified during the 2004 field activities. Visual signs of potential contamination related to former AST4 were not observed. A large, rusted AST is located east of Boring AST4-2. The current or former contents of this approximately 3,000 gallon tank are unknown (S&W 2006a).

The 2004 Focused RI activities at AOC D - AST4 consisted of collecting surface and subsurface soil samples, and advancing soil borings. Results at AOC D - AST4 indicate the presence of DRO at concentrations greater than the ADEC Method 2 migration to groundwater cleanup level in the surface and subsurface soils. DRO was detected in the surface samples up to a concentration of 400 mg/kg. DRO was also detected in two subsurface samples at concentrations of 1,300 mg/kg to 5,200 mg/kg (S&W 2006a).

The 2005 Focused RI activities at AOC D - AST4 consisted of collecting subsurface soil samples, and installing, developing, and sampling one groundwater monitoring well. Results at AOC D - AST4 indicate the presence of DRO and benzene concentrations less than the ADEC Method 2 migration to groundwater cleanup level in subsurface soil. Concentrations of DRO, benzene, or other target analytes, were not detected in groundwater samples from Well AST4-4 (S&W 2006b).

In the 2005 ROST/LIF investigation, petroleum [likely DRO] associated with former AST4 was identified at a depth of about 7 to 11 feet bgs. Although probe locations were limited, the plume appeared to be migrating to the north-northwest. The extent of contamination was defined to the northeast, south, and southwest, but has not been delineated to the east or west because probes could not be located in these areas. At Probe YAK-D-056, positioned approximately 30 feet northwest of the former tank AST4, DRO was encountered between 7 and 11 feet bgs at a concentration of 2,940 mg/kg. The northern extent of the plume was also not completely defined, and it may commingle with the contamination discovered at former AST3. At Probe YAK-D-055, positioned approximately 15 feet south and upslope from former AST4, petroleum contaminated soil was encountered from 2 feet to 4 feet bgs. The ROST/LIF report indicated this area of contamination is most likely not connected to the contaminant plume observed in the other probes due to the depth of contamination and upslope probe location (USACE 2006).

In summary, DRO in surface and subsurface soil are considered COCs at AOC D - AST4. AOC D - AST4 is included in the detailed FS. Figure 3.5-6 shows the approximate boundaries of the impacted surface and subsurface soil. At the former AST4 location (north site), the impacted soil is assumed to extend vertically from the ground surface to 12 feet bgs and laterally over an area of 3,775 sf. The estimated volume of impacted soil is approximately 1,929 cy. At the second near surface location (south site), the impacted soil is assumed to extend vertically from 2 to 4 feet bgs and laterally over an area of 314 sf. The estimated volume of impacted soil is approximately 27 cy with an estimated 27 cy of clean overburden.

3.5.5 AOC D - Former AST No. 5

Former AST No. 5 (AST5) is located in the southeast corner of AOC D, as shown on Figure 3.5-1. This area is referred to as AOC D - AST5. A site plan for AOC D - AST5 is provided as Figure 3.5-7. Remnants of the concrete foundation for former AST5 are present at the site surrounded by dense vegetation. The unpaved road, which bisects AOC D, borders the southwestern perimeter of the AST5 foundation as shown in Figure 3.5-1. The Yakutat City water wells ARCO #2 and ARCO #1 are located approximately 90 and 100 feet west-southwest and south-southwest of former AST5, respectively. Visual signs of potential contamination related to former AST5 were not observed. However, a petroleum odor was detected at the site (S&W 2006a).

Results of the 2004 Focused RI activities at AOC D - AST5 indicate the presence of DRO at concentrations greater than the Method 2 inhalation and ingestion cleanup levels in the surface soil and the migration to groundwater cleanup levels in the subsurface soil. DRO was detected in the three analytical surface soil samples at concentrations ranging from 380 mg/kg to 13,000 mg/kg. DRO was detected in four of the six subsurface samples at concentrations ranging from 480 mg/kg to 3,800 mg/kg (S&W 2006a).

The 2005 field work at AOC D - AST5 consisted of collecting subsurface soil samples, and installing, developing, and sampling one groundwater monitoring well. One boring (AST5-4) was drilled to a depth of 82 feet bgs, and a monitoring well was installed in the borehole. A total of 9 soil samples were collected from the boring, with three samples submitted for laboratory analyses. DRO or other target analytes were not detected in subsurface samples from the Boring AST5-4 at concentrations greater than the Method 2 soil cleanup levels. DRO or other target analytes were not detected in the groundwater sample collected from Well AST5-4 at concentrations exceeding the groundwater cleanup levels (S&W 2006b).

In the 2005 ROST/LIF investigation, the four probes advanced near the former AST5 location contained significant petroleum contamination. The logs indicated the presence of diesel and weathered-diesel fuels in the soils. At two probe locations, the LIF response was highest in the top 8 to 9 feet of the log, and decreased considerably with depth. At the two other probe locations, the LIF response increased with depth, and the highest response was observed at 20 feet bgs. Because of physical constraints (heavy vegetation and rough terrain), additional investigation north and east of former AST5 was not possible. The lateral extent of contamination at former AST5 has not been defined in these directions (USACE 2006).

In summary, DRO in surface and subsurface soil is considered a COC at AOC D - AST5. AOC D - AST5 is included in the detailed FS. Figure 3.5-7 shows the approximate boundary of the impacted surface and subsurface soil. The impacted soil is assumed to extend vertically from the ground surface to 24 feet bgs and laterally over an area of 4,369 sf. The estimated volume of impacted soil is approximately 4,466 cy. Note that two ROST/LIF probes indicated the presence of petroleum up to depths of 24 and 28 feet bgs. The other two probes showed petroleum up to 9 to 10 feet bgs which is within the assumed vertical extent of impacted soil.

3.5.6 AOC D - Former AST No. 6

Former AST No. 6 (AST6) is located in the southern portion of AOC D, as shown on Figure 3.5-1. This area is referred to as AOC D - AST6. With the exception of the AST6 foundation area and the adjacent cleared road to former AST7, AOC D - AST6 is covered with dense vegetation. The AOC D - AST6 site plan is provided as Figure 3.5-8. ARCO Well #2, enclosed within a small shed and chain-link fence, is located just south of the tank foundation. Visual signs of potential contamination related to former AST6 were not observed (S&W 2006a).

The 2004 Focused RI activities at AOC D - AST6 consisted of collecting surface and subsurface soil samples. Results at AOC D - AST6 indicate the presence of DRO at concentrations greater than the Method 2 inhalation and ingestion cleanup levels in the surface soil and the migration to groundwater cleanup level in the subsurface soil. DRO was detected in three analytical surface samples at concentrations ranging from 1,700 mg/kg to 13,000 mg/kg. DRO concentrations in subsurface samples ranged from 450 mg/kg and 1,400 mg/kg (S&W 2006a).

The 2005 Focused RI activities at AOC D - AST6 consisted of collecting subsurface soil samples, and installing, developing, and sampling one groundwater monitoring well. Results of the 2005 activities at AOC D - AST6 indicate DRO and other target analytes were not detected at concentrations greater than the ADEC cleanup criteria for soil and groundwater (S&W 2006b).

In the 2005 ROST/LIF investigation, POL contamination was found at former AST6. The LIF responses indicated the contamination only extended to a depth of approximately 10 feet bgs. Contamination from this former AST does not appear to be migrating to the east or south, but may be migrating to the northwest where the extent of contamination has not been delineated (USACE 2006).

In summary, DRO in surface and subsurface soil is considered a COC at AOC D - AST6. AOC D - AST6 is included in the detailed FS. Figure 3.5-8 shows the approximate boundaries of the impacted surface and subsurface soil. The impacted soil is assumed to extend vertically from the ground surface to 16.5 feet bgs and laterally over an area of 3,388 sf. The estimated volume of impacted soil is approximately 2,381 cy.

3.5.7 AOC D - Former AST No. 7

Former AST No. 7 (AST7) is located in the southwest corner of AOC D, as shown on Figure 3.5-1. This area is referred to as AOC D - AST7. AOC D - AST7 was originally identified as Concern D-2 by ENSR. The AOC D - AST7 site plan is provided as Figure 3.5-9. The area in the vicinity of former AST7 consists of dense vegetation, of which a portion was cleared to allow site access via the cleared truck road. Visual signs of potential contamination related to former AST7 were observed in the surface soils. The surface soils were a dark gray color, and a petroleum odor was encountered at the site (S&W 2006a).

During the 2001 ENSR investigation, soil samples collected in this area contained concentrations of DRO exceeding the ADEC Method 2 soil cleanup level of 230 mg/kg, with concentrations ranging from 276 mg/kg to 4,990 mg/kg. Surface soil contamination was documented in the flat areas surrounding the foundation. Subsurface soil contamination was documented in the hillside down slope (northwest) of the foundation. No wells were installed for groundwater sampling because subsurface soil conditions encountered at AOC D - AST7 prevented the soil borings from reaching the groundwater table by the drilling method used (ENSR 2003b).

Shannon & Wilson's 2004 field work at AOC D - AST7 consisted of collecting surface and subsurface soil samples, and installation of one groundwater monitoring well. Results of the Focused RI activities at AOC D - AST7 indicate the presence of DRO at concentrations greater than the Method 2 migration to groundwater cleanup level in the surface and subsurface soil. DRO was detected in all four analytical surface samples. Concentrations in three of the four surface soil samples exceed the ADEC Method 2 migration to groundwater cleanup level with magnitudes ranging from 7,100 mg/kg to 23,000 mg/kg. DRO concentrations in the subsurface samples were detected up to 8,000 mg/kg. A subsurface soil sample also contained 56 mg/kg 2-Methylnaphthalene, which exceeds the Method 2 migration to groundwater cleanup level of 6.1 mg/kg. Groundwater samples were not collected from the monitoring well placed at AOC D - AST7 due to lack of water in the well (S&W 2006a).

Shannon & Wilson's 2005 field work at AOC D - AST7 consisted of collecting subsurface soil samples, and installing, developing, and sampling one groundwater monitoring well. Results at AOC D - AST7 indicated the presence of DRO at concentrations greater than the ADEC soil cleanup criteria in the surface and subsurface soil. DRO was detected at concentrations ranging from 3,040 mg/kg to an estimated value of 8,460 mg/kg in the three subsurface soil samples and associated QC/QA replicates. One sample collected from 52 to 53 feet bgs within the groundwater smear zone, contained an estimated value of 6,880 mg/kg DRO, indicating that petroleum impacted soil extends from the surface to the underlying groundwater table. DRO was reported in groundwater samples at concentrations ranging from 3.200 mg/L to an estimated concentration of 4.250 mg/L which exceed the ADEC groundwater cleanup criteria of 1.5 mg/L. Petroleum sheen was observed on both the development and purge water from Well AST7-4 (S&W 2006b).

The 2005 ROST/LIF investigation results indicated a diesel fuel plume associated with former AST7. Contamination was identified near the surface in most probes, but extended to a depth of over 20 feet bgs in at least one location. The contaminant plume appears to be migrating to the northwest, but the horizontal extent has not been completely defined in any direction (USACE 2006).

In summary, DRO in surface and subsurface soil and groundwater and 2-Methylnaphthalene in subsurface soil are considered COCs at AOC D - AST7. AOC D - AST7 is included in the detailed FS. Figure 3.5-9 shows the approximate boundary of the impacted surface and subsurface soil. The designated area for remedial action extends out to the northeast from the former AST7 location although samples around this area did not have COCs exceeding ARARs. This area is considered impacted with COCs based on the 2005 ROST/LIF investigation results. Note that the area for remedial action has not been extended to the northeast of Probe YAK D 021a towards YAK D 020 as suggested in the 2005 ROST/LIF report. The impacted soil is assumed to extend vertically from the ground surface to groundwater at approximately 53 feet bgs and laterally over an area of 7,867 sf. The estimated volume of impacted soil is approximately 17,759 cy. The lateral extent of DRO-impacted groundwater is not known, however, for the purposes of this FS, the DRO-impacted groundwater plume is assumed to be about twice the lateral extent of the DRO-impacted soil or over an area of approximately 16,000 sf.

3.5.8 AOC D - Former AST No. 8

Former AST No. 8 (AST8) is located in the southern portion of AOC D, as shown on Figure 3.5-1. The area in the vicinity of former AST8, referred to as AOC D - AST8, is an unpaved gravel pad, presently occupied by a City of Yakutat water tank, pump house, and ARCO Wells #1 and #2. The AOC D - AST8 site plan is provided as Figure 3.5-10. The water tank is built on the foundation of former AST8. The former location of the diesel fuel pipeline used to fill the tank from the Army Dock loading facility is also shown on Figure 3.5-1. Visual signs of potential contamination related to former AST8 were not observed (S&W 2006a).

Shannon & Wilson's 2004 Focused RI activities at AOC D - AST8 consisted of collecting surface and subsurface soil samples. Results of these activities at AOC D - AST8 indicated the presence of DRO at concentrations greater than the ADEC Method 2 migration to groundwater and ingestion cleanup levels in the subsurface soil. Surface soil analytical results show low concentrations of contaminants that are less than the ADEC Method 2 soil cleanup levels. DRO was detected in subsurface samples at concentrations ranging from 880 ppm to 8,500 ppm. Additionally, the City of Yakutat water wells, ARCO Wells #1 and #2, were sampled. DRO or other target analytes were not detected in water samples collected from ARCO Wells #1 and #2 (S&W 2006a).

During the 2005 ROST/LIF investigation, POL contamination was found in association with former AST8. Contamination generally extends from a depth of 2 to 3 feet bgs to at least 20 feet bgs. The horizontal extent of the plume was delineated to the east and northwest and based on the geography of the area is not expected to extend to the south. The lateral extent of contamination due north of AST8 is unknown (USACE 2006).

In summary, DRO in subsurface soil is considered a COC at AOC D - AST8. AOC D - AST8 is included in the detailed FS. Figure 3.5-10 shows the approximate boundary of the impacted subsurface soil. The designated area for remedial action extends out to the west from the former AST8 location although soil samples were not collected in the area. This area is considered impacted with COCs based on the 2005 ROST/LIF investigation results. The impacted soil is assumed to extend vertically from 4 feet to 27 feet bgs and laterally over an area of 5,381 sf. The estimated volume of impacted soil is approximately 5,271 cy which is overlain by an estimated 917 cy of clean overburden.

3.5.9 AOC D - Diesel Pipeline (D1)

The location of the former Diesel Pipeline at AOC D, referred to as AOC D1, is shown on Figure 3.5-1. ENSR's 2001 investigation indicated that no surface soil samples contained analytes above ADEC Method 2 soil cleanup levels. No sediment or surface water samples contained analytes above the SQuiRT values or AWQS. One surface water sample contained a DRO concentration estimated at 0.0896 mg/L. This surface water sample had concentrations of TAqH of 0.0000978 mg/L and TAH of 0.0000978 mg/L which do not exceed the AWQS of 0.015 mg/l and 0.010 mg/l, respectively. Soil sampling at AOC D1 showed low level contamination associated with the former Diesel Pipeline but at concentrations that do not exceed the ADEC Method 2 soil cleanup criteria. AOC Dl is considered adequately characterized, and no further DoD action is indicated (ENSR 2003b).

In summary, COCs at AOC D1, the former Diesel Pipeline at AOC D, were not identified. AOC D1 will not be included in the detailed FS.

3.5.10 AOC D - AvGas Pipeline

Historical US Army drawings indicate an Aviation Gasoline (AvGas) Pipeline was constructed as part of the facilities of the Yakutat AFB. The Utilities Layout, Government Dock and Facility, dated July 6, 1943, and the Field Revisions, A.C Tactical Gas System, dated April 17, 1943, provided in Appendix A, show the pipeline extending aboveground from the fuel dock at the Army Dock Area (AOC D) to the Air Corps Operations Reserve (ACOR) Tank Farm (AOC L). The presumed location of the former AvGas Pipeline within AOC D is shown on Figure 3.5-1. No visual evidence was found of a former aboveground pipeline, or indications of contamination resulting from a historical pipeline within the AOC D vicinity (S&W 2006b). Based on discussions with the USACE PM, since no visual indication of contamination was found along the alignment of the former aboveground pipeline, additional investigation is not warranted.

In summary, COPCs at the former AvGas Pipeline at AOC D were not identified. The former AvGas Pipeline at AOC D will not be included in the detailed FS.

3.6 AOC E1 - Quartermaster Loop Area

In support of the runway and airfield facility construction, petroleum products were transported in 55-gallon drums to the Yakutat Air Base area. Empty 55-gallon drums were stockpiled in several clearings north of the airport (OSC 2001).

3.6.1 AOC E1 - Northwest Drum Dump/Quartermaster Loop Area

One stockpile area previously containing drums, referred to as the Northwest Drum Dump or AOC E1, was the site of a drum removal action in 1999. AOC E1, shown on Figure 3.6-1, is located in a clearing on the south side of the Rifle Range access road off the east side of Quartermaster Loop, approximately 300 feet north of Colorado Road (OSC 2001).

In 1994, an investigation of this area included the collection of one sediment and three triplicate soil samples from a drum area (E&E 1994). The specific locations of these samples are not known. DRO concentrations were 2,500 mg/kg in the sediment sample and ranging from 145 to 322 mg/kg in the soil samples. The DRO concentrations in the sediment sample and select soil samples exceed the ADEC soil cleanup criteria. TRPH was detected in all of the samples; however, only the sediment sample with 7,800 mg/kg exceeded cleanup levels. The area of contamination was estimated to be 160,000 square feet. Depth of contamination was not determined (ENSR 2003a). Information regarding other analytes detected, if any, was not available for comparison with SQuiRT values.

In 1996, another investigation included the collection of one sediment sample from a drainage ditch down slope of the drum dump sampled in 1994. It appears that this sample was collected from the drainage ditch on the north side of the Rifle Range access road, south of the 1994 sample locations. No COCs were identified in this sample (AGRA 1997). Information regarding other analytes detected, if any, was not available for comparison with SQuiRT values.

In 1997, surface soil samples were collected among the estimated 400 to 500 drums scattered over approximately 300 feet "along the east side of a trail off Colorado Road". Several drums also were noted in the drainage ditch to the west and parallel with the drum dump. The drums were described as rusted, and most were punctured or rusted through and overgrown with vegetation. Two samples contained DRO concentrations at 3,500 mg/kg and 11,000 mg/kg, and one sample contained RRO concentrations at 26,000 mg/kg which exceed the ADEC Method 2 soil cleanup criteria. The specific locations of these samples are not known, however, they appear to be collected in the vicinity of surface sample E1SS003 shown on Figure 3.6-1 (E&E 1997, ENSR 2003a).

In 1999, five hundred and forty-four empty drums were removed from the ground at AOC E1. Most of the drums were previously opened or punctured and, as a result, the contents were mostly limited to a few ounces of rainwater in each drum. Seventeen drums were removed from the roadside ditch. These drums had also been opened or punctured. Eight drums were removed from a small pond at the north end of the drum dump. Seven of these drums were empty. One drum was filled with grease. No excavation was performed to locate drums that may be buried at the project site or in the roadside ditch sediment. All of the recovered drums along with 12,513 pounds of metal debris found at AOC E1 were removed by OSC and shipped to Rabanco Recycling in Seattle, Washington, for disposal (OSC 2001).

The objective of the 2000 investigation by ENSR at AOC E1 was to confirm that no surface and subsurface objects or contaminants remained following the drum-removal activities. Results of the geophysical survey indicated that the remaining surface debris found in the area consists of small rust flakes presumed to be associated with the drums previously stored at this location. ENSR concluded that no surface or subsurface debris remains in the area investigated. Twelve surface soil samples, thirteen soil boring samples, six groundwater samples, and four sediment samples were collected and analyzed. DRO was detected at one surface soil sample location at concentrations of 570 and 630 mg/kg (primary and duplicate samples) which exceed the ADEC Method 2 soil cleanup level. One surface soil sample had an arsenic concentration of 22 mg/kg which exceeds the most stringent ADEC Method 2 soil cleanup level of 3.7 mg/kg and the established background concentration of 11.6 mg/kg. One surface soil sample had chromium concentration of 57 mg/kg which exceeds the ADEC Method 2 soil cleanup level of 25 mg/kg and the established background concentration of 37 mg/kg (ENSR 2003a).

DRO was detected in three subsurface soil samples at concentrations ranging from 270 mg/kg to 2,700 mg/kg which exceed the ADEC Method Two soil cleanup level. The lateral and vertical extent of DRO contamination was not fully defined; however, the elevated levels were detected in samples from the general area around rust flakes presumed to be associated with the drums previously stored at this location. Chromium was detected in two subsurface samples at concentrations of 38 and 50 mg/kg which exceed the established background concentration (ENSR 2003a).

Pentachlorophenol was detected at 0.053, 0.51, and 0.97 mg/kg in three sediment samples collected from the drainage ditch bounding the north edge of the investigation area. These concentrations exceed the sediment SQuiRT value of 0.01 mg/kg. Arsenic was detected at 52, 140, and 160 mg/kg in three sediment samples collected from the drainage ditch. These concentrations exceed the SQuiRT value of 5.9 mg/kg and the established background concentration for soil of 11.6 mg/kg. Cadmium was detected at 0.84 and 0.98 mg/kg in two sediment samples collected from the drainage ditch which exceed the SQuiRT value of 0.583 mg/kg. Chromium was detected at 44 and 49 mg/kg in two sediment samples collected from the drainage ditch. These concentrations exceed the established background concentration for soil of 37 mg/kg. Mercury was detected at 0.41 mg/kg in one sediment sample collected from the drainage ditch which exceeds the SQuiRT value of 0.174 mg/kg. Concentrations of DRO, pentachlorophenol, arsenic, and chromium in groundwater samples were either not detectable or were detected at levels that do not exceed ADEC groundwater cleanup criteria (ENSR 2003a).

The analytical results from the ROST/LIF investigation at AOC E1 indicated the presence of POL contamination in the near surface soils in an extremely limited area. Potential petroleum contamination was seen in only one of the seven probes pushed in this area, at a shallow depth (2-3 feet bgs). The other six probes surrounded this location and were clean, which clearly defined the extent to a discrete area. The USACE concluded that these results indicated no further remedial investigation is necessary to characterize the POL contamination at this site (USACE 2006).

In summary, DRO, arsenic, and chromium in surface soil, DRO and chromium in subsurface soil, and pentachlorophenol, arsenic, cadmium, chromium, and mercury in sediment are considered COCs at AOC E1. The presence of DRO in the drainage ditch, as indicated by E&E in 1994, should be investigated further. Also, the chromium concentration in surface soil is assumed to be Cr6+, a known carcinogen. AOC E1 may be retested to determine if the chromium concentration is due to Cr6+ and/or Cr3+. The cleanup level for Cr3+ is 124,000 mg/kg. If it is determined that the chromium concentrations are actually Cr3+, then chromium is not a COC at AOC E1. AOC E1 is included in the detailed FS. Figure 3.6-1 shows the approximate boundaries of the DRO, arsenic, and chromium-impacted surface and subsurface soil, the arsenic and chromium-impacted hotspots, and the pentachlorophenol, arsenic, cadmium, chromium, and mercury-impacted ditch sediment.

The larger DRO and chromium-impacted surface and subsurface soil area (drum dump), shown on Figure 3.6-1, is assumed to extend vertically from the ground surface to 4 feet bgs and laterally over an area of 903 sf. The estimated volume of impacted soil is 154 cy. The two arsenic or chromium-impacted hotspot areas are assumed to extend vertically from the ground surface to a depth of 2 feet bgs and laterally over an area of 78 sf (156 sf total). The estimated volume of impacted soil is approximately 13 cy. The DRO, pentachlorophenol and metals-impacted sediment in the drainage ditch is assumed to extend vertically from the ground surface to 3 feet bgs and laterally over an area of 1,347 sf (assumes a ditch width of 6 feet). The estimated volume of impacted sediment is 172 cy.

3.6.2 AOC E2 - Debris Disposal/Barrel Dump Area - Quartermaster Loop

The Debris Disposal/Barrel Dump Area, AOC E2, is located on Quartermaster Loop, approximately 1 mile from Engineer's Road. A site plan showing the general location of AOC E2 is provided on Figure 3.6-2. In the 1984 Environmental Assessment, Site 234 (Quartermaster Loop Barrel Dump) is described as an "old solid waste dump and empty barrel dump. Drums and debris spread over area; about 1.5 acres" (USACE 1984). In addition, a site note description on debris cleanup maps states: "Barrel dump, loosely scattered. Structures and other items shown but not identified to be disposed of, are to remain, or in many cases are nonexistent." (USACE 1984, ENSR 2003b).

In 1997, E&E investigated the Quartermaster Loop drum dump (AOC E2) located on the southwest side of Quartermaster Loop Road. The area was densely vegetated with alders, willows, and spruce. A wrecked Coast Guard airplane was observed off Quartermaster Loop Road on the way to the drum dump. No drums, debris, or other evidence of potential contamination were visible. No samples were collected (E&E 1997).

During the 1999 site walkover, one 55-gallon drum with a red stake was found along Quartermaster Loop about 200 yards northeast of the former rail line trail. The origin and contents of the drum (if any) were not determined. An additional 10 to 15 drums were found during the 2001 field season grouped in a ditch near the red stake. It appeared as if these drums had been run over by a tracked vehicle. Another grouping of 3 or 4 drums were found near the larger grouping of drums. A few other scattered drums were also observed partially buried in the sides of the ditch. The total number of drums in this area was not determined due to the condition of the drums and excessive vegetation in the area. This drum dump area does not appear to be the Quartermaster Loop Barrel Dump described in the 1984 Environmental Assessment (ENSR 2003b).

In 2001, two surface soil samples were retrieved (one down slope from each group of drums) in the most likely location for contamination, if present. No analytes in surface soil exceeded ADEC Method 2 soil cleanup levels. ENSR concluded that since no contamination associated with the two drum groups was detected and the two drum areas are considered adequately characterized, no further Department of Defense action is indicated for this portion of the site. However, the total number of drum locations along Quartermaster Loop Road has not been determined. ENSR recommended that further investigation may be warranted to better define overall site conditions in the Quartermaster Loop area (ENSR 2003b).

In summary, no COPCs were identified at AOC E2. AOC E2 is not included in the detailed FS. Additional investigation is warranted in AOC E2; however, the results will not be included in this FS.

3.7 AOC F1 - Khantaak Island

The Khantaak Island site consists of one AOC: Khantaak Potential Contamination (AOC F1). See Figure 1.2-1 for the location of Khantaak Island. This AOC is based on the military presence on the island during World War II and numerous drums identified through the public participation process reported in the eastern area of the island. Two separate site walkovers were conducted on the island, covering the central western area and the Sea Otter Bay (also called Deep Bay) area of the island. No roads, signs of infrastructure, or associated drums were observed, although approximately 10 scattered drums were observed along the beach, apparently washed up from Yakutat Bay rather than being associated with any island activities. No indications of environmental concern were observed, and the military presence on the island was not identified as a possible concern (ENSR 2005).

In summary, no COPCs were identified at AOC F1. AOC F1 is not included in the detailed FS.

3.8 AOC G - Seaplane Base

The Minor Naval Air Facility at Monti Bay, also referred to as the Seaplane Base or AOC G, was constructed between 1942 and 1943 to dock, house, and repair military floatplanes. AOC G is located on the north side of Point Carrew Road, just past the road leading to the seaplane ramp, approximately 1 mile from the Point Carrew Road junction. The 1943 Map of Naval Auxiliary Air Facility, Yakutat, Alaska, provided in Appendix A, shows the layout of Seaplane Base.

3.8.1 AOCs G1, G2 and G3 - Seaplane Base

AOCs G1 - Former Pipeline Paths, G2 - Suspected UST1 and Debris, and G3 - Suspected UST2 and UST3 at the Seaplane Base were grouped as AOC G during the 2000 and 2001 ENSR field activities due to the association between the USTs and pipelines and the close proximity of the debris area to one of the UST pits. Figure 3.8-1 shows AOCs G1, G2, and G3. Three rectangle-shaped excavation pits filled with water and/or soil were present in the area and are suspected to be former underground storage tank (UST) locations. Pronounced visible spoil piles can be seen on each end of the pits. Several ditches were also present. These ditches were about 2 feet deep and ran from the suspected UST pits downhill toward the dock area. The ditches are suspected to be the former locations of the piping system that connected the USTs to the Seaplane Base. A review of historical construction records created during World War II leaves some doubt about whether all three of the tanks were installed. The Field Progress Report for Yakutat Landing Field for the period ending June, 30 1943, indicates that under Navy construction, the "gasoline system" consisted of three steel, 25,000-gallon tanks. The project was identified as 33 percent complete, with a note that the remaining two tanks may be deleted from the construction schedule. It is assumed from this information that one of the tanks is verified as having been installed. No further clarification could be determined from these records. Three 55-gallon drums and five gasoline cans, all heavily rusted and presumed to be remnants from World War II, were found near one of the partially backfilled pits during the 1999 site walkover (ENSR 2003a, ENSR 2003b, USACE 2003).

Results of the 2000 geophysical surveys indicate that there is no buried metal associated with the excavated pits and trenches. No USTs or associated piping were found. The USTs and piping may have never been installed or used. No soil samples contained analytes that exceeded ADEC Method 2 cleanup levels. Petroleum contamination was detected at concentrations well below ADEC cleanup levels. No contamination was identified associated with the surface debris area. No wells were installed for groundwater sampling because subsurface soil conditions encountered at this site prevented the soil borings from reaching the groundwater table by the drilling method used. However, based on soil results, the presence of groundwater contamination is unlikely. ENSR concluded that AOCs G1, AOC G2, and AOC G3 are adequately characterized, and no further DoD action is indicated (ENSR 2003a, ENSR 2003b).

In summary, no COPCs were identified at AOCs G1, G2, and G3. AOCs G1, G2, and G3 are not included in the detailed FS.

3.8.2 AOC G4 - Seaplane Base, Seaplane Slough

A single drum was reported to exist in a slough near the property of a private resident of Yakutat. Based on 1942 Minor Naval Air Facilities maps, it appears that this slough was part of the draining system surrounding the Seaplane Base taxiway. The drum appeared to be similar in appearance to drums observed at other FUDS-eligible drum dumps in the Yakutat area. This drum site was referred to as AOC G4 and is shown on Figure 3.8-2.

During the 2000 investigation of this site by ENSR, co-located surface water and sediment samples were collected 14 feet from the end of the culvert, next to the submerged drum, to determine whether any contaminants have been released by the drum. The slough was 1.5 to 2 feet deep by 15 feet wide and somewhat overgrown with alders. The bottom of the slough was covered with 0.5 feet of decayed organic matter. Water flow within the slough was imperceptible. The surface water sample was clear with a brown tint. The sediment sample was collected from 4 to 8 inches below the bottom of the slough, 1.5 to 2.0 feet below water surface, and consisted of gray organic sand and silt. Petroleum sheen came to surface when bottom layers were disturbed, and the sediment sample had a strong petroleum odor. Analytical results for the sediment sample indicate a DRO concentration of 1,700 mg/kg which is above the ADEC Method 2 soil cleanup level of 230 mg/kg. Concentrations of chrysene (0.070 mg/kg), phenanthrene (0.310 mg/kg), and pyrene (0.096 mg/kg) in the sediment sample exceed the SQuiRT values of 0.0571 mg/kg, 0.0419 mg/kg, and 0.053 mg/kg, respectively. An arsenic concentration in the sediment sample of 22 mg/kg exceeds the SQuiRT value of 5.9 mg/kg and the established background concentration of 11.6 mg/kg. Cadmium (1.2 mg/kg) and mercury (0.3 mg/kg) concentrations in the sediment sample exceed the SQuiRT values of 0.583 mg/kg and 0.174 mg/kg, respectively. A chromium concentration in the sediment sample of 42 mg/kg exceeds the SQuiRT value of 37.3 mg/kg and the established background concentration of 37 mg/kg. The only analyte detected in the surface water sample was barium at 0.007 mg/L which exceeds the SQuiRT value of 0.0039 mg/L (ENSR 2003a, ENSR 2003b).

During a 2006 Remedial Investigation by BC-J, one 55-gallon drum and approximately 150 gallons of contaminated sediment were successfully removed from the Seaplane Slough. Excavation activities were ceased vertically when a clay layer was encountered approximately 3 feet below the sediments or about 5 feet below the top of the water surface (water in the slough was approximately 1.5 to 2 feet deep prior to excavation). The clay layer is most likely a confining layer currently acting as a barrier for migrating contamination. During the removal action, sediments were noted to have petroleum sheen and a moderate to strong petroleum odor. No sheen was noted on the surface of the water in the slough during excavation activities; however, once excavation activities were complete, petroleum sheen was noted. Five samples, including one duplicate, were collected in the immediate vicinity of the drum removal and sediment excavation, three samples were collected downgradient of the drum, and three samples were collected upgradient of the drum. In the immediate vicinity of the drum removal and sediment excavation, DRO concentrations ranged from 870 to 5,600 mg/kg, all above the ADEC Method 2 soil cleanup level (BC-J2007). Information regarding other analytes detected, if any, was not available for comparison with SQuiRT values.

In summary, DRO, chrysene, phenanthrene, pyrene, arsenic, cadmium, chromium, and mercury in sediment and barium in surface water are considered COCs at AOC G4. Note that the chromium concentration in sediment is assumed to be Cr6+, a known carcinogen. AOC G4 may be retested to determine if the chromium concentration is due to Cr6+ and/or Cr3+. The cleanup level for Cr3+ is 124,000 mg/kg. If it is determined that the chromium concentration in sediment is actually Cr3+, then chromium is not considered a COC at AOC G4. AOC G4 is included in the detailed FS. Figure 3.8-2 shows the approximate limits of excavation of sediment removed during the drum removal efforts. It is noted that the site plan, taken from the BC-J report, appears to exaggerate the size of the drum and aerial extent of excavation. We assume the drum and estimated 150 gallons of sediment were removed from an area measuring approximately 5 feet by 5 feet. The lateral extent of impacted sediment is assumed to extend 10 feet beyond the area of excavation for an estimated area of 625 sf. The impacted sediment is assumed to extend vertically from the sediment surface (located beneath water in the slough) to 3 feet bgs (top of the clay layer). The estimated volume of impacted sediment is approximately 80 cy. The concentration of barium in surface water at AOC G4 should be investigated further to determine if barium is still present.

3.9 AOC H - Ocean Cape Radio Relay Station (OCRR)

The OCRR Station facility is located approximately 5 miles west of the community of Yakutat on the Phipps Peninsula at the end of Point Carrew Road as shown on Figure 1.2-1. The OCRR served as a tropospheric communications station as part of the Ballistic Missile Early Warning System under the WACS. An additional 69.2 acres were obtained from the BLM in 1967 and 1968 for gravel removal. The site, located on the Phipps Peninsula at the end of Point

Carrew Road, approximately 5 miles west of the city of Yakutat, included industrial buildings, support facilities, water and petroleum storage tanks, pipelines, billboard antennae, a bridge, roads, and utility lines. The facilities were leased to Recording Company America Alaska Communications, Inc. between 1974 and 1976. The OCRR Station was declared excess by the U.S. Air Force in June 1976. This land was relinquished to the BLM in 1977, and conveyed to the Tlingit tribe in 1983. Property ownership is presently listed under Yak-Tat Kwaan, Inc., a corporate entity of the Tlingit tribe. The four tropospheric dishes, industrial buildings, and associated equipment were removed during the 1984 USACE cleanup activities. Sewer manholes were filled with gravel. A 130,000-gallon tank; a petroleum, oil, and lubricants pump house; a heavy equipment maintenance shop; and a water tower remain on site.

3.9.1 AOC H1 - OCRR, Suspected Drum Dump

AOC H1 is located approximately 1,200 feet northeast of Ocean Cape on the west side of Ocean Cape Road as shown on Figure 3.9-1. An OCRR as-built map shows a disposal area for burnable and non-burnable materials at AOC H1. Approximately 500 drums and a number of cable spools were removed from this area during the 1984 to 1995 USACE cleanup efforts. Two empty, rusted 55-gallon drums were found at this location by ENSR in 2001. The former contents of the drums could not be determined because no labeling or markings could be found (ENSR 2003b).

Two locations in the vicinity of one 55-gallon drum were sampled to determine whether surface soil contamination exists. Sample results indicate that target analytes did not exceed ADEC Method 2 soil cleanup levels (ENSR 2003b).

In summary, no COPCs were identified at AOC H1. AOC H1 is not included in the detailed FS. Additional investigation is warranted in AOC H1, however, the results will not be included in this FS.

3.9.2 AOC H2 - OCRR, Culture Camp

The Cultural Camp, AOC H2, is situated east of Point Carrew Road along the western edge of the Ankau Slough as shown in Figure 3.9-2. The Cultural Camp site was a World War II military site in the 1940s and part of the OCRR Station. It has been reported that aerial spraying of herbicides was performed at the active OCRR Station to control vegetation in the vicinity of a petroleum pipeline. An oblique aerial photograph taken in the 1960s shows an apparent denuded area extending west from the current Cultural Camp area. The Yakutat Tlingit Tribe (through Yak Tat Kwaan) formerly used the Cultural Camp to teach cultural heritage. During the summer, local Tlingit youth would learn from community elders and subsist on the area's natural resources. Cabins were constructed on the site as part of the Cultural Camp. The camp is no longer used because of dioxins measured in shellfish in the area. Wall tent frames are all that remain of the Cultural Camp (S&W 2006a).

In 1996, AGRA conducted an investigation for the Yakutat Tlingit Tribe Native Association. The study included collecting one surface soil sample, one sediment sample, and two shellfish tissue samples. Dioxin constituents were detected in the surface soil sample and one shellfish tissue sample. The sum of TEF concentrations in the surface soil sample, as referenced to the 2,3,7,8- TCDD congener, yields a TEQ of 0.074 ppt, which does not exceed the TEQ screening value of 38 ppt (AGRA 1997). One of the shellfish samples contained detectable concentrations of total 2,3,7,8-tetrachlorodibenzo-p-furan (TCDF) with a calculated TEQ of 0 ppt. Not enough tissue was submitted for testing of the other shellfish sample. The sediment sample was not analyzed for dioxins. The dioxin concentration in the surface soil sample did not exceed the EPA Region 3 risk-based concentration of 4 ppt or the ADEC accepted screening level of 38 ppt.

During the ENSR 2000 investigation, six surface soil samples, three sediment samples, and three surface water samples were collected and analyzed. Dioxins were detected in each surface soil sample with a maximum TEQ concentration of 19.11 ppt. Dioxins were detected in three sediment samples with a maximum TEQ concentration of 0.0034 ppt. Surface soil and sediment concentrations did not exceed the ADEC accepted screening level of 38 ppt. The surface water samples did not have detectable concentrations of dioxins (ENSR 2003a).

Information regarding other analytes detected in sediment samples, if any, was not available for comparison with SQuiRT values.

In 2004, Shannon & Wilson performed Focused RI activities at the Cultural Camp with results indicating the presence of dioxins in surface soil. The maximum TEQ concentration for these samples was 0.847 ppt. Based on the data collected during the 1996, 2000 and 2004 investigations, surface soil samples do not contain TEQ levels greater than the 38 ppt project screening level approved by ADEC (S&W 2006a).

In summary, dioxins in surface soil do not exceed the 38 ppt project screening level approved by ADEC and, therefore, no COCs were identified at AOC H2. AOC H2 is not included in the detailed FS.

3.10 AOC K1 - Solid Waste Disposal Dump No 4

The Solid Waste Disposal Dump No. 4 Area, AOC K1, is located on the southeast side of Cannon Beach Road, approximately 300 yards northeast of Tawah Creek. AOC K1 is shown on Figure 3.10-1. Records indicate that AOC K1 was a military disposal area. The area was leveled and covered with 2 feet of gravelly sand during the 1984 cleanup efforts. Currently, the landfill site is heavily vegetated with alders, spruce, and various berry bushes. The area surrounding the landfill consists of a flat grassy wetlands area with randomly scattered willow bushes. This area is often flooded from water overflowing from Tawah Creek. Water levels have been observed to rise and fall several feet within a day or so, depending on recent precipitation (ENSR 2003a, ENSR 2005).

A site walkover was conducted in 1994 by E&E. At that time, the site was considered ineligible for Defense Environmental Restoration Program (DERP) -funded cleanup because no petroleum sheen or stressed vegetation was noted.

A 1997 E&E investigation included the collection of five surface soil samples from the perimeter of the dump near observed drums and debris on the south side of the landfill and two surface water samples. The surface soil and water samples were analyzed for GRO, DRO, RRO, VOCs, base/neutral and acid extractable organic compounds (BNAs), pesticides, PCBs and metals. A DRO concentration in one surface soil sample at 400 mg/kg exceeds the ADEC soil cleanup level of 230 mg/kg. This sample also contained 1.0 mg/kg benzo(a)pyrene which exceeds the ADEC Method Two cleanup level of 0.4 mg/kg. Chromium was detected in four surface soil samples at concentrations ranging from 68 to 244 mg/kg which exceed the ADEC Method Two soil cleanup level of 25 mg/kg and the established background concentration of 37 mg/kg. One surface water sample was collected from the downgradient (south) side of the dump. One surface water sample was collected from the upgradient (north) side of the landfill as a background sample. Elevated concentrations of arsenic (0.030 mg/L), cadmium (0.015 mg/L), chromium (0.020 mg/L), and lead (0.257 mg/L) were detected in the downgradient surface water sample. The arsenic, cadmium and lead concentrations in surface water exceed the SQuiRT values and/or AWQS of 0.01 mg/L, 0.00025 mg/L and 0.0025 mg/L, respectively (E&E 1997).

The 2000 RI investigation at AOC K1 included delineating the extent of buried debris and determining whether contaminants are present in surface and subsurface soil as a result of the disposal area. Results of the geophysical survey indicate buried metal and/or surface debris in the dump area covers approximately 82,150 square feet. The boundary of the dump area is generally defined by the difference in vegetation between landfill and the surrounding wetlands. A large quantity of debris, including gas cans, drums, bottles, pipes, partially buried auto parts, and engines, were observed in the wetland area adjacent to Tawah Creek. Several large sheens were observed in the wetlands surrounding the landfill (ENSR 2003a).

Six surface and 12 soil boring samples were collected during the 2000 RI and tested for DRO, GRO, RRO, VOCs, PAHs, PCBs, pesticides, herbicides and metals. Pentachlorophenol was detected in one surface soil sample at a concentration of 0.170 mg/kg which exceeds the ADEC Method Two soil cleanup level of 0.047 mg/kg. Arsenic was detected in three surface soil and three soil boring samples at concentrations ranging from 5.4 to 32 mg/kg which exceeds the ADEC Method Two soil cleanup level of 3.7 mg/kg. Some of these arsenic concentrations also exceed the established background concentration of 11.6 mg/kg. Chromium was detected in one surface soil and one soil boring sample at concentrations of 39 and 59 mg/kg which exceed the ADEC Method Two soil cleanup level of 25 mg/kg and the established background concentration of 37 mg/kg (ENSR 2003a). Cadmium was detected in one surface soil sample at a concentration of 7.4 mg/kg which exceeds the ADEC Method Two soil cleanup level of 5 mg/kg.

During ENSR's 2001 RI, lead concentrations in groundwater exceeded the ADEC groundwater cleanup level of 0.015 mg/L. The maximum concentration detected was 0.068 mg/L. ENSR concluded that the elevated concentrations are likely due to suspended solids associated with turbidity in the sample resulting from purging and sampling using a bailer. No other analytes in groundwater exceeded ADEC groundwater cleanup levels (ENSR 2003b).

In 2004, Shannon & Wilson conducted groundwater sampling at AOC K1 during Focused RI field activities. Six monitoring wells at AOC K1 were appropriately purged and sampled for lead. Water samples from three of the monitoring wells were also analyzed for chromium. The maximum lead concentration detected was an estimated value of 0.0003 mg/L in the triplicate sample collected from the Well AP-045 which is less than the ADEC Table C groundwater cleanup criterion of 0.015 mg/L. The maximum chromium concentration detected was 0.0026 mg/L in the triplicate sample collected from the Well AP-045 which is less than the ADEC Table C groundwater cleanup criterion of 0.1 mg/L (S&W 2006a).

In summary, DRO, benzo(a)pyrene, pentachlorophenol, arsenic, cadmium and chromium in surface soil, arsenic in subsurface soil (2 to 4 feet bgs), and arsenic, cadmium and lead in surface water are considered COCs at AOC K1. Note that the chromium concentration is assumed to be Cr6+, a known carcinogen. AOC K1 may be retested to determine if the chromium concentration is due to Cr6+ and/or Cr3+. The cleanup level for Cr3+ is 124,000 mg/kg. If it is determined that the chromium concentration is actually Cr3+, then chromium is not considered a COC at AOC K1. AOC K1 is included in the detailed FS. Figure 3.10-1 shows the ten locations of the impacted surface and near surface (2 to 4 feet bgs) soil. Based on discussion with the USACE PM, the surface material over the entire landfill will be considered impacted with COCs. Results of the geophysical survey indicate the landfill covers approximately 82,150 square feet. The approximate boundary of the landfill, denoted as the geophysical anomaly, is shown on Figure 3.10-1 as the "Area for Remedial Action".

The concentration of arsenic, cadmium and lead in surface water on the downgradient (south) side of the dump should be appropriately re-sampled to determine if arsenic, cadmium and lead are still present. Care should be taken to not disturb the sediment.

3.11 AOC L - ACOR Tank Farm

The former ACOR Tank Farm (AOC L) is located to the southwest of Airport Road, approximately 2 miles from the airport, and is shown on Figure 1.2-1. Fifteen aboveground petroleum storage tanks and the associated pipeline system were built as part of the Air Corps

Tactical Gas System during World War II and held nearly 750,000 gallons of fuel. Yakutat Army Base War Department maps indicate that the fuel tanks were supported by concrete "saddles" and were connected by service lines to pipeline system lateral lines. The lateral lines were connected by a drainage lateral that drained toward a pump house located near the center of the tank farm. The pump house was at the low point of the tank farm and drained all lateral lines. The reserve tank farm was connected by a main line to the Army Dock where aviation gasoline deliveries were loaded directly from tankers. The piping system was buried in trenches, generally 2 to 5 feet bgs. A booster pump and associated oil-water separator on the main pipeline moved fuel to truck fill stands located along Airport Road and on the Air Base. Concrete vaults were constructed at the lateral line-drain line and lateral line-main line junctions. The 15 aboveground fuel storage tanks were removed shortly before the tank farm site was relinquished to the Territory of Alaska in 1948. The piping system was not removed (ENSR 2003a).

3.11.1 AOC L1 - ACOR Tank Farm, Drum Dumps

In 2001, two separate drum dumps within the tank farm were investigated by ENSR as AOC L1. AOC L1 is shown on Figure 3.11-1. One drum dump was located west of the Tank 1 foundation and the second drum dump was located west of the Tank 8 foundation. The drum dumps are sometimes referred to as the North Drum Dump and the South Drum Dump, respectively (ENSR 2003b).

During the 2001 RI/FS activities, one surface soil sample was collected west of Tank 1 and four surface soil samples were collected west and northwest of Tank 8. Additionally, one soil boring (AP-076) was advanced west of Tank 1 and two soil borings (AP-077 and AP-078) were advanced northwest of Tank 8. Monitoring wells were installed in each boring. A geophysical survey was conducted at the debris/drum dump site west of Tank 1 prior to sampling activities to delineate the extent of possible buried debris. Several anomalies observed within the survey area were interpreted as surface debris, indicating no drums or debris were buried at this site. No analytes in surface soil exceeded ADEC Method 2 soil cleanup levels (ENSR 2003b).

At the drum dump northwest of Tank 8, a strong hydrocarbon odor was noted in Boring AP-078 throughout the total depth (12.5 feet) of drilling. GRO was detected in the soil boring samples from AP-078 at concentrations up to 17,000 mg/kg which exceed the ADEC Method 2 cleanup level of 260 mg/kg. These concentrations are also above the ADEC maximum allowable concentrations for GRO of 1,400 mg/kg. Benzene concentrations up to 23 mg/kg and toluene concentrations up to 80 mg/kg were also detected in Boring AP-078 at levels that exceed the ADEC Method 2 cleanup levels (0.025 mg/kg and 6.5 mg/kg, respectively) (ENSR 2003b).

A GRO concentration of 4.94 mg/L and a benzene concentration of 0.059 mg/L were measured in groundwater collected from Well AP-078 which exceed ADEC groundwater cleanup levels of 2.2 mg/L and 0.005 mg/L, respectively. Arsenic, barium, cadmium, and chromium concentrations in groundwater collected from Wells AP-076 and/or AP-077 exceeded ADEC groundwater cleanup levels of 0.010 mg/L, 2.0 mg/L, 0.005 mg/L, and 0.1 mg/L, respectively. The maximum concentration detected for arsenic was 0.0905 mg/L, for barium was 4.13 mg/L, for cadmium was 0.0076 mg/L, and for chromium was 0.989 mg/L. Lead concentrations of 0.0924 mg/L and 0.407 mg/L were measured in groundwater collected from Wells AP-076 and AP-078, respectively, which exceed ADEC groundwater cleanup level of 0.015 mg/L. ENSR concluded that elevated concentrations of these metals are likely due to suspended solids associated with turbidity in the sample resulting from purging and sampling using a bailer. ENSR indicated that the lead concentration detected in Well AP-078 may be associated with a fuel release. It is assumed that this determination is based on the fact that GRO and benzene were detected in Boring AP-078 (ENSR 2003b). The 2001 groundwater sampling data for metals is considered invalid since ENSR attributed the elevated metals concentrations in groundwater at Wells AP-076, AP-077 and AP-078 to suspended solids in the samples.

In 2004, groundwater sampling was conducted again by Shannon & Wilson. Well AP-076 and AP-078 were appropriately purged and sampled. A water sample from AP-076 was analyzed for arsenic, chromium, and lead and a water sample from AP-078 was analyzed for chromium and lead. Concentrations of arsenic, chromium, and lead in the water sample from AP-076 were not detectable. The concentration of lead in Well AP-078 was 0.021 mg/L which exceeds the ADEC groundwater cleanup levels of 0.015 mg/L (S&W 2006a).

During the 2005 ROST/LIF investigation, eight probes were advanced in the drum dump area northwest of former Tank 1 and eight probes were advanced in the drum dump area northwest of Tank 8. Results indicate that there is no significant POL contamination. None of the correlation or confirmation samples had analytical results that exceed the applicable ADEC Method 2 soil cleanup level (USACE 2006).

In 2006, Monitoring Wells AP-077 and AP-078 were sampled by BC-J and analyzed for metals. Well AP-078 was analyzed for lead only while AP-077 was analyzed for arsenic, barium, cadmium, chromium, and lead. Although metals were detected, none exceeded ADEC Table C groundwater cleanup criteria (BC-J 2007).

In summary, GRO, benzene, and toluene in surface and subsurface soil, and GRO and benzene in groundwater are considered COCs at the drum dump northwest of Tank 8 (South Drum Dump) at AOC L1. AOC L1 (South Drum Dump) is included in the detailed FS. No COCs were identified at the North Drum Dump located northwest of Tank 1; therefore, the North Drum Dump is not included in the detailed FS. Figure 3.11-1 shows the approximate boundary of the impacted soil. The impacted soil is assumed to extend vertically from the ground surface to 12.5 feet bgs and laterally over an area of 314 sf. The estimated volume of impacted soil is approximately 167 cy. The lateral extent of GRO and benzene-impacted groundwater is not known, however, for the purposes of this FS, the GRO and benzene-impacted groundwater plume is assumed to be about twice the lateral extent of the GRO and benzene-impacted soil or over an area of approximately 630 sf.

3.11.2 AOC L2 - ACOR Tank Farm, Tank Farm Pipeline System Junctions

The pipeline system junctions investigated as AOC L2 consisted of seven concrete junction vaults within the tank farm, a fuel dispensing hose associated with a tank truck fill stand, 2 lateral and 1 drain line breaks, and a booster pump, oil-water separator, and air release tank. One of the seven pipeline junctions visited during a 1999 site walkover consisted of a 4 feet by 4 feet concrete vault extending approximately 5 feet bgs. Standing water was visible in the vault. The fuel dispensing hose was found by the edge of Airport Road about 250 feet northeast of Tank No. 3. A booster pump, oil-water separator, and air release tank on the main pipeline (separator tank), which moved fuel to truck fill stands located along Airport Road and on the Air Base, were found about 100 feet southeast of Tank 3 (ENSR 2003b). A site plan of AOC L2 is provided in Figure 3.11-2.

During the ENSR 2000 RI, six of the seven junction vaults, the fuel dispensing hose associated with a tank truck fill stand, and the separator tank were visited. Water was not present in the vaults or at the separator tank. The junction box near Tank 5 was in an area of thick, overgrown brush and could not be found. Boring/Monitoring Well AP-079 was advanced in the area of the tank truck fill stand by Airport Road. Surface soil, subsurface soil, and groundwater at the tank truck fill stand were sampled and analyzed. Very low levels of target analytes in surface and subsurface soil and groundwater were detected in the samples collected near the fuel hose. None of these detected analytes exceed ADEC cleanup levels (ENSR 2003b).

In 2004, groundwater sampling was conducted at AOC L2 by Shannon & Wilson during Focused RI field activities. Monitoring Well AP-079 was appropriately purged and sampled for the 8 RCRA metals. Primary and duplicate water samples from the monitoring well had low levels of barium (0.0276 mg/L) and lead (0.000699 mg/L). These concentrations are less than the ADEC Table C groundwater cleanup criterion of 2.0 mg/l and 0.015 mg/L, respectively (S&W 2006a).

During the 2005 ROST/LIF investigation, probes were advanced at Valve Pit A1 (6 probes), Valve Pit C5 (4 probes), Lateral C Break (5 probes), Drain Line Break (5 probes), Lateral D Break (9 probes), and the separator tank (5 probes). Results indicate that there is no significant POL contamination. None of the correlation or confirmation samples had analytical results that exceed the applicable ADEC Method 2 soil cleanup level (USACE 2006).

In summary, no COCs were identified at AOC L2. AOC L2 is not included in the detailed FS.

3.11.3 AOC L3 - ACOR Tank Farm, Tank Foundations (15 ASTs)

Fifteen ASTs were removed shortly before the ACOR Tank Farm site was relinquished to the Territory of Alaska in 1948. The connecting pipeline system was not removed. The tank end of the service lines were observed sticking out of the ground and filled with debris at most of the tank foundations. Sets of four concrete supports, each 3 feet high, 4 feet wide, and 10 feet long, remain at each former tank location. These supports appear to be in their original locations, with the exception of the supports at Tank 5 which appear to have been moved. The service line at Tank 5 was not visible but was delineated by a geophysical subcontractor (ENSR 2003b). The 15 former AST locations at AOC L3 are shown on Figure 3.11-3.

During the ENSR 2001 RI, two surface soil locations were sampled at each of 15 tank foundations to determine whether residual fuel contamination exists in the surface soil. A total of 15 soil borings were advanced (AP-080 through AP-094), one at each tank foundation to determine whether residual fuel contamination exists in the subsurface soil. Monitoring Wells AP-080 through AP-094 were installed in the borings. Samples were collected from each well to determine whether contaminants were leaching into the groundwater (ENSR 2003b).

Benzene was detected in five of the thirty surface soil samples with concentrations ranging from an estimated value of 0.00787 mg/kg to 0.0937 mg/kg. One reported concentration from Tank 14 (0.0937 mg/kg) exceeded the ADEC Method Two soil cleanup level of 0.025 mg/kg. Benzo(a)pyrene was detected in the surface soil samples collected from every tank foundation (except Tank 5) with sample concentrations ranging from an estimated value of 0.00158 mg/kg to 3.830 mg/kg. Samples collected at Tank 5 were near the displaced concrete supports but likely not at the original service line/tank connection location. Analytical results indicate that the benzo(a)pyrene concentrations in surface samples collected at Tank 1 (1.610 mg/kg), Tank 3 (0.460 mg/kg), Tank 7 (1.940 mg/kg), Tank 8 (3.830 mg/kg and 0.935 mg/kg), and Tank 11 (0.757 mg/kg) exceed the ADEC Method Two direct contact soil cleanup level of 0.4 mg/kg. In addition, analytical results indicate that the benzo(a)anthracene concentration in one surface sample collected at Tank 8 (4.270 mg/kg) exceeds the ADEC Method Two migration to groundwater soil cleanup level of 3.6 mg/kg. Very low levels of target analytes in subsurface soil and groundwater were detected in the samples collected from the 15 soil borings and monitoring wells at AOC L3. None of these detected analytes exceed ADEC cleanup levels (ENSR 2003b).

In 2004, groundwater sampling was conducted at AOC L3 by Shannon & Wilson during Focused RI field activities. Monitoring Wells AP-082, AP-086, AP-091 were appropriately purged and sampled for the 8 RCRA metals. Primary and duplicate water samples from the monitoring well had low levels of barium (0.0657 mg/L), chromium (0.00182 mg/L), and lead (0.00132 mg/L). These concentrations are less than the ADEC Table C groundwater cleanup criterion of 2.0 mg/L, 0.10 mg/L, and 0.015 mg/L, respectively (S&W 2006a).

During the 2005 ROST/LIF investigation, probes were advanced at Tank 1 (4 probes), Tank 7 (5 probes), Tank 8 (5 probes), and Tank 14 (5 probes). Results indicate that there is no significant POL contamination. None of the correlation or confirmation samples had analytical results that exceed the applicable ADEC Method 2 soil cleanup level (USACE 2006).

In 2006, groundwater sampling was conducted at AOC L3 by BC-J. Monitoring Wells AP-080, AP-081, AP-083, AP-084, AP-085, AP-087, AP-088, AP-089, AP-090, AP-092, and AP-093 were appropriately purged and sampled for the 8 RCRA metals. The maximum concentration detected for arsenic was 0.00515 mg/L, for barium was 0.0347 mg/L, for cadmium was 0.00002 mg/L, for chromium was 0.00152 mg/L, for lead was 0.00813 mg/L, for mercury was 0.00004 mg/L, for selenium was 0.00571 mg/L, and for silver was 0.00001 mg/L. Arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver concentrations in groundwater collected from these wells did not exceed ADEC groundwater cleanup levels of 0.010 mg/L, 2.0 mg/L, 0.005 mg/L, 0.1 mg/L, 0.015 mg/L, 0.002 mg/L, 0.05 mg/L, and 0.10 mg/L, respectively (BC-J 2007).

In summary, benzene in surface soil at Tank 14, benzo(a)pyrene in surface soil at Tank 1, Tank 3, Tank 7, Tank 8, and Tank 11, and benzo(a)anthracene in surface soil at Tank 8 are considered COCs at AOC L3. AOC L3 is included in the detailed FS. Figure 3.11-3 shows the approximate boundaries of the impacted soil at each tank site. The impacted area at each tank location with the exception of Tank 8 is treated as a hotspot since COCs were detected in a single sample location. The impacted soil at these tank locations is assumed to extend vertically from the ground surface to a depth of 2 feet bgs and laterally over an area of 314 sf. The estimated volume of impacted soil at each of the hotspots is approximately 27 cy. The impacted area at Tank 8 is assumed to extend vertically from the ground surface to a depth of 2 feet bgs and laterally over an area of 525 sf. The estimated volume of impacted soil at Tank 8 is 45 cy.

3.11.4 AOC L4 - ACOR Tank Farm, Truck Fill Stand No. 4

The Field Revisions, A.C. Tactical Gas System plan, dated April 17, 1943, and provided in Appendix A, shows the location of Truck Fill Stand No. 4 approximately 1,200 feet southeast of Ophir Creek, in the Temporary A.C. Gas Storage Area. A wood cribbing support for a small tank (approximately 20 feet long) was found at the end of a capped 6-inch diameter pipe that extended up from a small trench. The pipe in the trench continued southeast toward the ACOR Tank Farm and is believed to be the main delivery line from the Army Dock to the ACOR Tank Farm. AOC L4 is shown on Figure 3.11-4.

During the 2001 RI, two locations in the former truck fill stand area were sampled by ENSR to determine whether residual fuel contamination exists in the surface soil. Benzo(a)pyrene was detected in one surface soil sample at a concentration of 1.57 mg/kg which exceeds the ADEC Method 2 soil cleanup level of 0.4 mg/kg. DRO was detected in the other sample at a concentration of 236 mg/kg which exceeds the ADEC Method 2 soil cleanup level of 230 mg/kg. One boring and one monitoring well (AP-095) were advanced at AOC L4. No analytes in subsurface soil exceeded ADEC Method 2 soil cleanup levels. No analytes in groundwater exceeded ADEC groundwater cleanup levels (ENSR 2003b).

In 2004, groundwater sampling was conducted at AOC L4 by Shannon & Wilson during Focused RI field activities. Monitoring Well AP-095 was appropriately purged and sampled for the 8 RCRA metals. Primary and duplicate water samples from the monitoring well had low levels of barium (0.0274 and 0.0276 mg/L). These concentrations are less than the ADEC Table C groundwater cleanup criterion of 2.0 mg/L (S&W 2006a).

During the 2005 ROST/LIF investigation, eight probes were advanced at Truck Fill Stand No. 4. Results indicate that there is no significant POL contamination. None of the correlation or confirmation samples had analytical results that exceed the applicable ADEC Method 2 soil cleanup level (USACE 2006).

In summary, benzo(a)pyrene and DRO in surface soil are considered COCs at AOC L4. AOC L4 is included in the detailed FS. Figure 3.11-4 shows the approximate boundary of the impacted soil. The impacted soil is assumed to extend vertically from the ground surface to 2 feet bgs and laterally over an area of 570 sf. The estimated volume of impacted soil is approximately 49 cy. Note that two ROST/LIF probes (YAK L 081 and YAK L 082) are located within the assumed impacted area. These probes did not indicate the presence of contaminated soil.

3.11.5 AOC L5 - ACOR Tank Farm, Pump House

AOC L5, shown on Figure 3.11-5, is the location of the ACOR Tank Farm Pump House. According to the 1942 Yakutat Army Base War Department maps, the Pump House was located at the low point of the tank farm. The piping manifold was designed to permit pumping from tank in lateral line to tank in another lateral line or to the main line. The southwestern half of the foundation was framed by a vertical curb with a doorway in the west corner. A pump and part of the collapsed building were present on this part of the foundation. The northeastern half of the foundation was extended below grade to form an L-shaped concrete vault that contained part of the severely rusted and fragile pipe manifold. This vault extends under the western half of the facility. Petroleum sheen was observed on standing water within the vault, and a heavy, colorful sheen emerged after a stone was dropped in.

During the 2001 RI, four locations around the Pump House foundation were sampled to determine whether residual fuel contamination exists in the surface soil. Three soil borings (AP-096, AP-097, and AP-098) were advanced to a depth of 12 to 13 feet bgs. Monitoring Wells AP-096, AP-097, and AP-098 were installed in the borings. Samples were collected from each well to determine whether contaminants were leaching into the groundwater. No target analytes in surface soil, subsurface soil, or groundwater had concentrations exceeding ADEC cleanup levels (ENSR 2003b).

In 2004, groundwater sampling was conducted at AOC L5 by Shannon & Wilson during Focused RI field activities. Monitoring Wells AP-096, AP-097, and AP-098 were appropriately purged and sampled for the 8 RCRA metals. Primary, duplicate and/or triplicate water samples from the monitoring well had either non-detectable levels or very low levels of metals. Cadmium, selenium, and silver were not detected in the water samples. The maximum concentration for arsenic was an estimated value of 0.0008 mg/L, for barium was 0.0393 mg/L, for chromium was an estimated value of 0.000118 mg/L, for lead was 0.00038 mg/L, and for mercury was an estimated value of 0.0013 mg/L. Arsenic, barium, chromium, lead, and mercury concentrations in groundwater collected from these wells did not exceed ADEC groundwater cleanup levels of 0.010 mg/L, 2.0 mg/L, 0.1 mg/L, 0.015 mg/L, and 0.002 mg/L, respectively (S&W 2006a).

During the 2005 ROST/LIF investigation, ten probes were advanced at the Pump House. Results indicate that there is no significant POL contamination. None of the correlation or confirmation samples had analytical results that exceed the applicable ADEC Method 2 soil cleanup level (USACE 2006).

In summary, no COCs were identified at AOC L5. AOC L5 is not included in the detailed FS.

3.12 AOC M - Post Powerhouse/25,000 Gallon Tactical Tank

AOC M is the location of a former 25,000-gallon UST and fuel/water separator system located to the northwest of the Yakutat airport. The general location of AOC M is shown on Figure 1.2-1. The original Air Corps tactical gas system for the Yakutat Landing Field was designed to contain five 25,000-gallon storage tanks. The plans originally indicated that the tanks were to be located above ground in a wooded area for camouflage, but after further study, it was determined to be more advantageous to reduce the length of the service line to the fueling pits and accomplish camouflage by underground construction. Water was used to push fuel through the piping system. A review of reference information indicates that it is likely that only one tank was actually installed at this location (ENSR 2003a).

3.12.1 AOC M1 - Suspected Hangar Pipeline System/Tactical UST

A pipeline was suspected of connecting the ACOR Tank Farm to the airfield hangar area fueling pits and truck fill stand. The alignment of the pipeline path can be seen in 1948 aerial photographs. A ditch 8 feet wide and 3 feet deep was observed during the 1999 site walkover. The ditch is clearly visible in 1963 aerial photographs and follows the alignment of the pipeline path seen in the 1948 aerial photographs. An approximate 20 feet wide by 40 feet long by 5 feet deep pit was observed during the 1999 site walkover and in 1963 aerial photographs. This pit is in the approximate location of the 25,000-gallon storage tank indicated on the 1943 Field Revisions Air Corps Tactical Gas System map. The pit contained water at the time of the site walkover (ENSR 2003a). AOC M1 is shown on the site plan presented as Figure 3.12-1.

The 2000 RI investigation at AOC M1 by ENSR consisted of performing a geophysical survey and surface soil, subsurface soil, and groundwater sampling and analyses. The geophysical survey was conducted to determine the presence or absence of a buried pipeline and other objects associated with this former military site. The geophysical investigation indicated that no buried pipe was present in this area. Six surface locations were sampled to determine if contamination associated with the former military use of the site is present in the surface soils. Three soil borings (AP-047, AP-048, and AP-049) were advanced in the area of the suspected hangar pipeline and tactical UST. Monitoring Wells AP-047, AP-048, and AP-049 were installed in the borings. Samples were collected from each well to determine whether contaminants were leaching into the groundwater (ENSR 2003a).

Arsenic and chromium were the only analytes detected in surface and subsurface soil that exceeded ADEC Method 2 soil cleanup levels of 3.6 mg/kg and 25 mg/kg, respectively. The maximum concentration of arsenic reported in surface and subsurface soil was an estimated value of 5.2 mg/kg, which is less than the established background concentration of 11.6 mg/kg. The maximum concentration of chromium reported in surface and subsurface soil was an estimated value of 35 mg/kg which is less than the established background concentration of 37 mg/kg. No other target analytes in surface soil or subsurface soil had concentrations exceeding ADEC cleanup levels. No groundwater samples contained analytes that exceeded ADEC groundwater cleanup levels (ENSR 2003a).

In 2005, Shannon & Wilson performed a geophysical survey of the pipeline suspected of connecting the ACOR Tank Farm to the airfield hangar area fueling pits and truck fill stand. No anomalies suggesting the presence of buried piping were identified in the geophysical profiles run along roads and within clearings crossing the presumed pipeline alignment. Moreover, no visual evidence was found of support structures, a former aboveground pipeline, or indications of contamination resulting from a historical pipeline (S&W 2006b).

In summary, no COCs were identified at AOC M1. AOC M1 is not included in the detailed FS.

3.12.2 AOC M2 - Fuel/Water Separator and Pressure Tank Pit

The 1943 Field Revisions Air Corps Tactical Gas System map indicated that a fuel/water separator and pressure tank pit facility was located at a 45-degree bend in the piping system approximately 300 feet down line from the 25,000-gallon tank. This facility separated the water used to push fuel through the piping system. Details about ultimate disposal of the water were unable to be determined from the reference materials. A small, square, metal foundation was observed in the area during the 1999 site walkover and was suspected of being associated with the facility, but it was not possible to make that determination. A collapsed Quonset hut may be associated with the tactical gas system or with the airbase laundry facilities, which were also located in the general area. No pit was observed (ENSR 2003a). AOC M2 is shown on the site plan presented as Figure 3.12-1.

The 2000 RI investigation at AOC M2 by ENSR consisted of performing a geophysical survey and surface soil, subsurface soil, and groundwater sampling and analyses. The geophysical survey was conducted to determine the presence or absence of a buried pipeline and other objects associated with this former military site. The geophysical investigation indicated that no buried pipe was present in this area. Six surface locations were sampled to determine if contamination associated with the former military use of the site is present in the surface soils. Three soil borings (AP-050, AP-051, and AP-052) were advanced in the area of the suspected hangar pipeline and tactical UST. Monitoring Wells AP-050, AP-051, and AP-052 were installed in the borings. Samples were collected from each well to determine whether contaminants were leaching into the groundwater (ENSR 2003a).

Chromium was detected in eleven surface and subsurface soil samples at concentrations which exceed the ADEC Method 2 soil cleanup level of 25 mg/kg. Only one surface sample with a chromium concentration of 47 mg/kg is greater than the established background concentration of 37 mg/kg. DRO was reported in one near surface soil sample (0.5 to 2.5 feet bgs) at a concentration of 700 mg/kg which exceeds the ADEC Method 2 soil cleanup level of 230 mg/kg. However, associated field QC duplicate and QA referee samples were below the ADEC Method 2 soil cleanup level of 230 mg/kg. Groundwater samples did not contain target analytes exceeding the ADEC groundwater cleanup levels (ENSR 2003a).

During the 2005 ROST/LIF investigation, 45 ROST/LIF probes were pushed at AOC M2. The results at AOC M2 indicated the presence of diesel fuel in the soils associated with the former tank location and the fuel/water separator tank site. One confirmation sample collected from Probe M-002, located adjacent to a circular concrete tank foundation, showed a DRO concentration estimated to be greater than 7,970 mg/kg. Another confirmation sample collected from Probe M-027, located about 50 feet west of the north end of the collapsed Quonset hut, had a DRO concentration of 2,700 mg/kg. The contamination was limited to a depth of approximately 4 to 6 feet bgs, and extends in a northeast to southwest trending swath across the site. A second area of contamination, encountered at a depth of about 3.5 to 5 feet bgs, was identified to the southeast of the primary swath. The extent of the contamination was well defined in most areas, however, physical constraints excluded rig access in a few locations. The area of highest petroleum concentrations has been defined. The LIF screening results demonstrate that the concentrations are decreasing with distance from the source, and the edge of the contamination above cleanup levels is not predicted to extend much beyond the farthest probes (USACE 2006).

In summary, chromium in surface soil and DRO in subsurface soil are considered COCs at AOC M2. Note that the chromium concentration is assumed to be Cr6+, a known carcinogen. AOC M2 may be retested to determine if the chromium concentration is due to Cr6+ and/or Cr3+. The cleanup level for Cr3+ is 124,000 mg/kg. If it is determined that the chromium concentration is actually Cr3+, then chromium is not considered a COC at AOC M2. AOC M2 is included in the detailed FS. Figure 3.12-1 shows the approximate boundary of the impacted soil. The chromium-impacted area is treated as a hotspot since chromium was detected in a single sample location. The chromium-impacted soil is assumed to extend vertically from the ground surface to a depth of 2 feet bgs and laterally over an area of 78 sf. The estimated volume of chromium-impacted soil is approximately 7 cy.

The DRO-impacted soil appears to be located in two distinct locations. The primary northeast-southwest trending swath appears to be associated with the concrete tank foundation. The second smaller area is apparently associated with the former Quonset hut. At the former tank area, the DRO-impacted soil is assumed to extend vertically from 4 to 6 feet bgs and laterally over an area of 16,921 sf. The estimated volume of impacted soil is approximately 1,441 cy overlain with an estimated 2,883 cy of clean overburden. At the Quonset hut area, the DRO-impacted soil is assumed to extend vertically from 3.5 to 5 feet bgs and laterally over an area of 1,514 sf. The estimated volume of impacted soil is approximately 97 cy overlain with an estimated 226 cy of clean overburden.

3.12.3 AOC M3 - Air Corps Increase Group No. 1 Powerhouse

AOC M3 was made known through public involvement and is presumably located in the general area of AOC M. ENSR reported that USACE maps and documents indicate that the area had a power plant. Buildings in the area were demolished and buried in excavation pits and covered with soil during the 1984 to 1985 USACE cleanup effort. ENSR referred to AOC M3 as the Air Corps Increase Group No. 1 Powerhouse (ENSR 2003b, ENSR 2005). The 1943 Layout Plan (B-11), Yakutat Landing Field, provided in Appendix A, indicates that the Air Corps Increase Group No. 1 Powerhouse is located about 0.5 mile southwest of AOCs M1 and M2.

The Post Powerhouse was investigated by E&E in 1997. A site plan from the 1997 E&E report, Figure 5-3, showing the location of the Post Powerhouse, is provided in Appendix A. The Post Powerhouse location investigated by E&E coincides with the location of the Air Corps Increase Group No. 1 Powerhouse location shown on the 1943 Layout Plan (B-11), Yakutat

Landing Field, provided in Appendix A. E&E indicated that the Post Powerhouse is located in a grassy clearing at the end of a trail across from the US Forest Service housing on the northwest side of Cannon Beach Road. The trail is heavily overgrown with alders and willows. No sign of stressed vegetation, debris, spillage, or odor were noted. Three surface soil samples, designated PP01SS, PP02SS, and PP03SS were collected from the clearing and analyzed. Low levels of GRO, DRO, RRO, 4,4'-DDD, 4,4'-DDT, and dihedron were detected but at concentrations that do not exceed the ADEC Method 2 soil cleanup criteria (E&E 1997).

In summary, no COCs were identified at AOC M3, therefore, AOC M3 is not included in the detailed FS.

3.13 AOC N1 - Air Warning System Station (AWS)

AOC N1 is located on a hill at the end of Monti Road (now called Ridge Road) near the center of Yakutat. A site plan of AOC N1 is shown on Figure 3.13-1. The AWS monitored the position of all aircraft in the area and relayed the information to the Air Warning Filter Center for evaluation and distribution. Two barracks and one headquarters building were built in a heavy wooded area on the hill. Several detector buildings, transmission lines, a pump house, and a powerhouse also serviced the area. The site provided electrical power for the AWS Station. A 1943 layout map indicates that the generator for the powerhouse had not been installed although one was to be furnished. Two fuel storage tanks were to supply diesel fuel to the powerhouse. The area is presently privately owned and is the location of a llama farm (ENSR 2003b).

In 1999, ENSR personnel visited the site and observed a concrete pad that was identified by a local resident as the former powerhouse foundation. Two large storage trailers nearly covered the concrete foundation. Two drums and several metal cans were also observed (ENSR 2003a, ENSR 2003b).

For the 2001 RI, three locations at the powerhouse foundation were sampled to determine whether surface soil contamination associated with former military use exists. DRO was detected at an estimated value of 636 mg/kg which exceeds the ADEC Method 2 soil cleanup level of 230 mg/kg. Pentachlorophenol was detected in the surface soil samples at a maximum concentration of 0.0637 mg/kg which exceeds the ADEC Method 2 soil cleanup level of 0.047 mg/kg. Arsenic concentrations in soil exceeded the ADEC Method 2 soil cleanup level, however, the detected concentrations were below the established background concentration of 11.6 mg/kg. Cadmium was detected in one surface soil sample at a concentration of 6.98 mg/kg which exceeds the ADEC Method 2 soil cleanup level of 5.0 mg/kg. PCB contamination possibly associated with the former powerhouse was not detected at this site. No other target analytes in the surface soil samples exceeded ADEC Method 2 soil cleanup levels (ENSR 2003b).

In summary, DRO, pentachlorophenol, and cadmium in surface soil are considered COCs at AOC N1. USACE was not successful in obtaining a Right of Entry to further investigate the contaminants at AOC N1. USACE hopes to investigate this site further in the near future.

3.14 AOC O1 - Air Corps Warehouse Group No 2

Verbal reports indicated that several drums were present in the area labeled as A.C. Warehouse Group No. 2 on the 1943 Layout Plan (B-11), Yakutat Landing Field, provided in Appendix A. Over 45 drums, a concrete foundation with vertical curbs indicating former large door openings on the southwest and northeast ends, and 3 small drums containing what appeared to be petroleum grease were observed between the road and drainage ditch to the east (ENSR 2003b). A site plan of AOC O1 is shown on Figure 3.14-1

Two areas were investigated at AOC O1. The first area was a grouping of approximately 15 rusted drums in the middle of the A.C. Warehouse Group No. 2 area. The second area was a warehouse foundation near a drainage ditch with several drums. Three surface soil locations were sampled and three borings (AP-099, AP-100, and AP-101) were advanced at AOC O1 to determine whether surface and/or subsurface soil contamination exists. Water samples were collected from Monitoring Wells AP-099, AP-100, and AP-101 to determine whether contaminants were leaching into the groundwater. Two surface water and two co-located sediment samples were also collected from the drainage ditch to the south of the A.C. Warehouse Group No. 2 area to determine whether contaminants were migrating from the drum storage area (ENSR 2003b).

Arsenic concentrations in surface soil (13.4 mg/kg and 15 mg/kg) exceed the ADEC Method 2 soil cleanup level and the established background concentration of 11.6 mg/kg. An arsenic concentration in one sediment sample (8.38 mg/kg) exceeds the SQuiRT value of 5.9 mg/kg but is less than the established background concentration of 11.6 mg/kg. No other analytes in surface soil, subsurface soil, or sediment exceed the ADEC Method 2 soil cleanup level. Lead concentrations in groundwater samples from each of the monitoring wells exceeded the ADEC groundwater cleanup level of 0.015 mg/L. The maximum lead concentration detected was 0.0452 mg/L in AP-101. ENSR suggested that the elevated concentrations are likely due to suspended solids associated with turbidity in the sample resulting from purging and sampling using a bailer. No other analytes exceed the ADEC groundwater cleanup level. Lead concentrations (0.0127 mg/L and 0.0128 mg/L) in two surface water samples exceeded the SQuiRT value of 0.0025 mg/L. No other analytes were detected in surface water samples above SQuiRT values or AWQS (ENSR 2003b).

In 2004, groundwater sampling was conducted at AOC O1 by Shannon & Wilson during Focused RI field activities. Monitoring Wells AP-099 and AP-100 were appropriately purged and sampled for lead. Lead was not detected in the water samples. Monitoring Well AP-101 was not available for sampling (S&W 2006a). According to the USACE PM, the non-detectable lead concentrations in groundwater at the locations of Monitoring Wells AP-99 and AP-100 are considered representative of the groundwater conditions at Monitoring Well AP-101.

In summary, arsenic in surface soil and lead in surface water are considered COCs at AOC O1. AOC O1 is included in the detailed FS. Figure 3.14-1 shows the approximate boundary of the impacted surface soil. The impacted soil area is treated as two hotspots since arsenic was detected in two sample locations. The impacted soil is assumed to extend vertically from the ground surface to a depth of 2 feet bgs and laterally over an area of 78 sf at each hotspot for a total of 156 sf. The estimated volume of impacted soil is approximately 14 cy. The concentration of lead in surface water should be investigated further to determine if lead is still present.

3.15 Summit, Aka, and Kardy Lakes and Ankau Slough

Verbal reports indicated that drums and other debris may have been disposed of in the lakes southeast of the OCRR Station. Several roads were followed between Kardy and Aka Lakes, but no drums or metal were observed. Two dumps were observed between the south edge of Aka Lake and Coast Guard Road (also called Ophir Creek Road). One dump was found on the north side of Beach Road between Aka Lake and Coast Guard Road and the other dump was found approximately 0.5 miles north of Coast Guard Road and Beach Road. Two drums and other buried debris were also observed in this area. These lakes were still considered to be possible dump sites (ENSR 2003a). The Southeastern Lakes are shown on Figure 1.2-1.

In 2005, visual inspections and geophysical surveys were conducted at Summit, Aka, and Kardy Lakes and Ankau Slough by Shannon & Wilson during Focused RI field activities. Based on the visual inspection and the geophysical surveys, no evidence was found of a dump or debris pile at Summit and Kardy Lakes and Ankau Slough. One partially-submerged barrel/drum of unknown origin was identified along the shoreline of Aka Lake (S&W 2006b).

Sediment and surface water samples were collected from the area around the drum at Aka Lake. The sediment and surface water samples were analyzed for GRO, DRO, RRO, VOCs, semi-volatile organic compounds (SVOCs), PCBs, dioxins, and metals. The sediment samples contained concentrations of cadmium, lead and mercury which exceed the SQuiRT values. It is not known whether the elevated metal concentrations in the sediment are within naturally occurring background concentrations or are anthropogenic in nature. The other COPCs, including GRO, DRO, RRO, VOCs, SVOCs, and PCBs, were either not detected or were reported at concentrations less than the SQuiRT values and the ADEC Method 2 cleanup levels for soil. Dioxin concentrations did not exceed the ADEC-accepted screening level of 38 ppt TEQ.

The surface water sample and associated replicates contained an estimated concentration of 0.00681 mg/L up to 0.015 mg/L bis(2-ethylhexyl)phthalate and up to 0.00771 mg/L lead. These concentrations of bis(2-ethylhexyl)phthalate and lead exceed the SQuiRT values and/or AWQS of 0.0003 mg/L and 0.0025 mg/L, respectively. As with the sediment sample, it is not known whether the elevated lead concentration in the surface water is within naturally occurring background concentrations or is the result of a release associated with the drum. Bis(2-ethylhexyl)phthalate is a common contaminant introduced to samples during sampling procedures and analytical testing. Shannon & Wilson recommended additional investigation efforts be conducted at Aka Lake to determine whether the results of the sediment and surface water samples were due to background concentrations or anthropogenic sources (S&W 2003b).

In summary, lead and bis(2-ethylhexyl)phthalate in surface water are considered COCs at Aka Lake. We understand that the USACE has performed additional investigative work at the Aka Lake drum site and has determined that the drum was the property of Chevron. No further DoD action is warranted at this time and, therefore, Aka Lake will not be included in the detailed FS.

3.16 AACS Transmitter Station Powerhouse

For the 2000 ENSR RI, access to the AACS Transmitter Station Powerhouse was not possible due to high surface water in the drainage ditch along the west side of Cannon Beach Road. Additional investigation in this area was recommended by ENSR. There is no site plan for this AOC (ENSR 2003a).

In summary, no COPCs were identified at the AACS Transmitter Station Powerhouse. The AACS Transmitter Station Powerhouse is not included in the detailed FS. Additional investigation is warranted at the AACS Transmitter Station Powerhouse, however, the results will not be included in this FS.

3.17 Rifle Range

The Rifle Range consisted of a skeet range, a 300-yard firing line, a 200-yard firing line, a target berm with a concrete backside, and a backstop (USACE 2008). A site plan of the Rifle Range is shown on Figure 3.17-1.

In their 1997 report, E&E indicated that the Rifle Range berm along the northwest side of Colorado Road is heavily vegetated with alders, and metal debris was observed protruding from the berm. Additionally, a second berm with a concrete wall was located north of the drum dump northwest of the airport and is believed to be an additional Rifle Range. Three surface soil samples, designated RR01SS, RR02SS, and RR03SS, were collected from the berm along Colorado Road. One surface soil sample, designated YA01SS, was collected from the berm with a concrete wall. Lead concentrations ranging from 3.83 to 12.39 mg/kg were detected in Samples RR01SS, RR02SS, and RR03SS. Sample YA01SS had an elevated concentration of lead at 2,983 mg/kg (E&E 1997). Based on a review of the aerial photographs, Samples RR01SS, RR02SS, and RR03SS appear to have been collected several hundred feet west of the 300-yard and 200-yard firing lines where lead is not expected to be encountered. Sample YA01SS appears to have been collected from the target berm with a concrete backside.

In 2006, the non-concrete side of the target berm was sampled by BC-J representatives. Forty-one samples were collected and analyzed for total lead. Six samples were also tested for TCLP lead. Analytical results from the Rifle Range show lead concentrations ranging from 3.14 to 2,800 mg/kg. Six of these samples exceed the ADEC Method 2 soil cleanup level for lead at a commercial/industrial site of 800 mg/kg. Lead concentrations exceeding the ADEC cleanup level were only detected to a maximum depth of 1.0 foot bgs, with the highest concentrations found at the surface (0 to 0.5 feet bgs). TCLP lead results ranged from 0.06 to 54.7 mg/L, with three results above the RCRA toxicity characteristic criteria of 5 mg/L. BC-J concluded that elevated concentrations of lead are localized to surface or near-surface soil and mainly concentrated in the center of the berm (BC-J 2007).

It appears that the target berm with a concrete backside has been sampled by E&E and BC-J representatives with analyses confirming the presence of lead at concentrations that exceed both the ADEC Method 2 soil cleanup level and the RCRA toxicity characteristic criteria. There is no information available indicating that soil at the backstop berm or in the skeet range area have been sampled and analyzed.

In summary, lead in surface soil is considered a COC at the Rifle Range. The Rifle Range is included in the detailed FS. Figure 3.17-1 shows the approximate boundary of the impacted surface soil at the target berm with a concrete backside, and of the backstop berm behind it. Although the backstop berm has not been sampled, it will be included in this FS. The impacted soil at each berm is assumed to extend vertically from the ground surface to a depth of 2 feet bgs and laterally over an area of 2,702 sf. The estimated volume of impacted soil within both berms is approximately 460 cy.

3.18 Former Coast Artillery Outpost

The Former Coast Artillery Outpost was the site of two 6-inch Naval guns located at the south end of Cannon Beach Road. The approximate location of the Former Coast Artillery Outpost is shown on Figure 1.2-1. A June 1948 real estate appraisal report says "Two 6-inch Naval guns installed on the coast three miles south of the hangar required little in the way of shore facilities and as a consequence, little salvageable material is to be found here." Although not mentioned in either report, the barrels for these two guns were cut off and left in place meeting the requirements for demilitarization (USACE 2008).

A building at the Former Coast Artillery Outpost served as a power source for a small installation on Cannon Beach Road. In 2000, the ENSR field team investigated this area and found a small metal and debris pile and a wooden foundation in the forested area (ENSR 2003a).

In summary, no COPCs were identified at the Former Coast Artillery Outpost. The Former Coast Artillery Outpost is not included in the detailed FS. Additional investigation is warranted at the Former Coast Artillery Outpost, however, the results will not be included in this FS.

3.19 AOCs Summary

Based on previous investigations and site histories, 28 AOCs have been identified for detailed analyses at the former Yakutat AFB. Fifteen of the individual AOCs identified at the former Yakutat AFB are those initially selected by the USACE for inclusion in the FS. These include AOCs C2, C4, C6, D-AST1, D-AST2, D-AST3, D-AST4, D-AST5, D-AST6, D-AST7, D-AST8, E1 (Northwest Drum Dump), G4, M2, and the Rifle Range. During a meeting held on November 14, 2008 with representatives from the USACE, the ADEC, and Shannon & Wilson, an additional 7 AOCs including AOCs K1, L1 (South Drum Dump), L3 (Tanks 1, 7, 8, and 14), and L4 were selected for inclusion in the FS. After review of the available Yakutat soil data, the USACE performed a statistical analysis and established background concentrations for arsenic and chromium. As a result, 3 additional AOCs (C1, C7, and O1) were added to the FS based solely on elevated concentrations of arsenic and chromium. The soil and groundwater cleanup standards listed in 18 AAC 75 were revised on October 9, 2008, affecting several COPCs detected at the AOCs (e.g., benzene, pentachlorophenol, benzo(a)pyrene, etc.). As a result, 2 additional sites (AOC L3 Tanks 3 and 11) have been included in the FS. Based on our detailed review of the GFM, 1 additional AOC, the Drainage Ditch at AOC E1, was identified as a separate AOC from the Northwest Drum Dump. Note that AOC N1 is not considered in this FS due to access restrictions by the present property owner. The 28 AOCs identified for inclusion in the FS are listed in Table 3.0-1.

Volume of impacted media calculated for these 28 AOCs are shown in Table 3.1-2. As indicated in Table 3.1-2, the volume of contaminated soil is estimated at approximately 82,000 cubic yards. The volume of petroleum contaminated soil is estimated at approximately 80,000 cubic yards. The volume of metal contaminated soil and sediment is estimated at approximately 500 cubic yards and the volume of multiple COC type contaminated soil and sediment is estimated at approximately 900 cubic yards.

The assumed aerial extent of the impacted groundwater plumes are indicated in Table 3.1-3. The aerial extent of impacted surface water cannot be estimated based on available data. For the purpose of this FS, the aerial extent of impacted surface water is uncertain. As indicated in Table 3.1-3, the assumed aerial extent of the groundwater plumes is estimated at approximately 57,000 square feet.

TABLE 3.0-1 - SUMMARY OF AREAS OF CONCERN (AOC)

Site	Area of Concern	FUDS Eligible	Requiring Further Action	COC	Affected Media	Recommended for Full Analysis	Landowner [a]
A	Air Corps Increase Group No. 2 - Building and Miscellaneous Debris Disposal Area (A1)	Yes	No	None			USFS
B	Air Warning Filter Center - Powerhouse No. 1 (B1)	Yes	No	None			USFS
	Air Warning Filter Center - Auxiliary Powerhouse No. 2 (B2)	Yes	No	None			USFS
	Air Warning Filter Center - Tank and Associated Piping (B3)	Yes	No	None			USFS
C	Point Carrew - Ankau Bridge Garbage/Drum Dump (C1)	Yes	Yes	chromium	SS	**Yes**	RNCL
				dioxins	SW	**Yes**	
	Point Carrew - Garrison Area Drum Dump (C2)	Yes	Yes	diesel range organics	SS, S, Sd	**Yes**	RNCL
				silver	SS	**Yes**	
				diesel range organics, cadmium, mercury	Sd	**Yes**	
				PCBs, bis(2-ethylhexyl)phthalate, lead, 2-methylnaphthalene	SW	**Yes**	
	Point Carrew - Garrison Area Powerhouse Foundation 1 Potential Release (C3)	Yes	No	None			RNCL
	Point Carrew - Garrison Area Surface Debris (C4)	Yes	Yes	diesel range organics	SS, S, Sd	**Yes**	RNCL
				chromium	SS	**Yes**	
	Point Carrew - Powerhouse No. 1092 (C5)	Yes	No	None (powerhouse not located)			RNCL
	Point Carrew - 50,000-Gallon Fuel Tank (C6)	Yes	Yes	diesel range organics	SS, S, GW	**Yes**	RNCL
	Point Carrew - Powerhouse No. 1093 (C7)	Yes	Yes	arsenic, chromium	SS	**Yes**	RNCL
D	Army Dock Area - Former AST No. 1 (D - AST1)	Yes	Yes	diesel range organics	S	**Yes**	RNCL
	Malaspina Investment Garage Building (D - AST1)	No	Yes	benzene	SS		RNCL
	Army Dock Area - Former AST No. 2 (D - AST2)	Yes	Yes	diesel range organics, benzene	SS	**Yes**	Yakutat
	Army Dock Area - Former AST No. 3 (D - AST3)	Yes	Yes	diesel range organics	S, SS	**Yes**	RNCL, Yakutat
				benzene	SS	**Yes**	
	Army Dock Area - Former AST No. 4 (D - AST4)	Yes	Yes	diesel range organics	S, SS	**Yes**	RNCL
	Army Dock Area - Former AST No. 5 (D - AST5)	Yes	Yes	diesel range organics	S, SS	**Yes**	RNCL, Yakutat
	Army Dock Area - Former AST No. 6 (D - AST6)	Yes	Yes	diesel range organics	S, SS	**Yes**	Yakutat
	Army Dock Area - Former AST No. 7 (D - AST7/D2)	Yes	Yes	diesel range organics	S, SS, GW	**Yes**	Yakutat
				2-methylnaphthalene	S	**Yes**	
	Army Dock Area - Former AST No. 8 (D - AST8)	Yes	Yes	diesel range organics	S	**Yes**	Yakutat
	Army Dock Area - Former Diesel Pipeline (D1)	Yes	No	None			Yakutat
	Army Dock Area - Former AvGas Pipeline	Yes	No	None			RNCL, Yakutat
E	Northwest Drum Dump/Quartermaster Loop Area (E1)	Yes	Yes	diesel range organics, arsenic, chromium	SS	**Yes**	AK
				diesel range organics, chromium	S	**Yes**	
	Drainage Ditch (E1)	Yes	Yes	diesel range organics, pentachlorophenol, arsenic, cadmium, chromium, mercury	Sd	**Yes**	AK
	Debris Disposal/Barrel Dump Area - Quartermaster Loop (E2)	Yes	No	None			RNCL
F	Khantaak Island (F1)	Yes	No	None			RNCL
G	Seaplane Base - Former Pipeline Paths (G1)	Yes	No	None			Yakutat
	Seaplane Base - Suspected UST 1 and Debris (G2)	Yes	No	None			Yakutat
	Seaplane Base - Suspected UST 2 and 3 (G3)	Yes	No	None			Yakutat, AK
	Seaplane Base - Seaplane Slough (G4)	Yes	Yes	diesel range organics, chrysene, phenanthrene, pyrene, arsenic, cadmium, chromium, mercury	Sd	**Yes**	Yakutat, AK
				barium	SW	**Yes**	
H	Ocean Cape Radio Relay Station - Suspected Drum Dump (H1)	Yes	No	None			RNCL
	Ocean Cape Radio Relay Station - Culture Camp (H2)	Yes	No	None			RNCL
K	Solid Waste Disposal Dump No. 4 Area (82,150 sq ft) surrounded by wetlands (K1)	Yes	Yes	diesel range organics, pentachlorophenol, arsenic, cadmium, chromium, benzo(a)pyrene	SS	**Yes**	USFS
				arsenic	S	**Yes**	
				arsenic, cadmium, lead	SW	**Yes**	

TABLE 3.0-1 - SUMMARY OF AREAS OF CONCERN (AOC)

Site	Area of Concern	FUDS Eligible	Requiring Further Action	COC	Affected Media	Recommended for Full Analysis	Landowner [a]
L	Air Corps Operations Reserve Tank Farm - North Drum Dump (L1)	Yes	No	None			AK
	Air Corps Operations Reserve Tank Farm - South Drum Dump (L1)	Yes	Yes	gasoline range organics, benzene, toluene	SS, S	**Yes**	AK
				gasoline range organics, benzene	GW	**Yes**	
	Air Corps Operations Reserve Tank Farm - Pipeline System Junctions Tank Truck Fill Stand (L2)	Yes	No	None			AK
	Air Corps Operations Reserve Tank Farm - Pipeline System Junctions Valve Pit A1 (L2)	Yes	No	None			AK
	Air Corps Operations Reserve Tank Farm - Pipeline System Junctions Valve Pit C5 (L2)	Yes	No	None			AK
	Air Corps Operations Reserve Tank Farm - Pipeline System Junctions Lateral C Break (L2)	Yes	No	None			AK
	Air Corps Operations Reserve Tank Farm - Pipeline System Junctions Drain Line Break (L2)	Yes	No	None			AK
	Air Corps Operations Reserve Tank Farm - Pipeline System Junctions Lateral D Break (L2)	Yes	No	None			AK
	Air Corps Operations Reserve Tank Farm - Pipeline System Junctions Separator Tank (L2)	Yes	No	None			AK
	Air Corps Operations Reserve Tank Farm - Tank Foundations Potential Release Tank 1 (L3)	Yes	Yes	benzo(a)pyrene	SS	**Yes**	AK
	Air Corps Operations Reserve Tank Farm - Tank Foundations Potential Release Tank 2 (L3)	Yes	No	None			AK
	Air Corps Operations Reserve Tank Farm - Tank Foundations Potential Release Tank 3 (L3)	Yes	Yes	benzo(a)pyrene	SS	**Yes**	AK
	Air Corps Operations Reserve Tank Farm - Tank Foundations Potential Release Tank 4 (L3)	Yes	No	None			AK
	Air Corps Operations Reserve Tank Farm - Tank Foundations Potential Release Tank 5 (L3)	Yes	No	None			AK
	Air Corps Operations Reserve Tank Farm - Tank Foundations Potential Release Tank 6 (L3)	Yes	No	None			AK
	Air Corps Operations Reserve Tank Farm - Tank Foundations Potential Release Tank 7 (L3)	Yes	Yes	benzo(a)pyrene	SS	**Yes**	AK
	Air Corps Operations Reserve Tank Farm - Tank Foundations Potential Release Tank 8 (L3)	Yes	Yes	benzo(a)pyrene, benzo(a)anthracene	SS	**Yes**	AK
	Air Corps Operations Reserve Tank Farm - Tank Foundations Potential Release Tank 9 (L3)	Yes	No	None			AK
	Air Corps Operations Reserve Tank Farm - Tank Foundations Potential Release Tank 10 (L3)	Yes	No	None			AK
	Air Corps Operations Reserve Tank Farm - Tank Foundations Potential Release Tank 11 (L3)	Yes	Yes	benzo(a)pyrene	SS	**Yes**	AK
	Air Corps Operations Reserve Tank Farm - Tank Foundations Potential Release Tank 12 (L3)	Yes	No	None			AK
	Air Corps Operations Reserve Tank Farm - Tank Foundations Potential Release Tank 13 (L3)	Yes	No	None			AK
	Air Corps Operations Reserve Tank Farm - Tank Foundations Potential Release Tank 14 (L3)	Yes	Yes	benzene	SS	**Yes**	AK
	Air Corps Operations Reserve Tank Farm - Tank Foundations Potential Release Tank 15 (L3)	Yes	No	None			AK
	Air Corps Operations Reserve Tank Farm - Truck Fill Stand No. 4 (L4)	Yes	Yes	diesel range organics, benzo(a)pyrene	SS	**Yes**	AK
	Air Corps Operations Reserve Tank Farm - Tank Farm Pumphouse (L5)	Yes	No	None			AK
M	Post Powerhouse - Suspected Hangar Pipeline System/ Tactical Tank (M1)	Yes	No	None			USFS, AK
	Post Powerhouse - Fuel/Water Separator (M2)	Yes	Yes	chromium	SS	**Yes**	USFS
				diesel range organics	S	**Yes**	
	Post Powerhouse - No known COPCs (M3)	Yes	No	None			USFS
N	AWS Powerhouse/suspected Drum Dump (presently privately owned - 2001) (N1)	Yes	Yes	diesel range organics, pentachlorophenol, cadmium	SS	[b]	Privately owned
O	Air Corps Warehouse Group No. 2 - Suspected Drum Dump (O1)	Yes	Yes	arsenic	SS	**Yes**	AK
				lead	SW	**Yes**	
Kardy, Summit, and Aka Lakes, and Ankau Slough	Suspected Drum and Other Debris Dump	No	No	Chevron drum; Not a FUDS site	SW		AK, USFS, RNCL
AACS Transmitter Station Powerhouse	Powerhouse	Yes	?	Additional Investigation May be Warranted			USFS
Rifle Range	Rifle Range - Target Pits	Yes	Yes	lead	SS	**Yes**	AK
Former Coast Artillery Outpost	Small Power Source	Yes	?	Additional Investigation May be Warranted			USFS

KEY	DESCRIPTION
ARAR	Applicable or Relevant and Appropriate Requirements
COC	Chemical of Concern (Measured at concentrations greater than ARAR)
(shaded)	Recommended for Full Analysis in Feasibility Study
S	Sub-Surface Soil
SS	Surface Soil
GW	Groundwater
SW	Surface Water

KEY	DESCRIPTION
Sd	Sediment
FUDS	Formerly Used Defense Site
AK	State of Alaska
Yakutat	City of Yakutat
USFS	US Forest Service
RNCL	Regional Native Corporation Lands

NOTES

(a) Designated landowner based on Figure 1-2 Major Land Ownership in ENSR 2000 RI/FS Report

(b) USACE will investigate AOC N1 further if landowner agrees to allow access

TABLE 3.1-1 - COPCs AND ARARs FOR FORMER YAKUTAT AFB AOCs

COPC	Surface Soil (a) (mg/kg)		Subsurface Soil (a) (mg/kg)		Sediment (e) (mg/kg)		Surface Water (f) (mg/L)		Groundwater (g) (mg/L)	TCLP Criteria (h) (mg/L)
DRO	**230**	(1)	**230**	(1)	**230**	(1)	1.5	(6)	**1.5**	NA
GRO	**260**	(1)	**260**	(1)	260	(1)	2.2	(6)	**2.2**	NA
RRO	8,300	(1)	8,300	(1)	8,300	(1)	1.1	(6)	1.1	NA
TAqH	NA		NA		NA		0.015	(4)	NA	NA
TAH	NA		NA		NA		0.01	(4)	NA	NA
Benzene	**0.025**	(1)	**0.025**	(1)	0.025	(1)	0.005	(5)	**0.005**	0.5
Toluene	**6.5**	(1)	**6.5**	(1)	0.01	(3)	0.002	(3)	1.0	NA
Benzo(a)anthracene	**3.6**	(1)	3.6	(1)	0.01572	(3)	0.000027	(3)	0.0012	NA
Benzo(a)pyrene	**0.4**	(1)	2.1	(1)	0.0319	(3)	0.000014	(3)	0.0002	NA
Bis(2-ethylhexyl)phthalate	13	(1)	13	(1)	13	(1)	**0.0003**	(3)	0.006	NA
Chrysene	360	(1)	360	(1)	**0.02683**	(3)	0.12	(6)	0.12	NA
2-methylnaphthalene	6.1	(1)	**6.1**	(1)	6.1	(1)	**0.330**	(3)	0.15	NA
Pentachlorophenol	0.047	(1)	0.047	(1)	**0.01**	(3)	0.001	(5)	0.001	100.0
Phenanthrene	3,000	(1)	3,000	(1)	**0.01873**	(3)	0.0036	(3)	11	NA
Pyrene	1,000	(1)	1,000	(1)	**0.04427**	(3)	0.000025	(3)	1.1	NA
DDD	7.2	(1)	7.2	(1)	0.00354	(3)	0.000011	(3)	0.0035	NA
DDT	7.3	(1)	7.3	(1)	0.00119	(3)	0.0000005	(3)	0.0025	NA
PCBs	1	(1)	1	(1)	0.03162	(3)	**0.000014**	(3)	0.0005	NA
Arsenic (b)	**11.6**	(2)	**11.6**	(2)	**11.6**	(2)	0.010	(5)	0.010	5.0
Barium	1,100	(1)	1,100	(1)	1,100	(1)	**0.0039**	(3)	2.0	100.0
Cadmium	**5.0**	(1)	5.0	(1)	**0.583**	(3)	**0.00025**	(3)	0.005	1.0
Chromium (b)	**37**	(2)	**37**	(2)	**37**	(2)	0.1	(3)	0.10	5.0
Lead	**400**	(1)	400	(1)	31	(3)	**0.0025**	(3)	0.015	**5.0**
Lead at Rifle Range (c)	**800**	(1)	800	(1)	31	(3)	**0.0025**	(3)	0.015	**5.0**
Mercury	1.4	(1)	1.4	(1)	**0.174**	(3)	0.00077	(3)	0.002	0.2
Selenium	3.4	(1)	3.4	(1)	3.4	(1)	0.005	(3)	0.05	1.0
Silver	**11.2**	(1)	11.2	(1)	0.5	(3)	0.00036	(3)	0.10	5.0
Dioxins (d)	0.000038	(1)	0.000038	(1)	0.000038	(1)	0.00000001	(3)	0.00000003	NA

KEY	DESCRIPTION
230	ARAR concentrations in bold are exceeded for specified COPC at the project site.
(a)	The surface and subsurface soil cleanup levels are the most stringent ADEC Method 2 standards for the "Over 40 Inches" precipitation zone, as listed in Tables B1 and B2, 18 AAC 75.341 (October 2008), except for arsenic, chromium, lead and dioxins (see key notes).
(b)	The surface and subsurface soil and sediment cleanup levels for arsenic and chromium are established background concentrations.
(c)	ADEC Method 2 standard for lead in soil is 800 mg/kg for a commercial/industrial site (Rifle Range specific).
(d)	ADEC has accepted a dioxin screening level of 38 ppt TEQ for soil and sediment and EPA drinking water MCL of 0.03 ppt TEQ as a groundwater screening level criterion.
(e)	The sediment cleanup levels are the NOAA screening quick reference tables (SQuiRT) values (November 2008) or ADEC Method 2 standards listed in Tables B1 and B2, 18 AAC 75.341 if a SQuiRT value for a COPC is not given (except for arsenic and chromium which are based on established background concentrations).
(f)	The surface water cleanup levels are the most stringent criteria between the SQuiRT values, the AWQS as listed in 18 AAC 70.020(b) (September 2009) and EPA drinking water MCLs listed in EPA 816-F-09-0004 (May 2009). If a surface water cleanup level for a COPC is not given, the ADEC 18 AAC 75.345 Table C Cleanup Levels are used.
(g)	The groundwater cleanup levels are the ADEC standards listed in Table C, 18 AAC 75.345.
(h)	TCLP standards are the concentrations listed in Table 1, 40 CFR 261.24.
(1)	ADEC Method 2 cleanup level
(2)	Established background concentration
(3)	NOAA SQuiRT most stringent value
(4)	Alaska Water Quality Standard as listed in 18 AAC 70.020(b) or referenced guidance
(5)	EPA drinking water MCL as listed in EPA 816-F-09-0004
(6)	ADEC standards listed in Table C, 18 AAC 75.345

KEY	DESCRIPTION
ADEC	Alaska Department of Environmental Conservation
AOC	Area of Concern
ARARs	Applicable or Relevant and Appropriate Requirements
AWQS	Alaska Water Quality Standards
COPC	Chemical of Potential Concern
DRO	Diesel range organics
DDD	Dichlorodiphenyldichloroethane
DDT	Dichlorodiphenyltrichloroethane
PCBs	Polychlorinated Biphenyls
EPA	Environmental Protection Agency
GRO	Gasoline range organics
MCL	Maximum Contaminant Levels
mg/kg	Milligrams per kilogram
mg/L	Milligrams per liter
NA	Not Applicable
NOAA	National Oceanic and Atmospheric Administration
ppt	Parts per trillion
TEQ	Toxic Equivalency Quotient
TAH	Total Aromatic Hydrocarbons
TAqH	Total Aqueous Hydrocarbons
TCLP	Toxicity Characteristic Leaching Procedure

TABLE 3.1-2 - ROUGH ORDER OF MAGNITUDE VOLUMES OF CONTAMINATED SOIL

Area of Concern	Affected Media	Chemical of Concern	Areal Extent of Impacted Soil (Square Feet)	Depth to Top of Contaminated Soil Interval (Feet bgs)	Depth to Bottom of Contaminated Soil Interval (Feet bgs)	Volume of Impacted Soil (Cubic Yards)	Overburden Soil Volume (Cubic Yards)	Total Volume (Cubic Yards)
C1	surface soil*	chromium	78	0	2	7	0	7
C2	surface soil, subsurface soil (<15 ft)	diesel range organics	10,845	1	4	1,386	462	1,848
C2	sediment	diesel range organics	470	0	4	80	0	80
C2	surface soil*	silver	78	0	2	7	0	7
C2	sediment**	diesel range organics, cadmium, mercury	314	0	2	27	0	27
C4	surface soil, subsurface soil (<15 ft)	diesel range organics	1,426	0	4	243	0	243
C4	sediment**	diesel range organics	314	0	2	27	0	27
C4	surface soil* (two hotspots)	chromium	156	0	2	13	0	13
C6	surface soil, subsurface soil (<15 ft)	diesel range organics	19,893	0	15	12,709	0	12,709
C7	surface soil*	arsenic, chromium	78	0	2	7	0	7
D - AST1	subsurface soil (<15 ft)	diesel range organics	15,100	4	15	7,075	2,573	9,647
	subsurface soil (>15 ft)	diesel range organics		15	47	20,581	0	20,581
D - AST1 (downslope)	subsurface soil (<15 ft)	diesel range organics	11,100	7	15	3,782	3,309	7,092
	subsurface soil (>15 ft)	diesel range organics		15	16	473	0	473
D - AST2	surface soil	diesel range organics, benzene	314	0	2	27	0	27
D - AST3	surface soil, subsurface soil (<15 ft)	diesel range organics, benzene	3,188	0	12	1,629	0	1,629
D - AST4 (north)	subsurface soil (<15 ft), surface soil**	diesel range organics	3,775	0	12	1,929	0	1,929
D - AST4 (south)	subsurface soil (<15 ft)**	diesel range organics	314	2	4	27	27	53
D - AST5	surface soil, subsurface soil (<15 ft)	diesel range organics	4,369	0	15	2,791	0	2,791
	subsurface soil (>15 ft)	diesel range organics		15	24	1,675	0	1,675
D - AST6	surface soil, subsurface soil (<15 ft)	diesel range organics	3,388	0	15	2,165	0	2,165
	subsurface soil (>15 ft)	diesel range organics		15	16.5	216	0	216
D - AST7 (D2)	surface soil, subsurface soil (<15 ft)	diesel range organics	7,867	0	15	5,026	0	5,026
	subsurface soil (>15 ft)	diesel range organics, 2-methylnaphthalene		15	53	12,733	0	12,733
D - AST8	subsurface soil (<15 ft)	diesel range organics	5,381	4	15	2,521	917	3,438
	subsurface soil (>15 ft)	diesel range organics		15	27	2,750	0	2,750
E1 - Drum Dump	surface soil, subsurface soil (<15 ft)	diesel range organics, chromium, arsenic	903	0	4	154	0	154
E1 - Drum Dump	surface soil* (two hotspots)	arsenic, chromium	156	0	2	13	0	13
E1 - Drainage Ditch	sediment	diesel range organics, pentachlorophenol, arsenic, cadmium, chromium, and mercury	1,347	0	3	172	0	172
G4	sediment	diesel range organics, chrysene, phenanthrene, pyrene, arsenic, cadmium, chromium, and mercury	625	0	3	80	0	80
K1	surface soil	diesel range organics, pentachlorophenal, arsenic, cadmium, chromium, benzo(a)pyrene	82,150	0	2	6,998	0	6,998
K1	subsurface soil (<15 ft at two locations)	arsenic	156	2	4	13	13	27
L1 - South Dump	surface soil, subsurface soil (<15 ft)**	gasoline range organics, benzene, toluene	314	0	12.5	167	0	167
L3 - Tank 1	surface soil**	benzo(a)pyrene	314	0	2	27	0	27
L3 - Tank 3	surface soil**	benzo(a)pyrene	314	0	2	27	0	27
L3 - Tank 7	surface soil**	benzo(a)pyrene	314	0	2	27	0	27
L3 - Tank 8	surface soil	benzo(a)pyrene, benzo(a)anthracene	525	0	2	45	0	45
L3 - Tank 11	surface soil**	benzo(a)pyrene	314	0	2	27	0	27
L3 - Tank 14	surface soil**	benzene	314	0	2	27	0	27
L4	surface soil	diesel range organics, benzo(a)pyrene	570	0	2	49	0	49
M2	surface soil*	chromium	78	0	2	7	0	7
M2 (Tank)	subsurface soil (<15 ft)	diesel range organics	16,921	4	6	1,441	2,883	4,324
M2 (Quonset Hut)	subsurface soil (<15 ft)	diesel range organics	1,514	3.5	5	97	226	322
O1	surface soil* (two hotspots)	arsenic	156	0	2	13	0	13
Rifle Range	surface soil	lead	5,404	0	2	460	0	460
Total						**89,748**	**10,409**	**100,157**

NOTES:

1. Areal extent of impacted soil determined using polygonal area shown on Site Plans, provided in Section 3 except for AOC K1. Areal extent of impacted surface soil in AOC K1 assumed to cover entire landfill.

2. Volumes shown include a 15% bulking factor following excavation.

3. The estimates shown on this table should not be interpreted as exact areas or volumes. Table is linked to Table 6.0-2 and numbers are not rounded for ease of use.

KEY	DESCRIPTION
AST	Aboveground storage tank
*	Treated as "hotspot" with assumed diameter of 10 feet
**	Treated as "hotspot" with assumed diameter of 20 feet
bgs	Below ground surface

TABLE 3.1-3 - ROUGH ORDER OF MAGNITUDE AREAL EXTENT OF CONTAMINATED WATER

SURFACE WATER

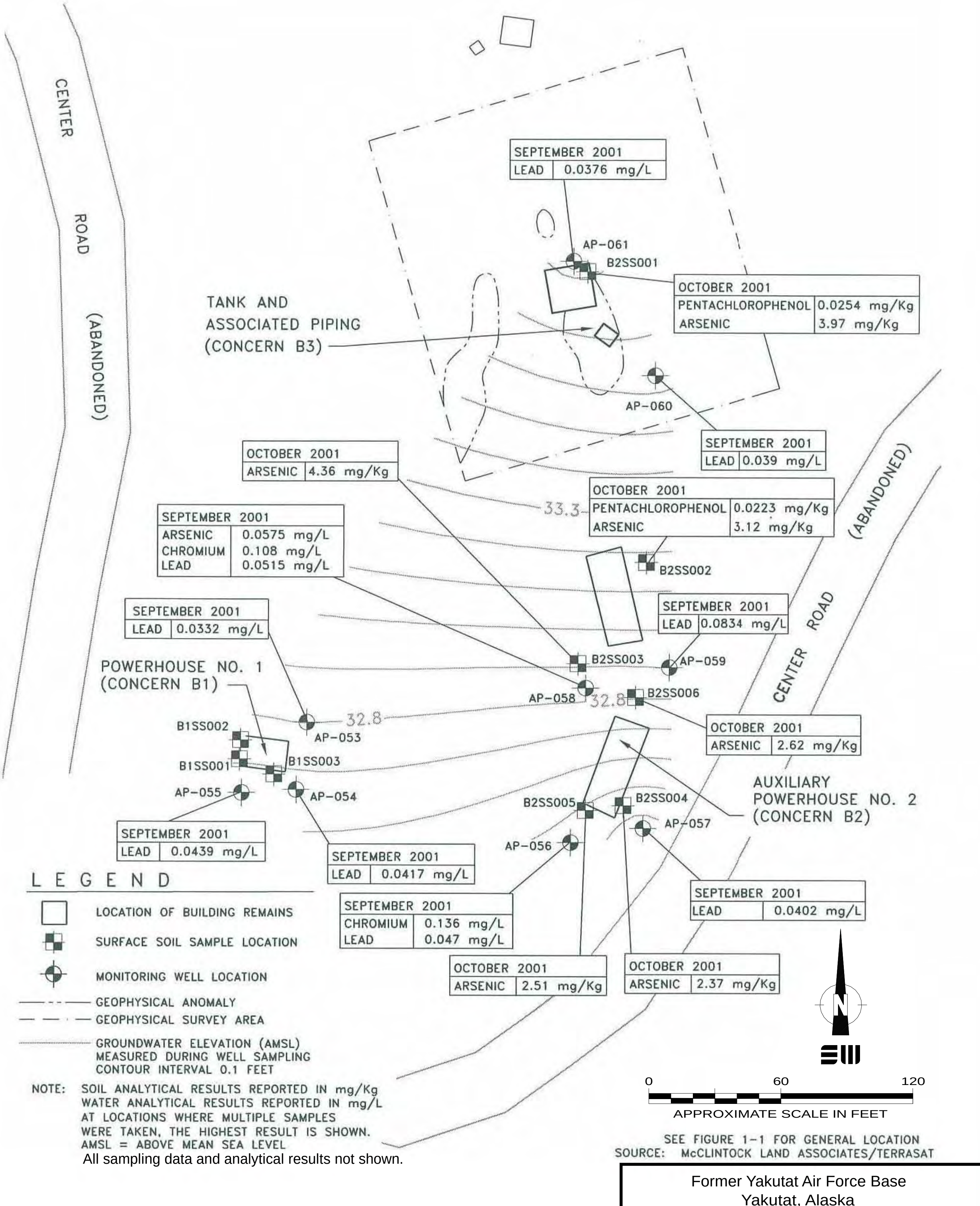
Area of Concern	Affected Media	Chemical of Concern	Areal Extent of Impacted Water (Square Feet)
C1	Surface Water	dioxins	Uncertain
C2	Surface Water	polychlorinated biphenyls, bis(2-ethylhexyl)phthalate, lead	Uncertain
G4	Surface Water	barium	Uncertain
K1	Surface Water	arsenic, cadmium, lead	Uncertain
O1	Surface Water (two locations)	lead	Uncertain

GROUNDWATER

Area of Concern	Affected Media	Chemical of Concern	Areal Extent of Impacted Soil (Square Feet)	Areal Extent of Impacted Water (Square Feet)	Depth to Water (Feet bgs)	Depth to Bottom of Deepest Boring (Feet bgs)	Saturated Zone Thickness Minimum (Feet)
C6	Groundwater	diesel range organics	19,893	40,000	14	25	11
D - AST7 (D2)	Groundwater	diesel range organics	7,867	16,000	53	65	13
L1 - South Dump*	Groundwater	gasoline range organics, benzene	314	630	10	13	4

KEY	DESCRIPTION
AST	Above Ground Storage Tank
bgs	Below ground surface
*	Treated as "hotspot" with assumed diameter of 20 feet

NOTES:
1. Areal extent of impacted surface water is uncertain and cannot be estimated with available data.
2. Areal extent of impacted groundwater assumed to be double the areal extent of impacted soil determined using polygonal area shown on Site Plans, provided in Section 3.
3. The estimates shown on this table should not be interpreted as exact areas or volumes. Table is linked to Table 6.0-3 and the numbers are not rounded for ease of use.



LEGEND

- LOCATION OF BUILDING REMAINS
- SURFACE SOIL SAMPLE LOCATION
- MONITORING WELL LOCATION
- GEOPHYSICAL ANOMALY
- GEOPHYSICAL SURVEY AREA
- GROUNDWATER ELEVATION (AMSL) MEASURED DURING WELL SAMPLING CONTOUR INTERVAL 0.1 FEET

NOTE: SOIL ANALYTICAL RESULTS REPORTED IN mg/Kg
WATER ANALYTICAL RESULTS REPORTED IN mg/L
AT LOCATIONS WHERE MULTIPLE SAMPLES WERE TAKEN, THE HIGHEST RESULT IS SHOWN.
AMSL = ABOVE MEAN SEA LEVEL

All sampling data and analytical results not shown.

SEE FIGURE 1-1 FOR GENERAL LOCATION
SOURCE: McCLINTOCK LAND ASSOCIATES/TERRASAT

Base map prepared for USACE by ENSR and presented in "2001 Remedial Investigation Report-Final-RI/FS, Yakutat Area, AK". Modified by Shannon & Wilson for 2010 Feasibility Study.

Former Yakutat Air Force Base
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AOC B1, B2, AND B3 SITE PLAN

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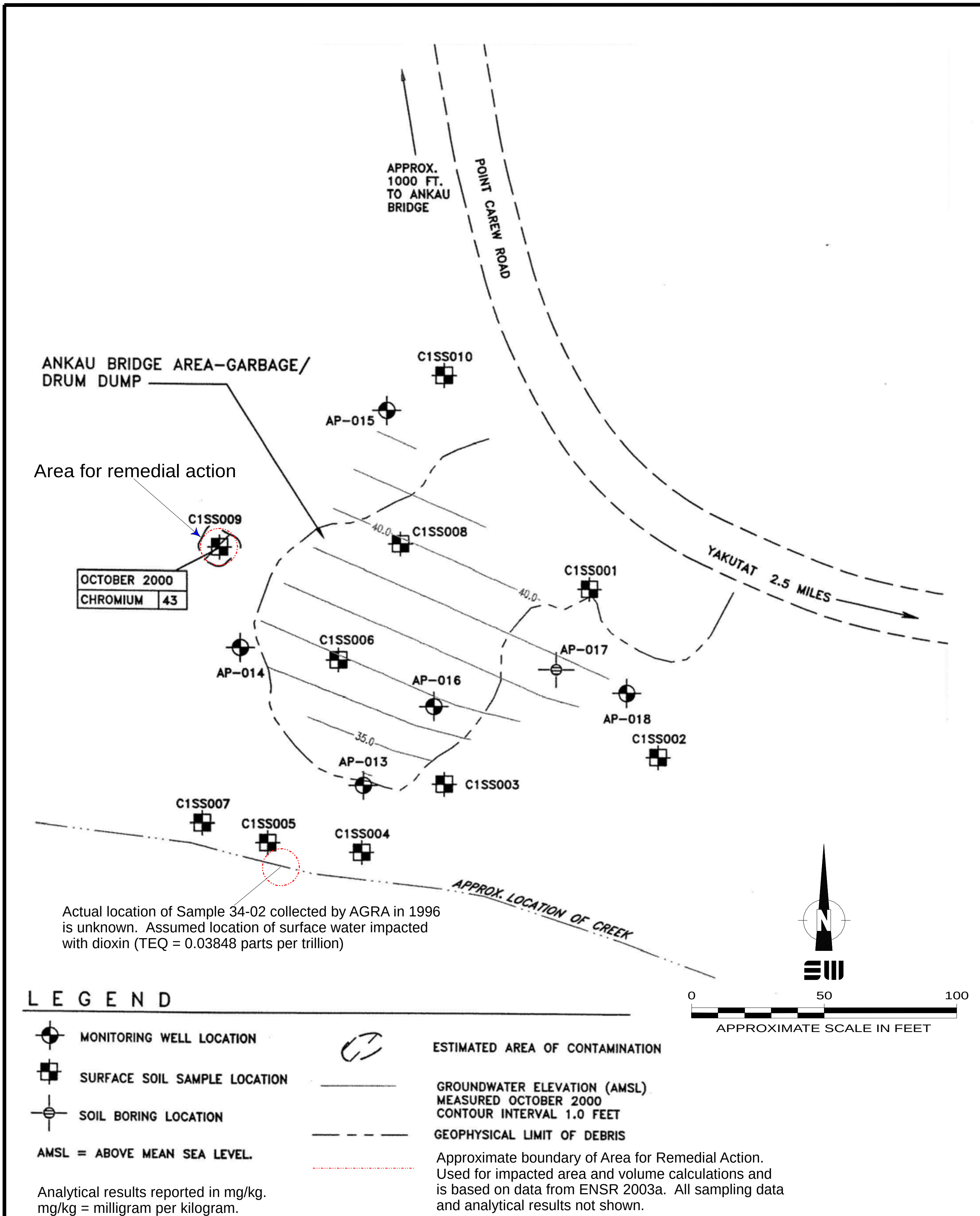
Fig. 3.3-1



Base map prepared for USACE by ENSR and presented in "2001 Remedial Investigation Report-Final-RI/FS, Yakutat Area, AK". Modified by Shannon & Wilson for 2010 Feasibility Study.

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AOC C1 SITE PLAN

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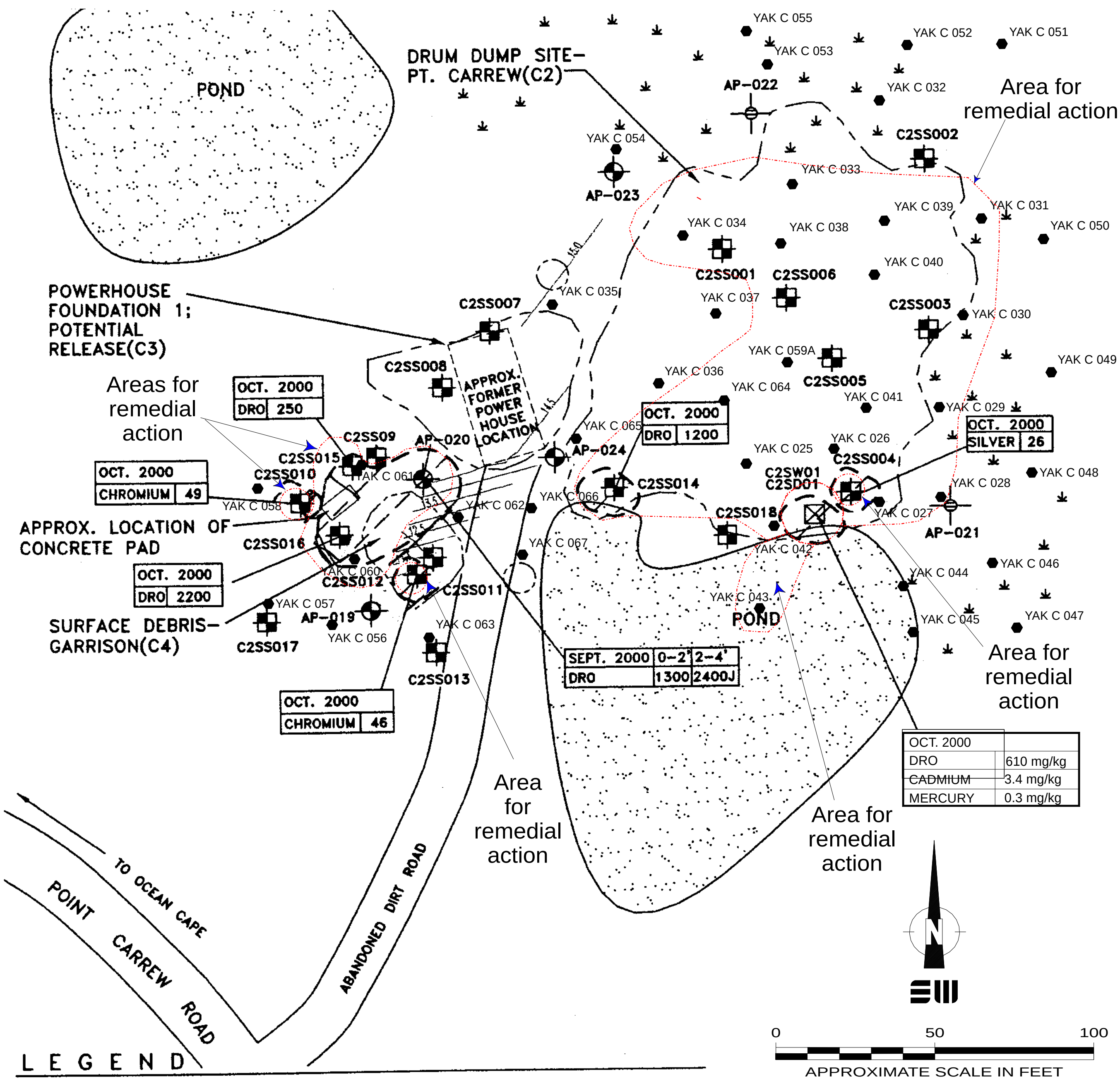
Fig. 3.4-1



LEGEND

- SEDIMENT AND WATER SAMPLE LOCATION
- SURFACE SOIL SAMPLE LOCATION
- SOIL BORING LOCATION
- MONITORING WELL LOCATION
- WETLAND AREA
- ESTIMATED AREA OF CONTAMINATION
- GEOPHYSICAL LIMIT OF DEBRIS
- DRO — DIESEL RANGE ORGANICS
- GROUNDWATER ELEVATION (AMSL) MEASURED OCTOBER 2000 CONTOUR INTERVAL 0.5 FEET

AMSL = ABOVE MEAN SEA LEVEL.

SEE FIGURE 1–1 FOR GENERAL LOCATION.
SOURCE: McCLINTOCK LAND ASSOCIATES/TERRASAT

AT LOCATIONS WHERE MULTIPLE SAMPLES WERE TAKEN, THE HIGHEST RESULT IS SHOWN.
ANALYTICAL RESULTS REPORTED IN mg/Kg.
mg/Kg = MILLIGRAMS PER KILOGRAM.

- **Approximate ROST probe location by USACE, July 2005 (USACE 2006)**

Approximate boundary of Area for Remedial Action. Used for impacted area and volume calculations and is based on data from ENSR 2003a and USACE 2006. All sampling data and analytical results not shown.

Base map prepared for USACE by ENSR and presented in "Final Feasibility Study, Yakutat Area RI/FS, January 2005". Modified by Shannon & Wilson for 2010 Feasibility Study.

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AOC C2, C3, AND C4 SITE PLAN

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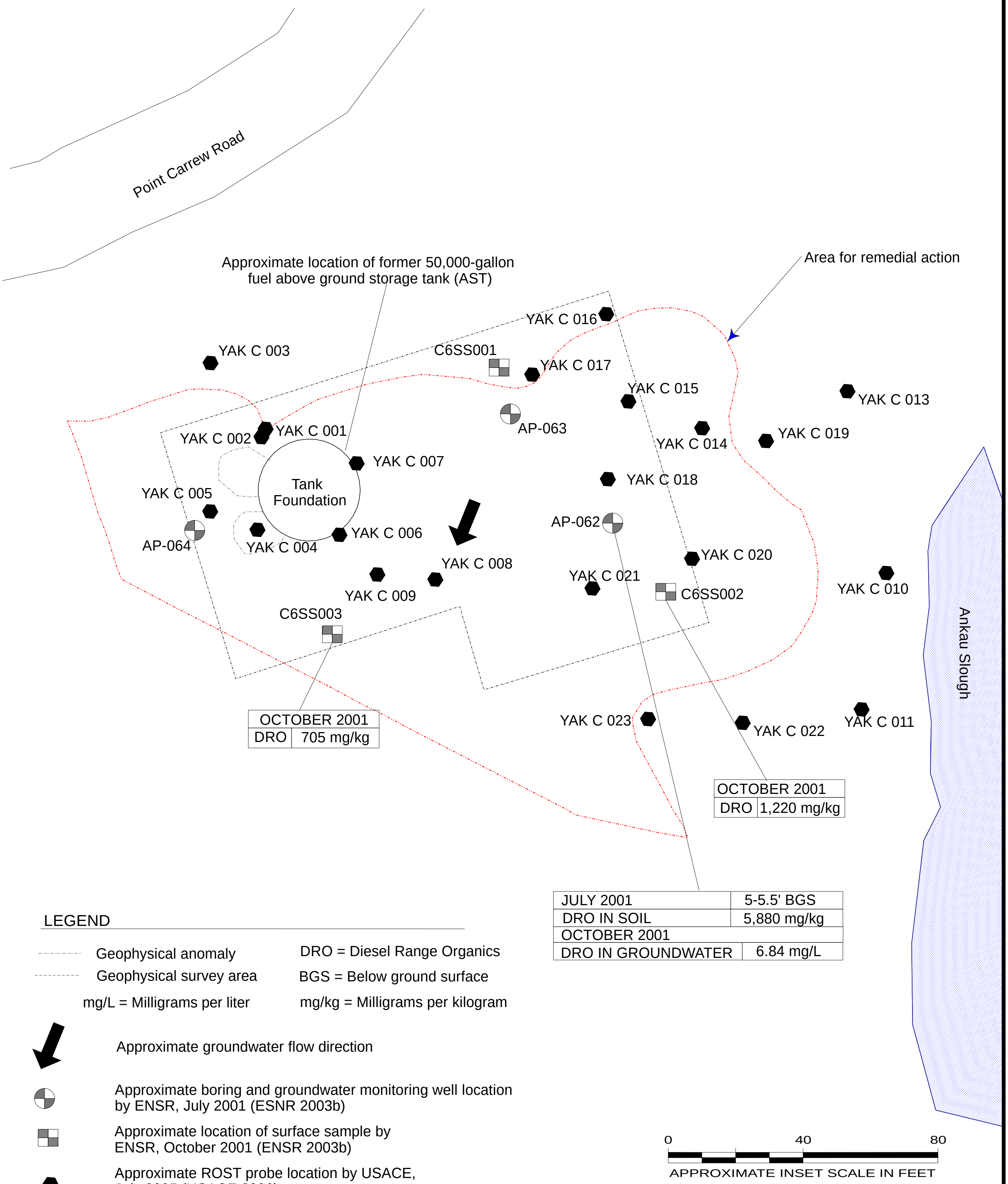
Fig. 3.4-2



LEGEND

Geophysical anomaly
Geophysical survey area
mg/L = Milligrams per liter
DRO = Diesel Range Organics
BGS = Below ground surface
mg/kg = Milligrams per kilogram

Approximate groundwater flow direction

Approximate boring and groundwater monitoring well location by ENSR, July 2001 (ESNR 2003b)

Approximate location of surface sample by ENSR, October 2001 (ENSR 2003b)

Approximate ROST probe location by USACE, July 2005 (USACE 2006)

Approximate boundary of Area for Remedial Action. Used for impacted area and volume calculations and is based on data from ENSR 2003b and USACE 2006. All sampling data and analytical results not shown.

Base map prepared by USACE and presented in "FINAL ROST/ LIF Focused Remedial Investigation, Former Yakutat Air Force Base, Yakutat, AK". Modified by Shannon & Wilson for 2010 Feasibility Study.

Former Yakutat Air Force Base
Yakutat, Alaska

AOC C6 SITE PLAN

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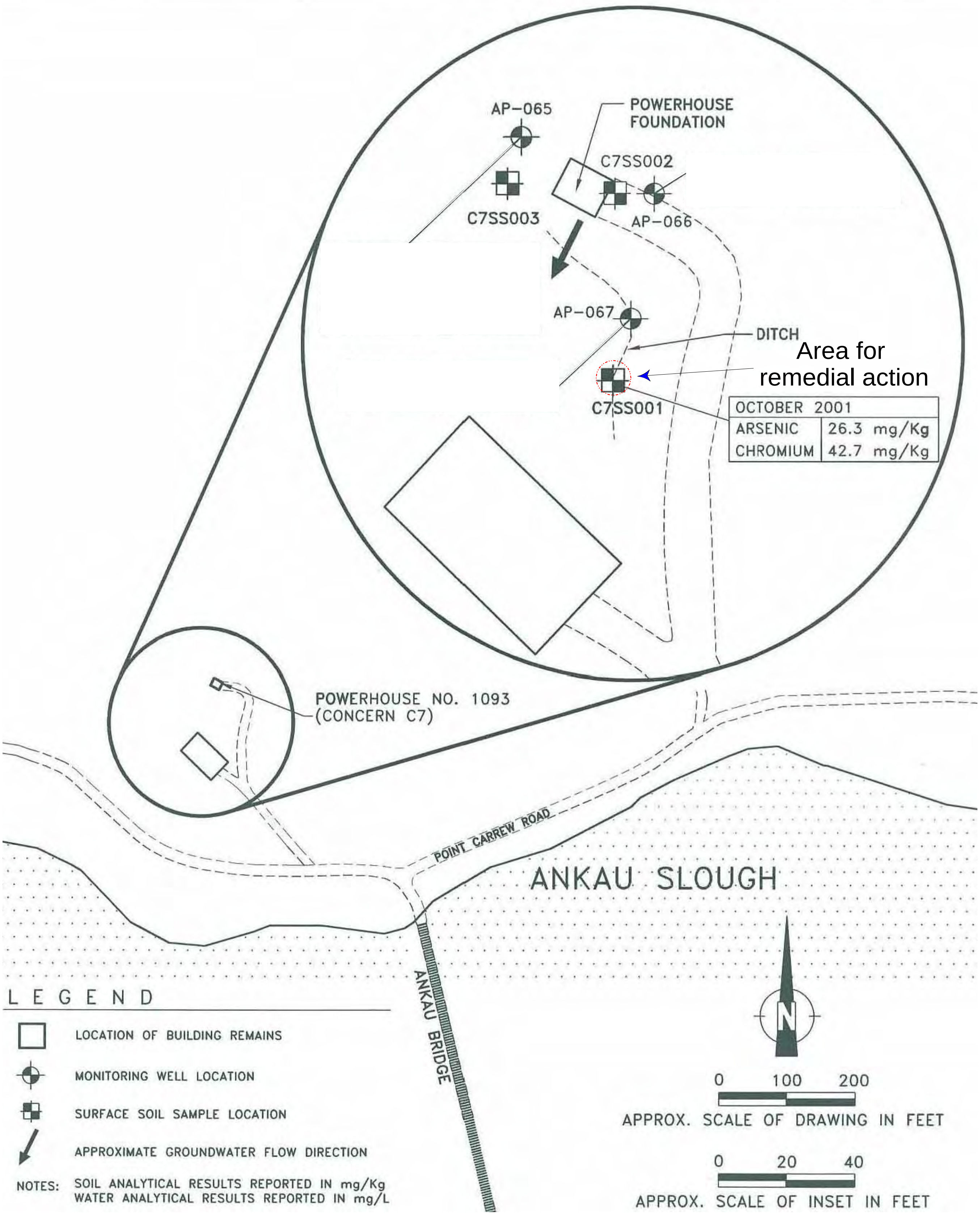
Fig. 3.4-3



Approximate boundary of Area for Remedial Action. Used for impacted area and volume calculations and is based on data from ENSR 2003b. All sampling data and analytical results not shown.

Base map prepared for USACE by ENSR and presented in "2001 Remedial Investigation Report-Final-RI/FS, Yakutat Area, AK". Modified by Shannon & Wilson for 2010 Feasibility Study.

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AOC C7 SITE PLAN

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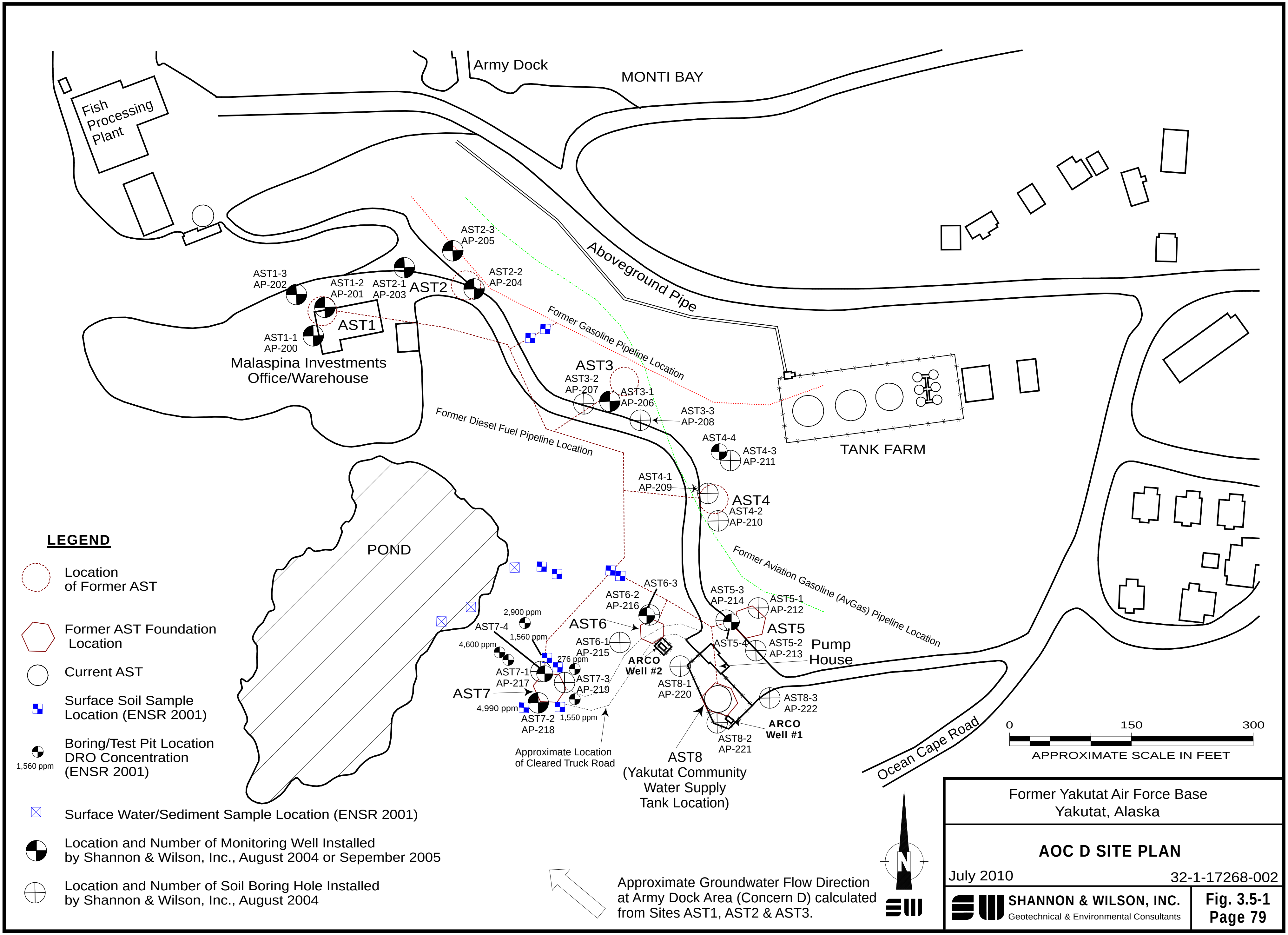
Fig. 3.4-4



Army Dock
MONTI BAY
Fish Processing Plant
Aboveground Pipe
Malaspina Investments Office/Warehouse
AST1
AST1-1 AP-200
AST1-2 AP-201
AST1-3 AP-202
AST2
AST2-1 AP-203
AST2-2 AP-204
AST2-3 AP-205
Former Gasoline Pipeline Location
AST3
AST3-1 AP-206
AST3-2 AP-207
AST3-3 AP-208
TANK FARM
Former Diesel Fuel Pipeline Location
AST4
AST4-1 AP-209
AST4-2 AP-210
AST4-3 AP-211
AST4-4
Former Aviation Gasoline (AvGas) Pipeline Location
POND
AST5
AST5-1 AP-212
AST5-2 AP-213
AST5-3 AP-214
AST5-4
Pump House
AST6
AST6-1 AP-215
AST6-2 AP-216
AST6-3
ARCO Well #2
ARCO Well #1
AST7
AST7-1 AP-217
AST7-2 AP-218
AST7-3 AP-219
AST7-4
2,900 ppm
1,560 ppm
4,600 ppm
276 ppm
4,990 ppm
1,550 ppm
AST8-1 AP-220
AST8-2 AP-221
AST8-3 AP-222
Approximate Location of Cleared Truck Road
AST8 (Yakutat Community Water Supply Tank Location)
Ocean Cape Road
0 150 300
APPROXIMATE SCALE IN FEET
LEGEND
Location of Former AST
Former AST Foundation Location
Current AST
Surface Soil Sample Location (ENSR 2001)
Boring/Test Pit Location DRO Concentration (ENSR 2001)
1,560 ppm
Surface Water/Sediment Sample Location (ENSR 2001)
Location and Number of Monitoring Well Installed by Shannon & Wilson, Inc., August 2004 or Sepember 2005
Location and Number of Soil Boring Hole Installed by Shannon & Wilson, Inc., August 2004
Approximate Groundwater Flow Direction at Army Dock Area (Concern D) calculated from Sites AST1, AST2 & AST3.
N
Former Yakutat Air Force Base
Yakutat, Alaska
AOC D SITE PLAN
July 2010
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Fig. 3.5-1
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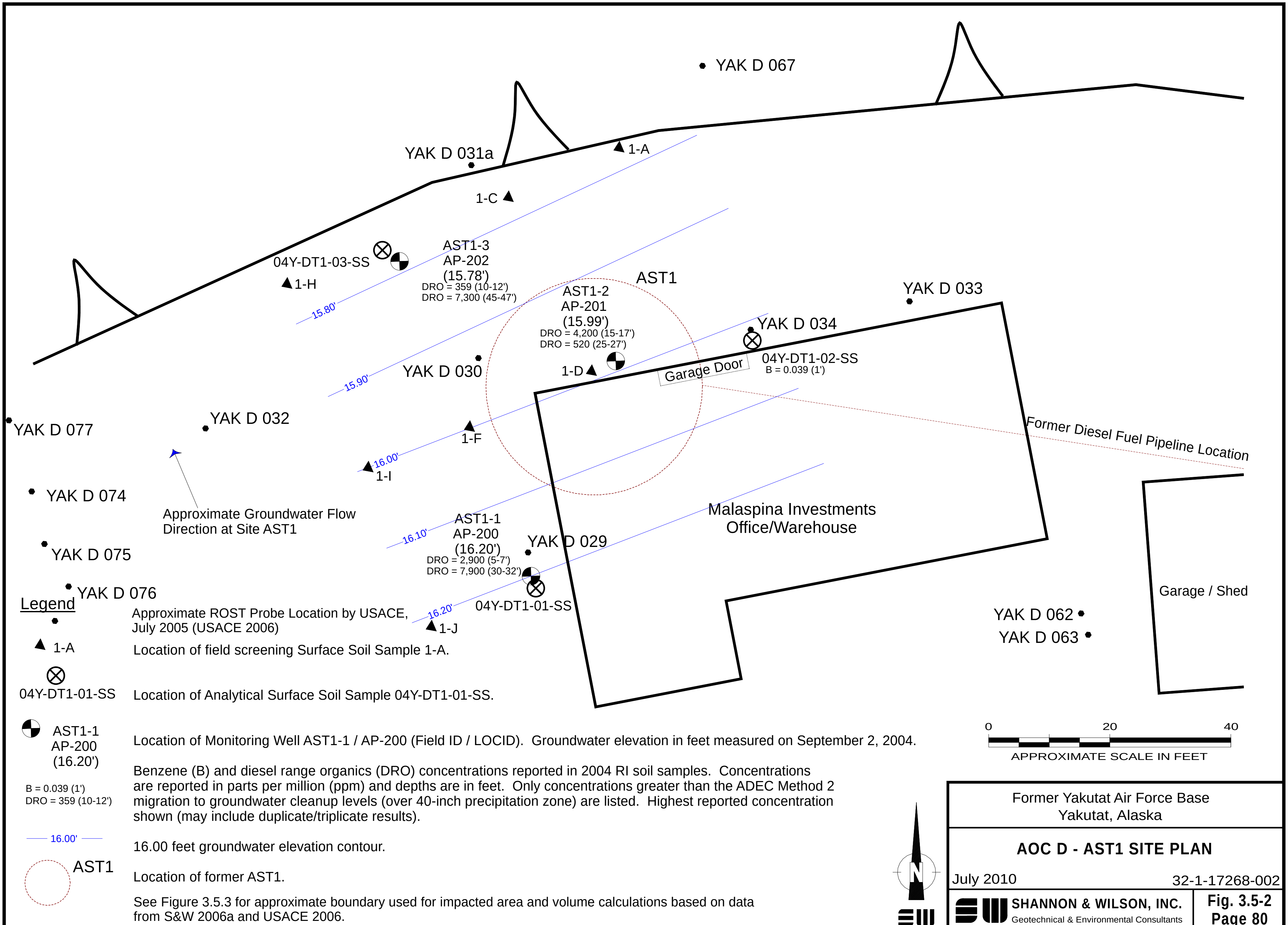
YAK D 067
YAK D 031a
1-A
1-C
04Y-DT1-03-SS
AST1-3
AP-202
(15.78')
DRO = 359 (10-12')
DRO = 7,300 (45-47')
1-H
15.80'
AST1
AST1-2
AP-201
(15.99')
DRO = 4,200 (15-17')
DRO = 520 (25-27')
YAK D 033
YAK D 034
04Y-DT1-02-SS
B = 0.039 (1')
Garage Door
1-D
15.90'
YAK D 030
YAK D 077
YAK D 032
1-F
16.00'
1-I
Former Diesel Fuel Pipeline Location
YAK D 074
Approximate Groundwater Flow
Direction at Site AST1
Malaspina Investments
Office/Warehouse
AST1-1
AP-200
(16.20')
DRO = 2,900 (5-7')
DRO = 7,900 (30-32')
16.10'
YAK D 029
YAK D 075
YAK D 076
16.20'
04Y-DT1-01-SS
1-J
Garage / Shed
YAK D 062
YAK D 063
Legend
Approximate ROST Probe Location by USACE,
July 2005 (USACE 2006)
1-A
Location of field screening Surface Soil Sample 1-A.
04Y-DT1-01-SS
Location of Analytical Surface Soil Sample 04Y-DT1-01-SS.
AST1-1
AP-200
(16.20')
Location of Monitoring Well AST1-1 / AP-200 (Field ID / LOCID). Groundwater elevation in feet measured on September 2, 2004.
B = 0.039 (1')
DRO = 359 (10-12')
Benzene (B) and diesel range organics (DRO) concentrations reported in 2004 RI soil samples. Concentrations are reported in parts per million (ppm) and depths are in feet. Only concentrations greater than the ADEC Method 2 migration to groundwater cleanup levels (over 40-inch precipitation zone) are listed. Highest reported concentration shown (may include duplicate/triplicate results).
16.00'
16.00 feet groundwater elevation contour.
AST1
Location of former AST1.
See Figure 3.5.3 for approximate boundary used for impacted area and volume calculations based on data from S&W 2006a and USACE 2006.
0
20
40
APPROXIMATE SCALE IN FEET
N
Former Yakutat Air Force Base
Yakutat, Alaska
AOC D - AST1 SITE PLAN
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Fig. 3.5-2
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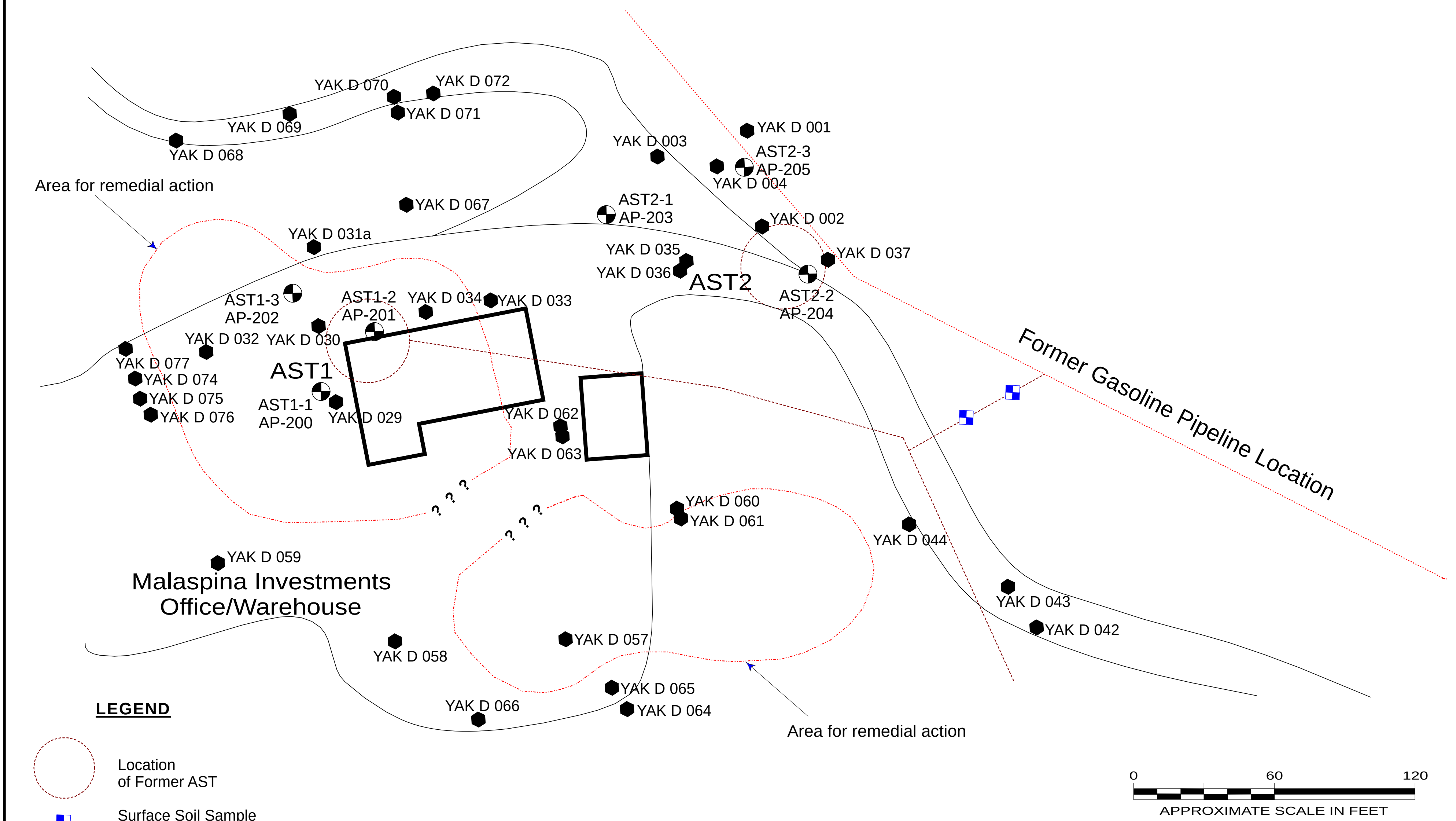

LEGEND

Location of Former AST

Surface Soil Sample Location (ENSR 2001)

Location and Number of Monitoring Well Installed by Shannon & Wilson, Inc., August 2004

Approximate boundary of Area for Remedial Action. Used for impacted area and volume calculations and is based on data from S&W 2006a and USACE 2006. All sampling data and analytical results not shown.

Approximate ROST Probe Location by USACE, July 2005 (USACE 2006)

Former Yakutat Air Force Base
Yakutat, Alaska

AOC D - AST1
IMPACTED AREA BOUNDARY

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Fig. 3.5-3
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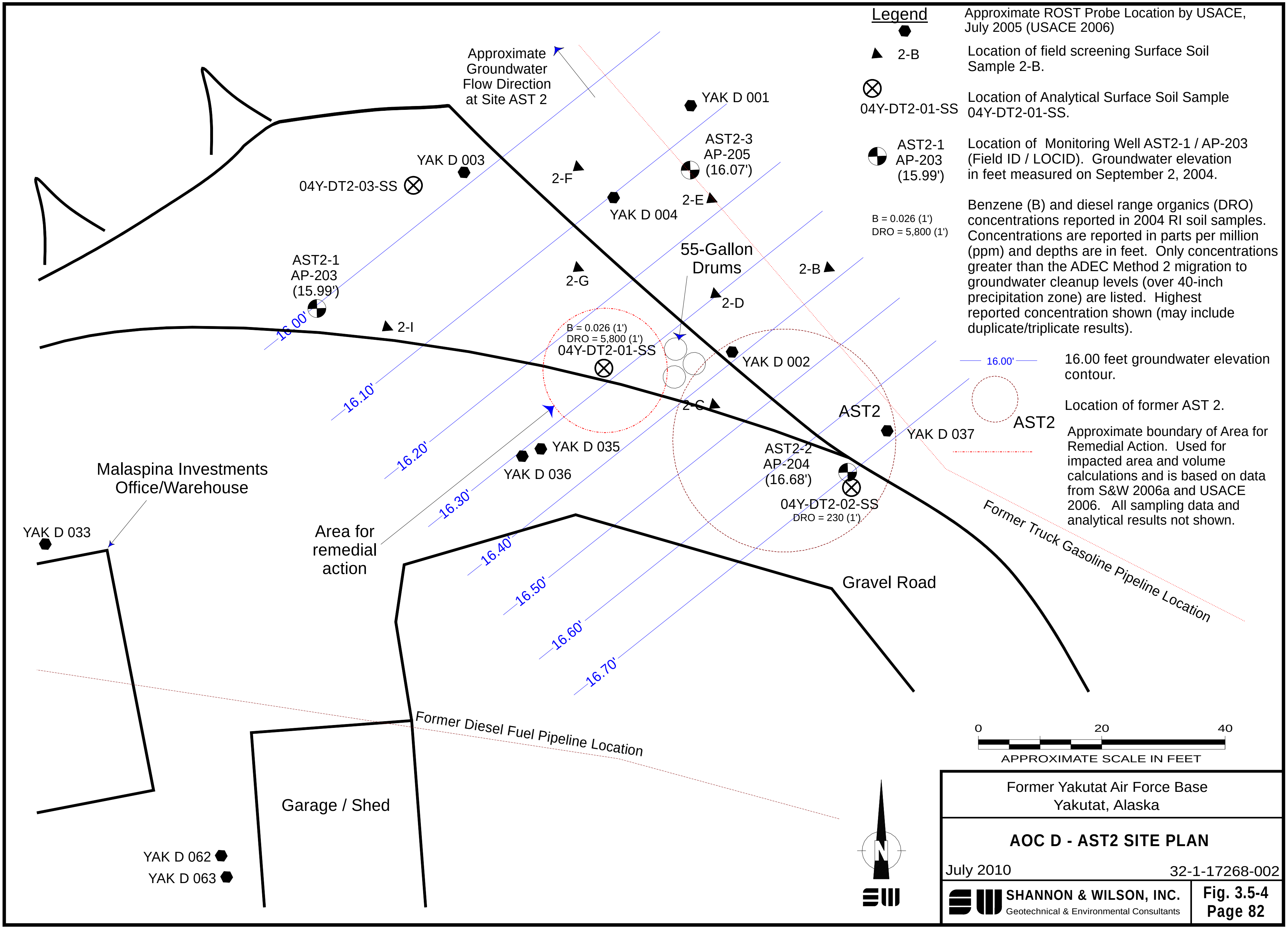

Legend
Approximate ROST Probe Location by USACE, July 2005 (USACE 2006)
2-B
Location of field screening Surface Soil Sample 2-B.
04Y-DT2-01-SS
Location of Analytical Surface Soil Sample 04Y-DT2-01-SS.
AST2-1
AP-203
(15.99')
Location of Monitoring Well AST2-1 / AP-203 (Field ID / LOCID). Groundwater elevation in feet measured on September 2, 2004.
B = 0.026 (1')
DRO = 5,800 (1')
Benzene (B) and diesel range organics (DRO) concentrations reported in 2004 RI soil samples. Concentrations are reported in parts per million (ppm) and depths are in feet. Only concentrations greater than the ADEC Method 2 migration to groundwater cleanup levels (over 40-inch precipitation zone) are listed. Highest reported concentration shown (may include duplicate/triplicate results).
16.00'
16.00 feet groundwater elevation contour.
AST2
Location of former AST 2.
Approximate boundary of Area for Remedial Action. Used for impacted area and volume calculations and is based on data from S&W 2006a and USACE 2006. All sampling data and analytical results not shown.
Approximate Groundwater Flow Direction at Site AST 2
YAK D 001
AST2-3
AP-205
(16.07')
YAK D 003
04Y-DT2-03-SS
2-F
YAK D 004
2-E
55-Gallon Drums
2-B
AST2-1
AP-203
(15.99')
2-G
2-D
2-I
B = 0.026 (1')
DRO = 5,800 (1')
04Y-DT2-01-SS
YAK D 002
16.00'
16.10'
16.20'
16.30'
16.40'
16.50'
16.60'
16.70'
2-C
AST2
YAK D 037
YAK D 035
YAK D 036
AST2-2
AP-204
(16.68')
04Y-DT2-02-SS
DRO = 230 (1')
Malaspina Investments Office/Warehouse
YAK D 033
Area for remedial action
Gravel Road
Former Truck Gasoline Pipeline Location
Former Diesel Fuel Pipeline Location
Garage / Shed
YAK D 062
YAK D 063
N
0 20 40
APPROXIMATE SCALE IN FEET
Former Yakutat Air Force Base
Yakutat, Alaska
AOC D - AST2 SITE PLAN
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Fig. 3.5-4
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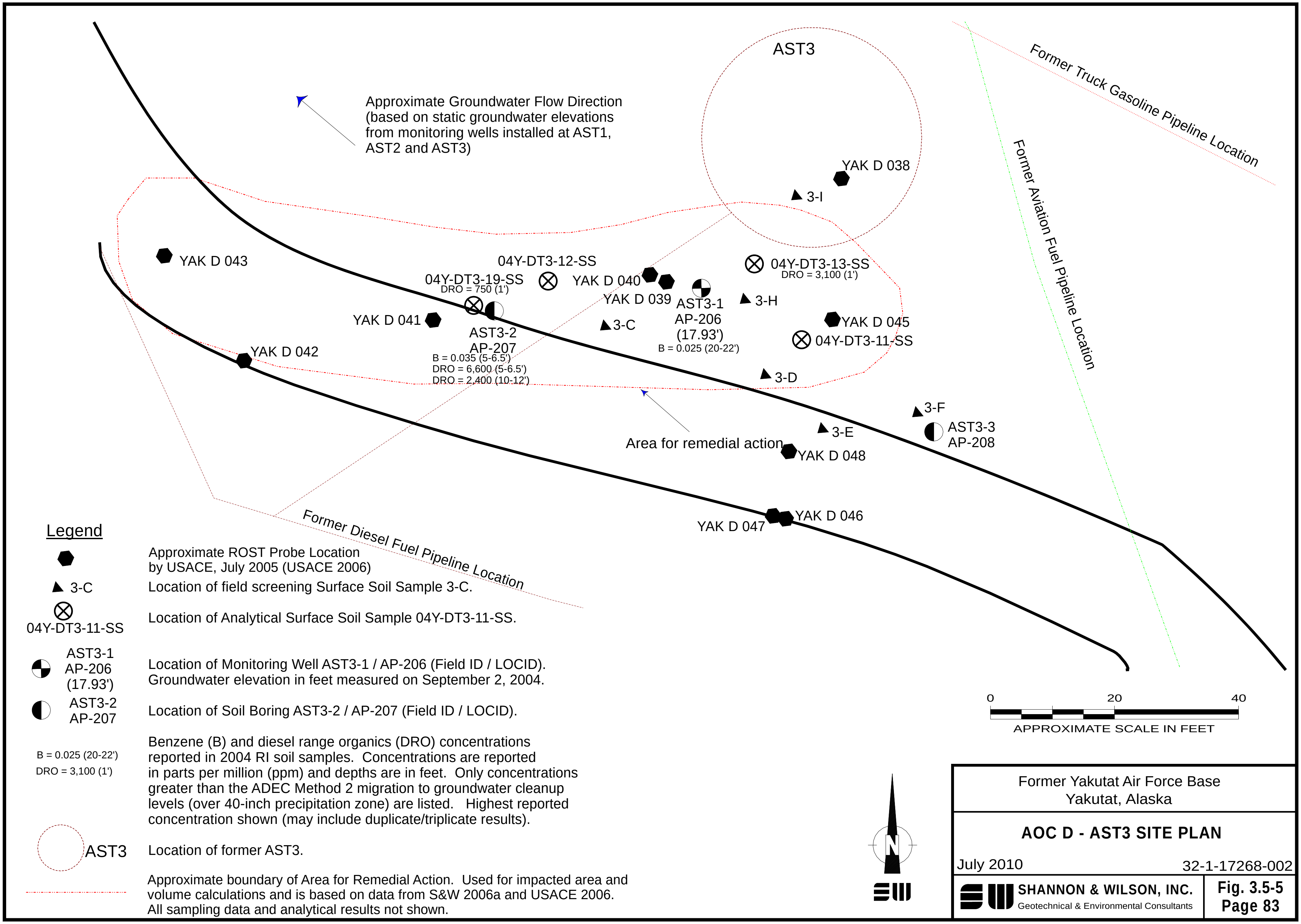
AST3
Former Truck Gasoline Pipeline Location
Former Aviation Fuel Pipeline Location
Approximate Groundwater Flow Direction (based on static groundwater elevations from monitoring wells installed at AST1, AST2 and AST3)
YAK D 038
3-I
YAK D 043
04Y-DT3-12-SS
04Y-DT3-13-SS
DRO = 3,100 (1')
04Y-DT3-19-SS
DRO = 750 (1')
YAK D 040
YAK D 039
AST3-1
AP-206
(17.93')
B = 0.025 (20-22')
3-H
YAK D 041
AST3-2
AP-207
B = 0.035 (5-6.5')
DRO = 6,600 (5-6.5')
DRO = 2,400 (10-12')
3-C
YAK D 045
04Y-DT3-11-SS
YAK D 042
3-D
3-F
AST3-3
AP-208
3-E
Area for remedial action
YAK D 048
YAK D 047
YAK D 046
Former Diesel Fuel Pipeline Location
Legend
Approximate ROST Probe Location by USACE, July 2005 (USACE 2006)
3-C
Location of field screening Surface Soil Sample 3-C.
04Y-DT3-11-SS
Location of Analytical Surface Soil Sample 04Y-DT3-11-SS.
AST3-1
AP-206
(17.93')
Location of Monitoring Well AST3-1 / AP-206 (Field ID / LOCID). Groundwater elevation in feet measured on September 2, 2004.
AST3-2
AP-207
Location of Soil Boring AST3-2 / AP-207 (Field ID / LOCID).
B = 0.025 (20-22')
DRO = 3,100 (1')
Benzene (B) and diesel range organics (DRO) concentrations reported in 2004 RI soil samples. Concentrations are reported in parts per million (ppm) and depths are in feet. Only concentrations greater than the ADEC Method 2 migration to groundwater cleanup levels (over 40-inch precipitation zone) are listed. Highest reported concentration shown (may include duplicate/triplicate results).
AST3
Location of former AST3.
Approximate boundary of Area for Remedial Action. Used for impacted area and volume calculations and is based on data from S&W 2006a and USACE 2006. All sampling data and analytical results not shown.
0
20
40
APPROXIMATE SCALE IN FEET
N
Former Yakutat Air Force Base
Yakutat, Alaska
AOC D - AST3 SITE PLAN
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Fig. 3.5-5
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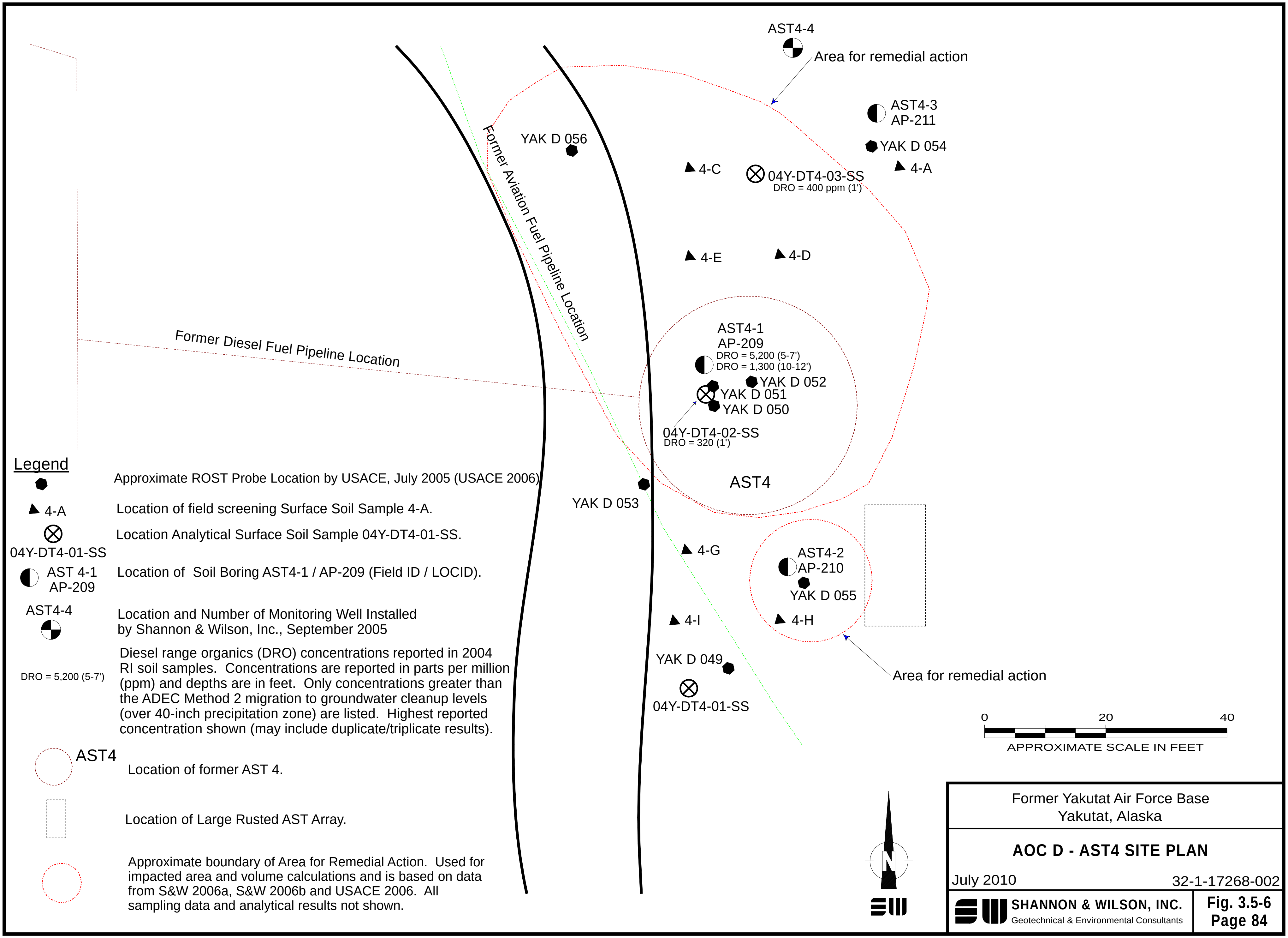
AST4-4
Area for remedial action
AST4-3
AP-211
YAK D 054
4-A
YAK D 056
4-C
04Y-DT4-03-SS
DRO = 400 ppm (1')
Former Aviation Fuel Pipeline Location
4-E
4-D
Former Diesel Fuel Pipeline Location
AST4-1
AP-209
DRO = 5,200 (5-7')
DRO = 1,300 (10-12')
YAK D 052
YAK D 051
YAK D 050
04Y-DT4-02-SS
DRO = 320 (1')
AST4
YAK D 053
4-G
AST4-2
AP-210
YAK D 055
4-I
4-H
YAK D 049
Area for remedial action
04Y-DT4-01-SS
0
20
40
APPROXIMATE SCALE IN FEET
N
Legend
Approximate ROST Probe Location by USACE, July 2005 (USACE 2006)
4-A
Location of field screening Surface Soil Sample 4-A.
04Y-DT4-01-SS
Location Analytical Surface Soil Sample 04Y-DT4-01-SS.
AST 4-1
AP-209
Location of Soil Boring AST4-1 / AP-209 (Field ID / LOCID).
AST4-4
Location and Number of Monitoring Well Installed
by Shannon & Wilson, Inc., September 2005
DRO = 5,200 (5-7')
Diesel range organics (DRO) concentrations reported in 2004
RI soil samples. Concentrations are reported in parts per million
(ppm) and depths are in feet. Only concentrations greater than
the ADEC Method 2 migration to groundwater cleanup levels
(over 40-inch precipitation zone) are listed. Highest reported
concentration shown (may include duplicate/triplicate results).
AST4
Location of former AST 4.
Location of Large Rusted AST Array.
Approximate boundary of Area for Remedial Action. Used for
impacted area and volume calculations and is based on data
from S&W 2006a, S&W 2006b and USACE 2006. All
sampling data and analytical results not shown.
Former Yakutat Air Force Base
Yakutat, Alaska
AOC D - AST4 SITE PLAN
July 2010
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Fig. 3.5-6
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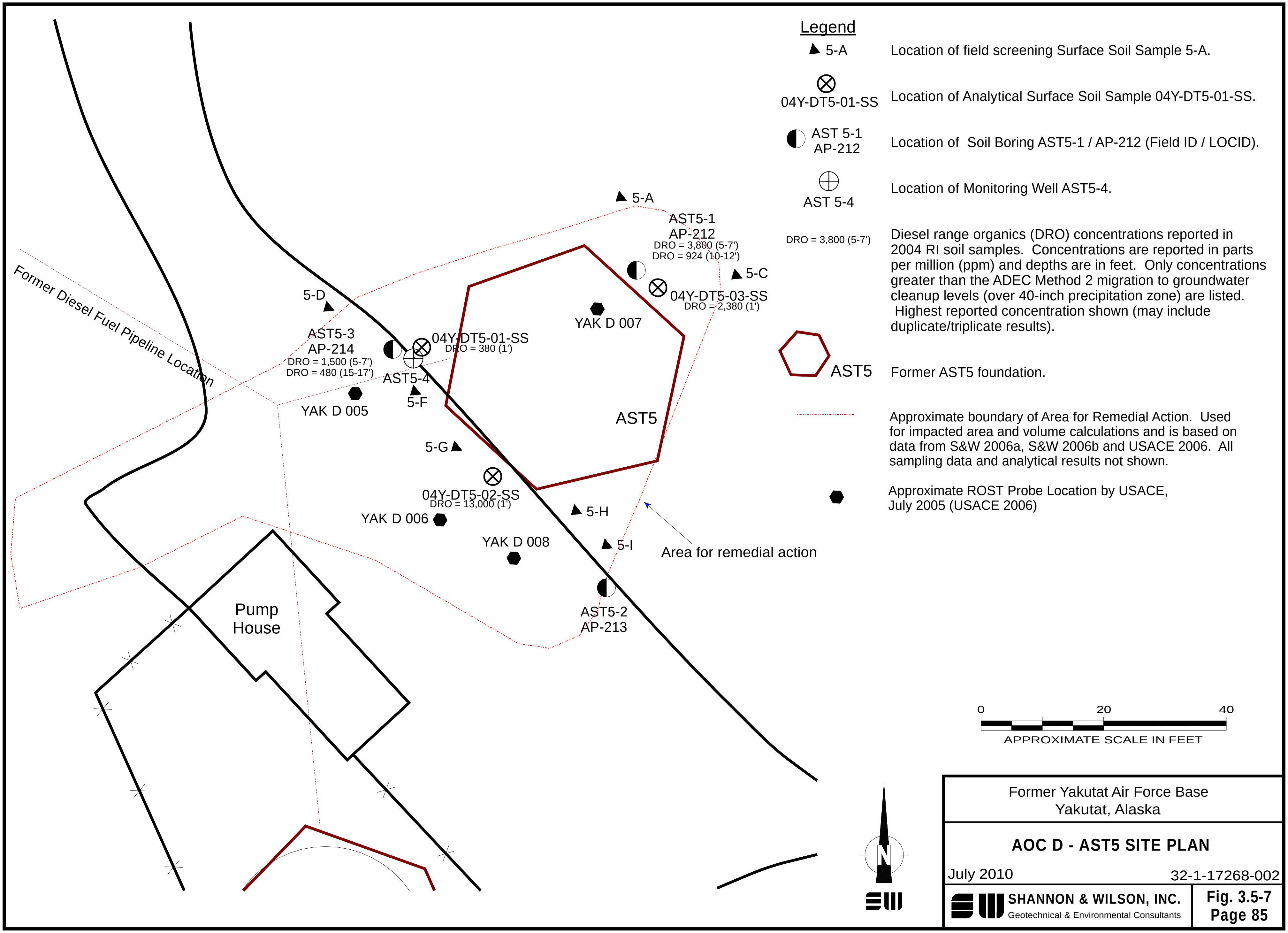

Legend
5-A Location of field screening Surface Soil Sample 5-A.
04Y-DT5-01-SS Location of Analytical Surface Soil Sample 04Y-DT5-01-SS.
AST 5-1 AP-212 Location of Soil Boring AST5-1 / AP-212 (Field ID / LOCID).
AST 5-4 Location of Monitoring Well AST5-4.
DRO = 3,800 (5-7') Diesel range organics (DRO) concentrations reported in 2004 RI soil samples. Concentrations are reported in parts per million (ppm) and depths are in feet. Only concentrations greater than the ADEC Method 2 migration to groundwater cleanup levels (over 40-inch precipitation zone) are listed. Highest reported concentration shown (may include duplicate/triplicate results).
AST5 Former AST5 foundation.
Approximate boundary of Area for Remedial Action. Used for impacted area and volume calculations and is based on data from S&W 2006a, S&W 2006b and USACE 2006. All sampling data and analytical results not shown.
Approximate ROST Probe Location by USACE, July 2005 (USACE 2006)
Former Diesel Fuel Pipeline Location
5-A
AST5-1
AP-212
DRO = 3,800 (5-7')
DRO = 924 (10-12')
5-C
04Y-DT5-03-SS
DRO = 2,380 (1')
YAK D 007
5-D
AST5-3
AP-214
DRO = 1,500 (5-7')
DRO = 480 (15-17')
04Y-DT5-01-SS
DRO = 380 (1')
AST5-4
5-F
YAK D 005
AST5
5-G
04Y-DT5-02-SS
DRO = 13,000 (1')
YAK D 006
5-H
YAK D 008
5-I
Area for remedial action
AST5-2
AP-213
Pump House
0 20 40
APPROXIMATE SCALE IN FEET
N
SW
Former Yakutat Air Force Base
Yakutat, Alaska
AOC D - AST5 SITE PLAN
July 2010
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Fig. 3.5-7
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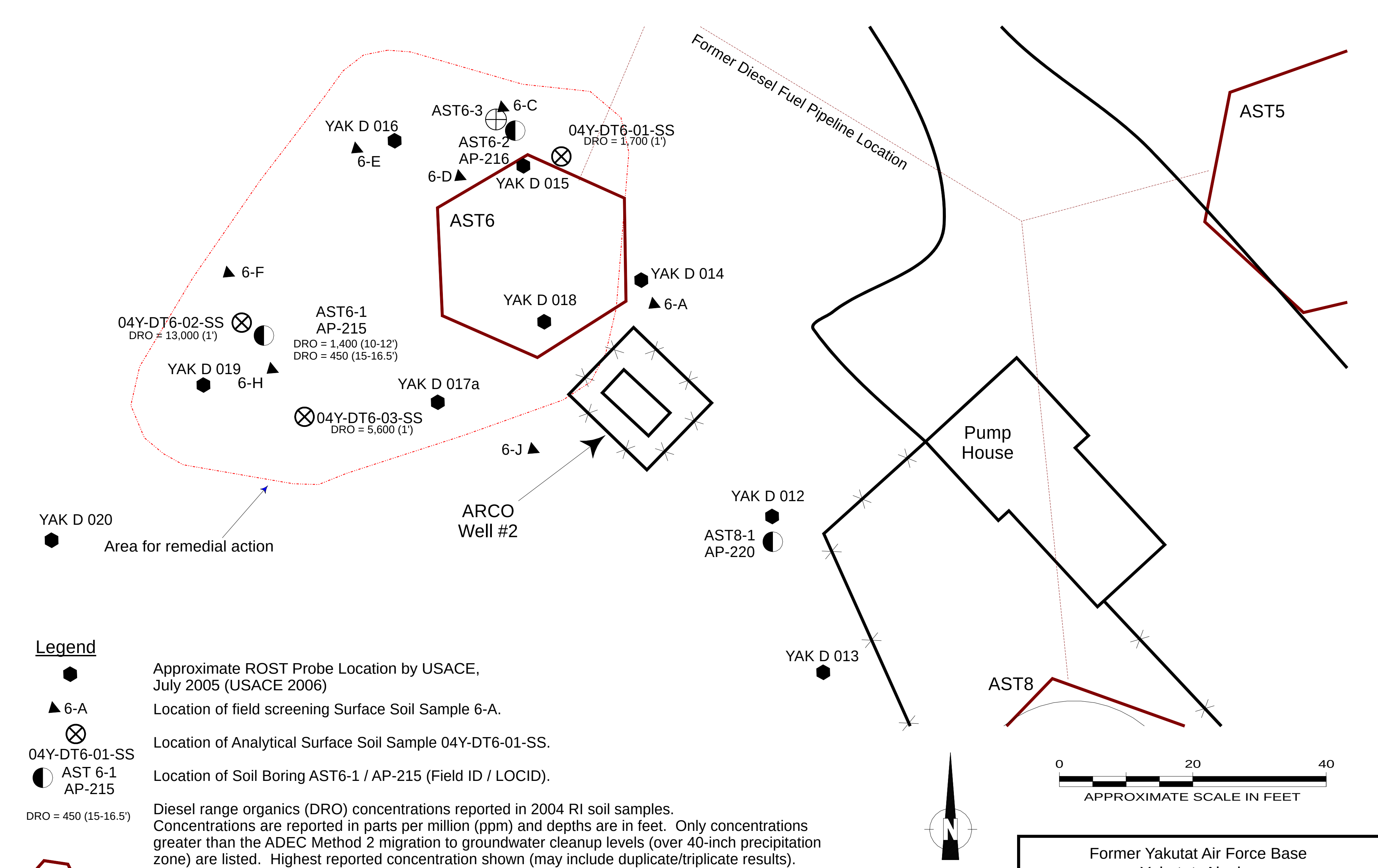

Legend

(hexagon)	Approximate ROST Probe Location by USACE, July 2005 (USACE 2006)
6-A	Location of field screening Surface Soil Sample 6-A.
04Y-DT6-01-SS	Location of Analytical Surface Soil Sample 04Y-DT6-01-SS.
AST 6-1 AP-215	Location of Soil Boring AST6-1 / AP-215 (Field ID / LOCID).
DRO = 450 (15-16.5')	Diesel range organics (DRO) concentrations reported in 2004 RI soil samples. Concentrations are reported in parts per million (ppm) and depths are in feet. Only concentrations greater than the ADEC Method 2 migration to groundwater cleanup levels (over 40-inch precipitation zone) are listed. Highest reported concentration shown (may include duplicate/triplicate results).
AST6	Former AST6 foundation.
AST6-3	Location of Monitoring Well AST6-3.
(dotted line)	Approximate boundary of Area for Remedial Action. Used for impacted area and volume calculations and is based on data from S&W 2006a, S&W 2006b and USACE 2006. All sampling data and analytical results not shown.

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Yakutat, Alaska

AOC D - AST6 SITE PLAN

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Fig. 3.5-8
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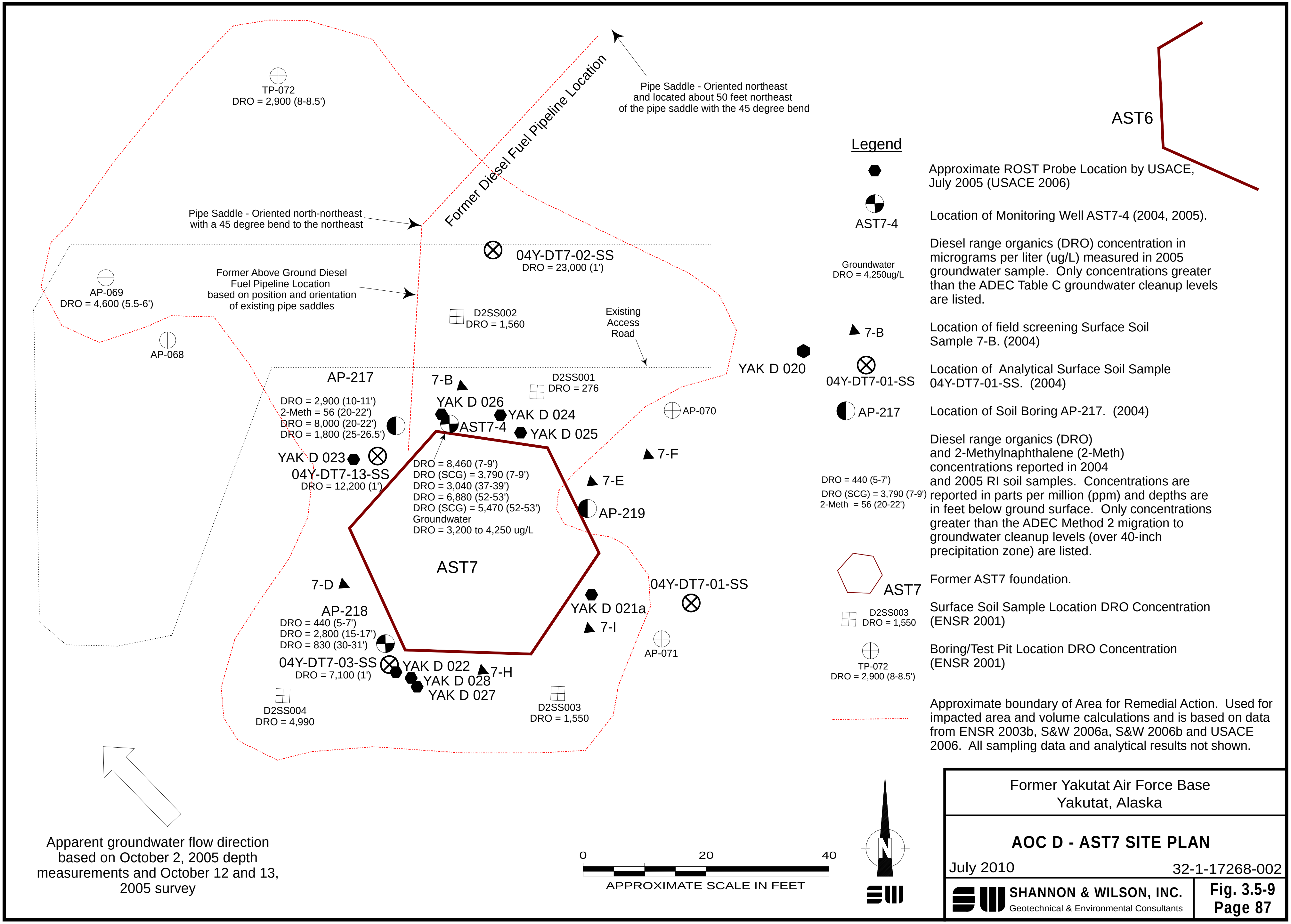
TP-072
DRO = 2,900 (8-8.5')
Former Diesel Fuel Pipeline Location
Pipe Saddle - Oriented northeast and located about 50 feet northeast of the pipe saddle with the 45 degree bend
AST6
Legend
Approximate ROST Probe Location by USACE, July 2005 (USACE 2006)
AST7-4
Location of Monitoring Well AST7-4 (2004, 2005).
Groundwater
DRO = 4,250ug/L
Diesel range organics (DRO) concentration in micrograms per liter (ug/L) measured in 2005 groundwater sample. Only concentrations greater than the ADEC Table C groundwater cleanup levels are listed.
7-B
Location of field screening Surface Soil Sample 7-B. (2004)
04Y-DT7-01-SS
Location of Analytical Surface Soil Sample 04Y-DT7-01-SS. (2004)
AP-217
Location of Soil Boring AP-217. (2004)
DRO = 440 (5-7')
DRO (SCG) = 3,790 (7-9')
2-Meth = 56 (20-22')
Diesel range organics (DRO) and 2-Methylnaphthalene (2-Meth) concentrations reported in 2004 and 2005 RI soil samples. Concentrations are reported in parts per million (ppm) and depths are in feet below ground surface. Only concentrations greater than the ADEC Method 2 migration to groundwater cleanup levels (over 40-inch precipitation zone) are listed.
AST7
Former AST7 foundation.
D2SS003
DRO = 1,550
Surface Soil Sample Location DRO Concentration (ENSR 2001)
TP-072
DRO = 2,900 (8-8.5')
Boring/Test Pit Location DRO Concentration (ENSR 2001)
Approximate boundary of Area for Remedial Action. Used for impacted area and volume calculations and is based on data from ENSR 2003b, S&W 2006a, S&W 2006b and USACE 2006. All sampling data and analytical results not shown.
Pipe Saddle - Oriented north-northeast with a 45 degree bend to the northeast
04Y-DT7-02-SS
DRO = 23,000 (1')
AP-069
DRO = 4,600 (5.5-6')
Former Above Ground Diesel Fuel Pipeline Location based on position and orientation of existing pipe saddles
D2SS002
DRO = 1,560
Existing Access Road
AP-068
YAK D 020
AP-217
7-B
D2SS001
DRO = 276
DRO = 2,900 (10-11')
2-Meth = 56 (20-22')
DRO = 8,000 (20-22')
DRO = 1,800 (25-26.5')
YAK D 026
YAK D 024
AST7-4
YAK D 025
AP-070
YAK D 023
04Y-DT7-13-SS
DRO = 12,200 (1')
7-F
DRO = 8,460 (7-9')
DRO (SCG) = 3,790 (7-9')
DRO = 3,040 (37-39')
DRO = 6,880 (52-53')
DRO (SCG) = 5,470 (52-53')
Groundwater
DRO = 3,200 to 4,250 ug/L
7-E
AP-219
AST7
7-D
04Y-DT7-01-SS
YAK D 021a
AP-218
DRO = 440 (5-7')
DRO = 2,800 (15-17')
DRO = 830 (30-31')
7-I
AP-071
04Y-DT7-03-SS
DRO = 7,100 (1')
YAK D 022
YAK D 028
YAK D 027
7-H
D2SS004
DRO = 4,990
D2SS003
DRO = 1,550
Apparent groundwater flow direction based on October 2, 2005 depth measurements and October 12 and 13, 2005 survey
0
20
40
APPROXIMATE SCALE IN FEET
N
Former Yakutat Air Force Base
Yakutat, Alaska
AOC D - AST7 SITE PLAN
July 2010
32-1-17268-002
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Fig. 3.5-9
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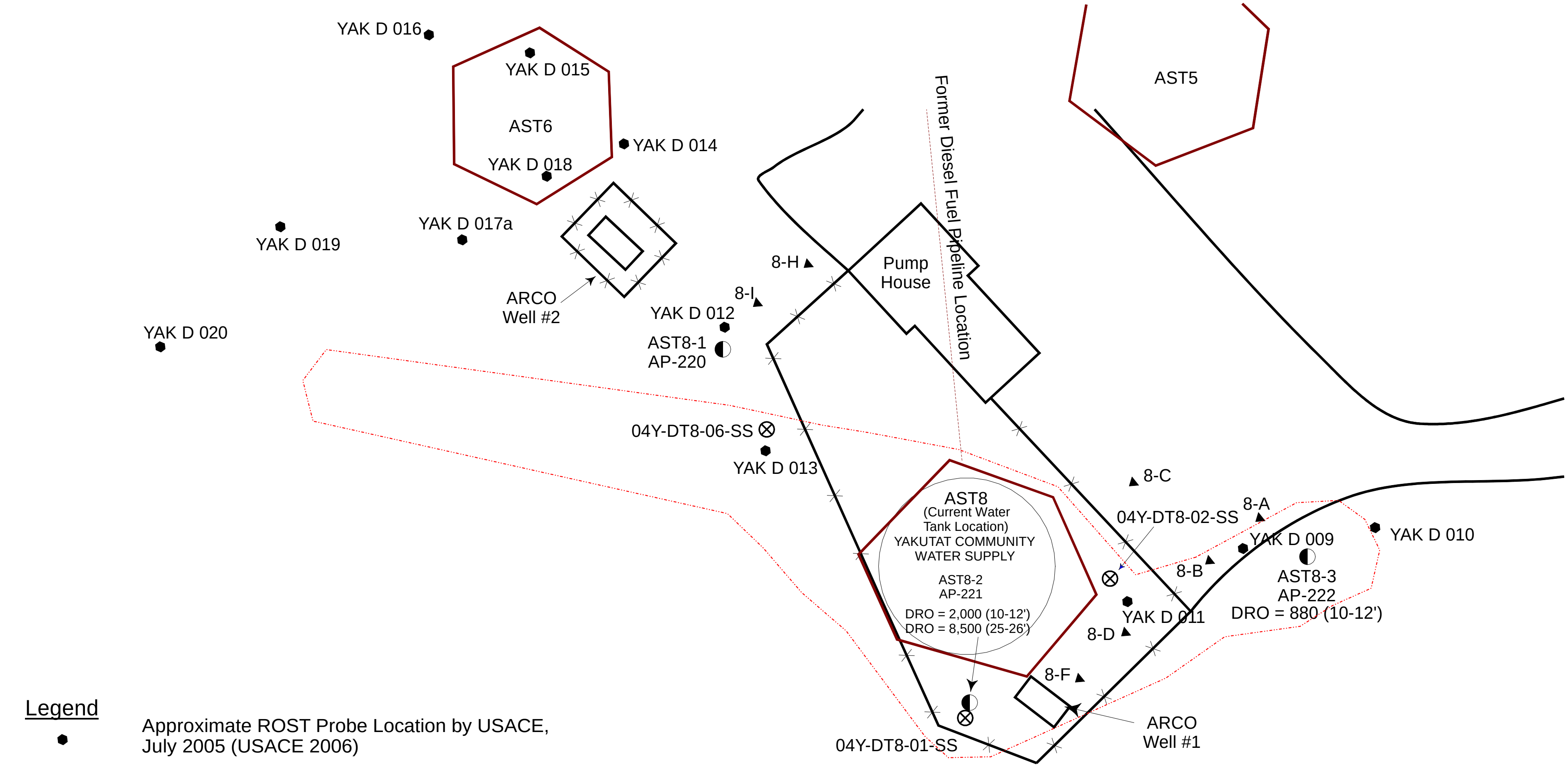

Legend

Approximate ROST Probe Location by USACE, July 2005 (USACE 2006)

8-A Location of field screening Surface Soil Sample 8-A.

04Y-DT8-01-SS Location of Analytical Surface Soil Sample 04Y-DT8-01-SS.

AST 8-1 AP-220 Location of Soil Boring AST8-1 / AP-220 (Field ID / LOCID).

DRO = 880 (10-12') Diesel range organics (DRO) concentrations reported in 2004 RI soil samples. Concentrations are reported in parts per million (ppm) and depths are in feet. Only concentrations greater than the ADEC Method 2 migration to groundwater cleanup levels (over 40-inch precipitation zone) are listed. Highest reported concentration shown (may include duplicate/triplicate results).

AST8 Former AST8 foundation.

Approximate boundary of Area for Remedial Action. Used for impacted area and volume calculations and is based on data from S&W 2006a and USACE 2006. All sampling data and analytical results not shown.

0 30 60
APPROXIMATE SCALE IN FEET

N

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Yakutat, Alaska

AOC D - AST8 SITE PLAN

July 2010 32-1-17268-002

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Fig. 3.5-10
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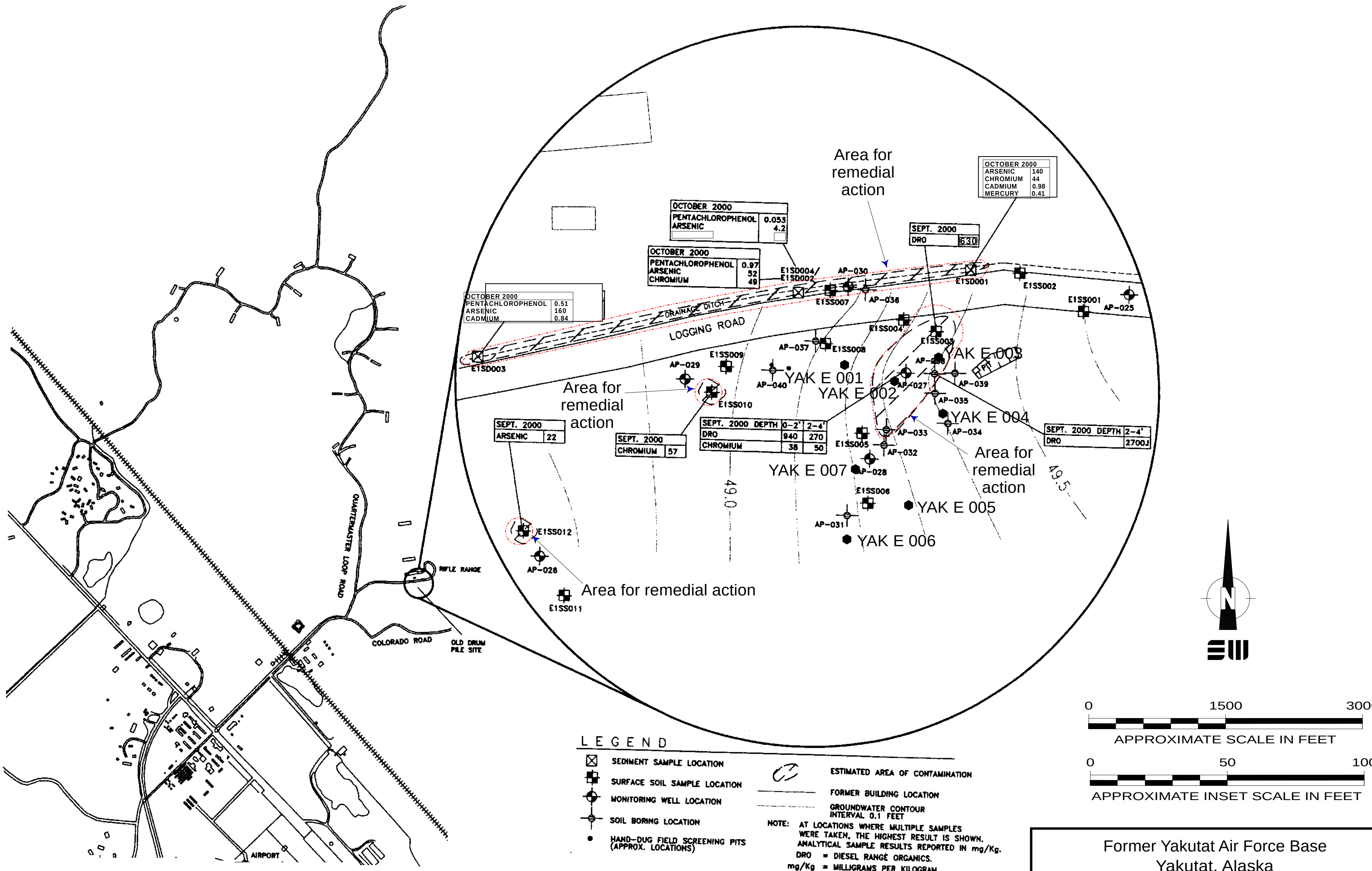

Approximate ROST Probe Location by USACE, July 2005 (USACE 2006)

Approximate boundary of Area for Remedial Action. Used for impacted area and volume calculations and is based on data from ENSR 2003a. All sampling data and analytical results not shown.

Base map prepared for USACE by ENSR and presented in "Final Feasibility Study, Yakutat Area RI/FS". Modified by Shannon & Wilson for 2010 Feasibility Study.

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Yakutat, Alaska

AOC E1 SITE PLAN

July 2010 32-1-17268-002

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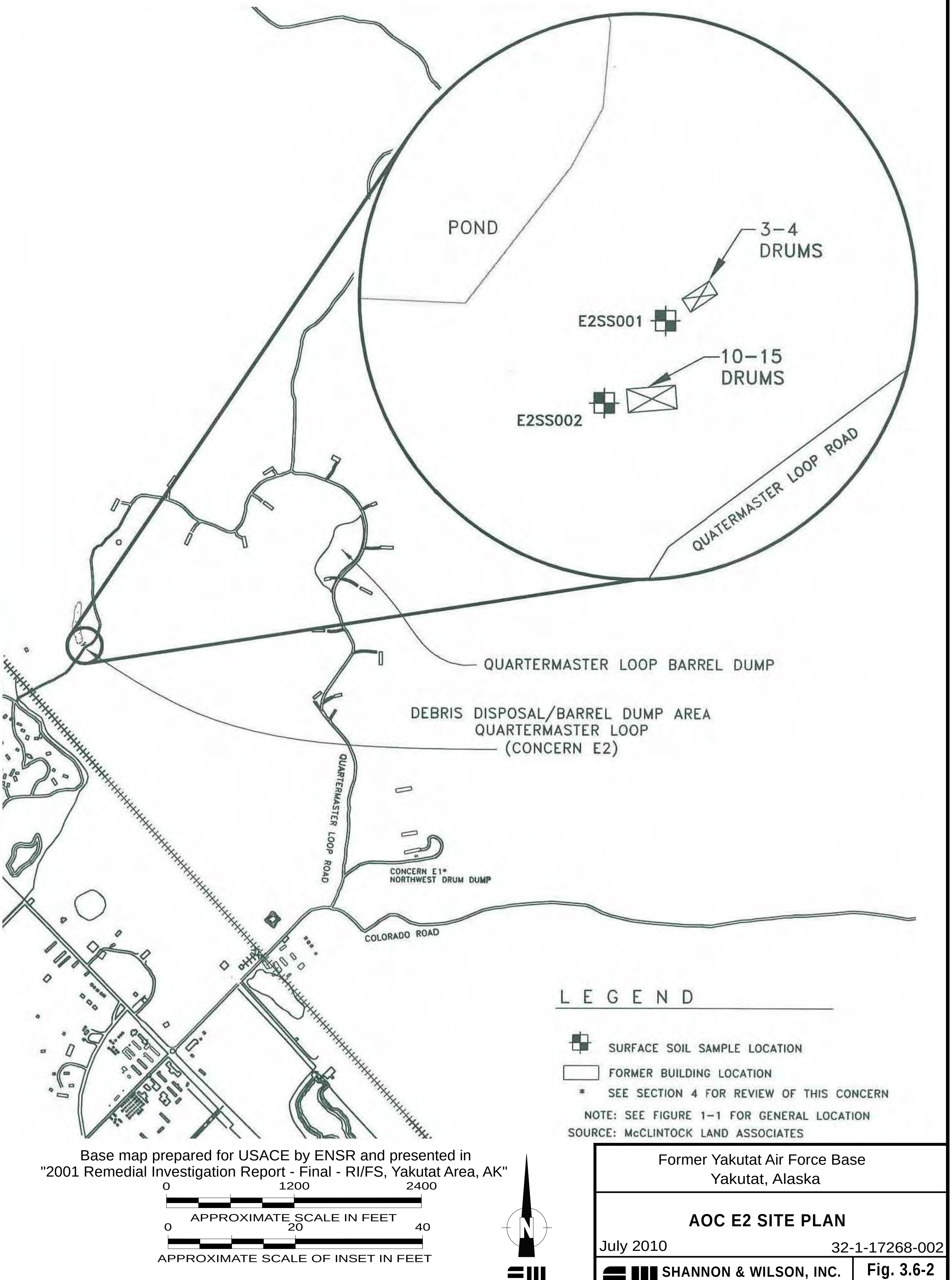
Fig. 3.6-1



Base map prepared for USACE by ENSR and presented in "2001 Remedial Investigation Report - Final - RI/FS, Yakutat Area, AK"

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Yakutat, Alaska

AOC E2 SITE PLAN

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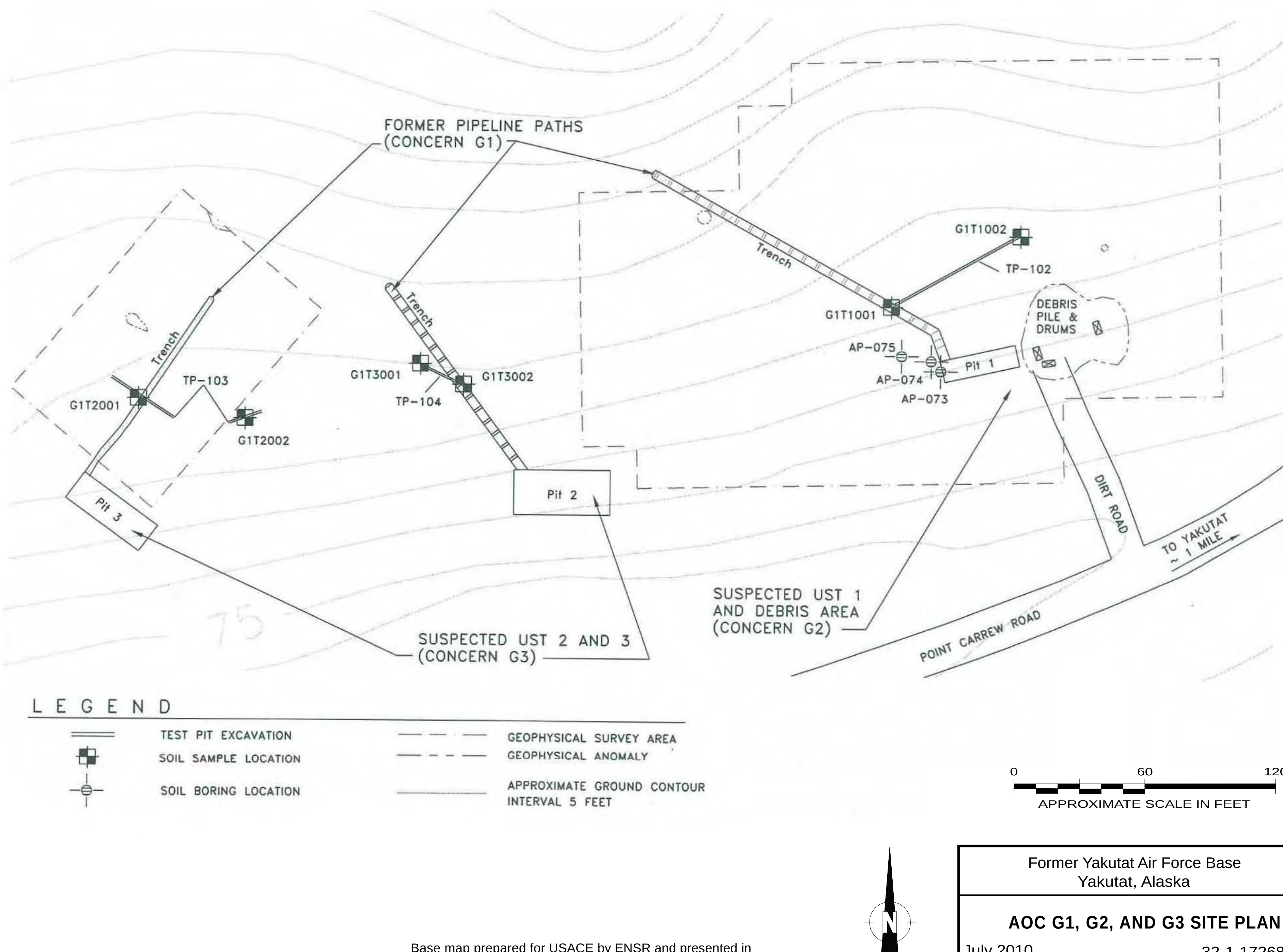
Fig. 3.6-2



Base map prepared for USACE by ENSR and presented in
"2001 Remedial Investigation Report - Final - RI/FS, Yakutat Area, AK".
Modified by Shannon & Wilson for 2010 Feasibility Study.

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Yakutat, Alaska

AOC G1, G2, AND G3 SITE PLAN

July 2010 32-1-17268-002

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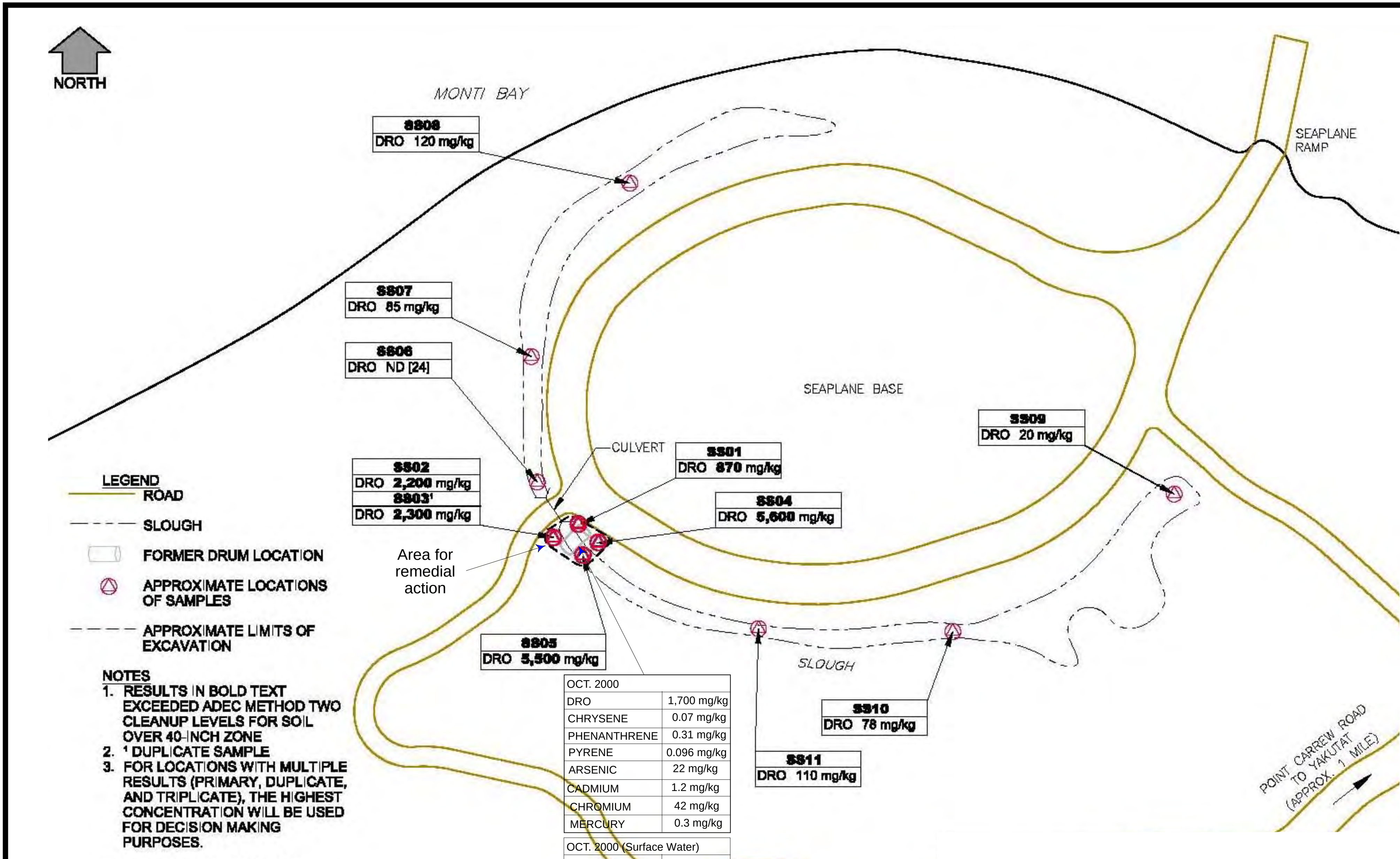
Fig. 3.8-1



OCT. 2000	
DRO	1,700 mg/kg
CHRYSENE	0.07 mg/kg
PHENANTHRENE	0.31 mg/kg
PYRENE	0.096 mg/kg
ARSENIC	22 mg/kg
CADMIUM	1.2 mg/kg
CHROMIUM	42 mg/kg
MERCURY	0.3 mg/kg

OCT. 2000 (Surface Water)	
Barium	0.007 mg/L

NOTES
1. RESULTS IN BOLD TEXT EXCEEDED ADEC METHOD TWO CLEANUP LEVELS FOR SOIL OVER 40-INCH ZONE
2. ¹ DUPLICATE SAMPLE
3. FOR LOCATIONS WITH MULTIPLE RESULTS (PRIMARY, DUPLICATE, AND TRIPLICATE), THE HIGHEST CONCENTRATION WILL BE USED FOR DECISION MAKING PURPOSES.

ACRONYMS/ABBREVIATIONS
DRO DIESEL-RANGE ORGANICS
mg/kg MILLIGRAMS PER KILOGRAM
ND NOT DETECTED; PQL SHOWN IN BRACKETS

Base map prepared for USACE by BC Contractors-Jacobs Joint Venture (BC-J) and presented in "March 2007, Final Former Yakutat Air Force Base Remedial Investigation Report, Yakutat, Alaska". Modified by Shannon & Wilson for 2010 Feasibility Study.

Former Yakutat Air Force Base
Yakutat, Alaska

AOC G4 SITE PLAN

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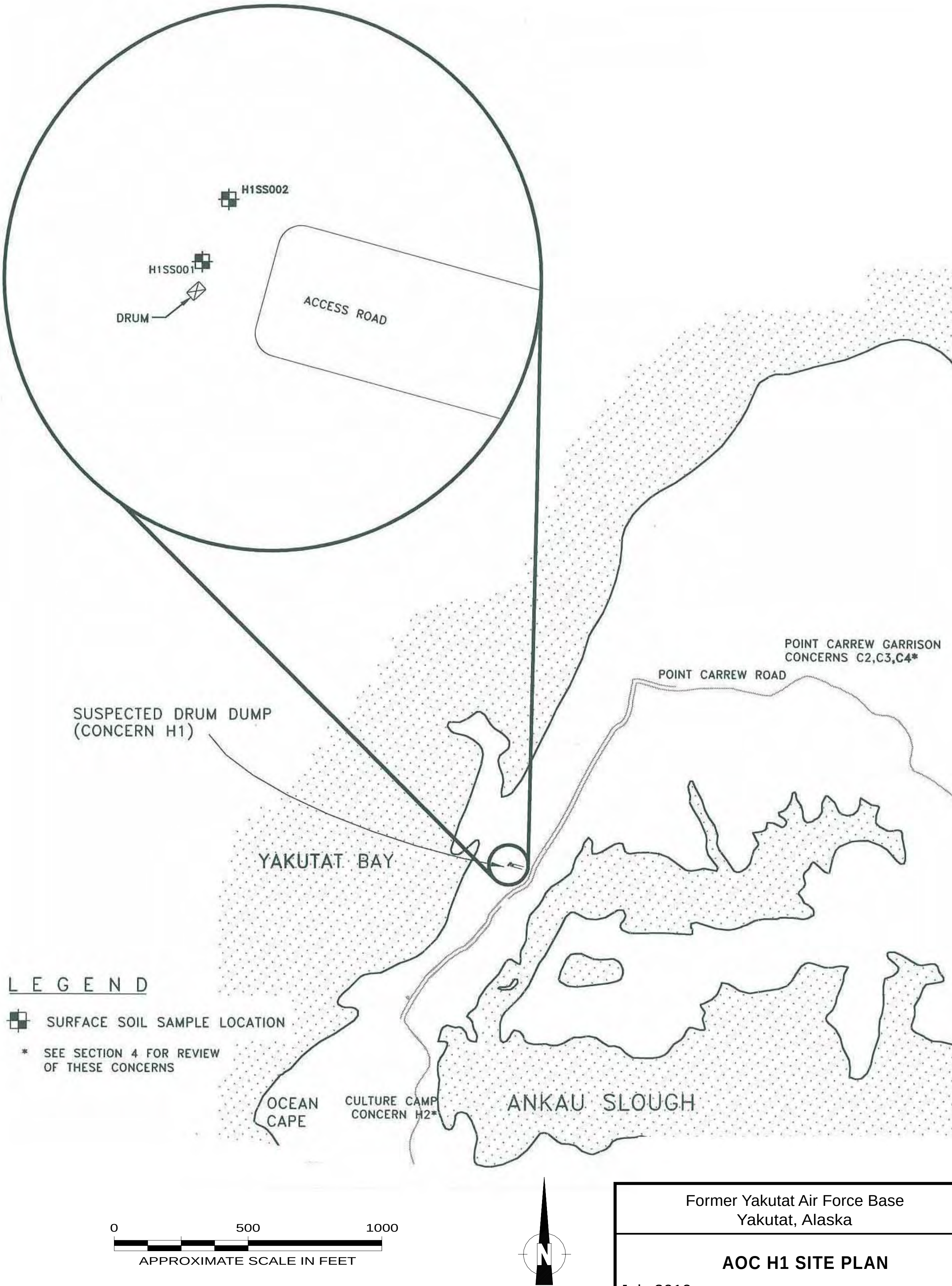

Base map prepared for USACE by ENSR and presented in "2001 Remedial Investigation Report - Final - RI/FS, Yakutat Area, AK".

Former Yakutat Air Force Base
Yakutat, Alaska

AOC H1 SITE PLAN

July 2010 32-1-17268-002

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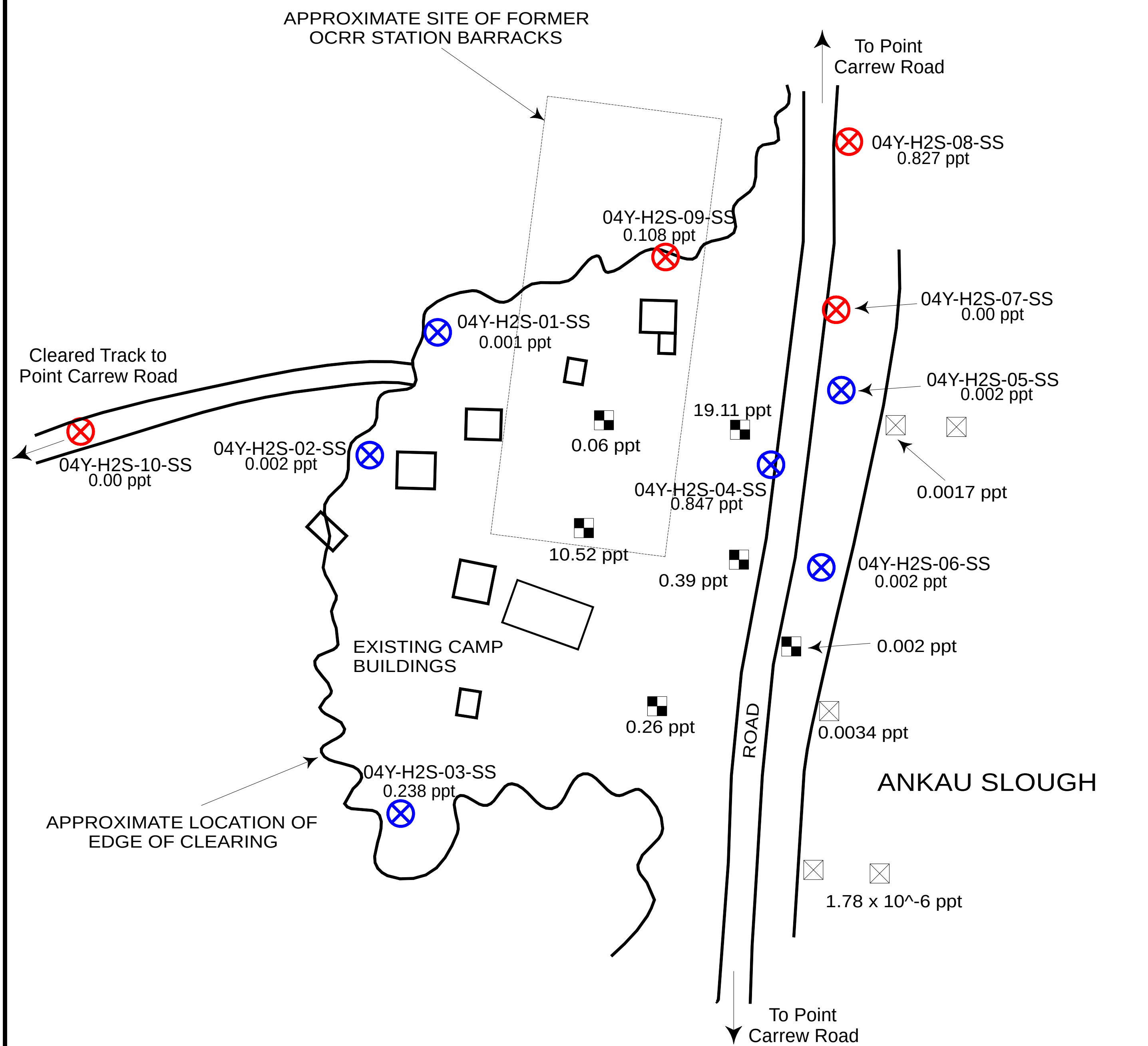
Fig. 3.9-1



Legend

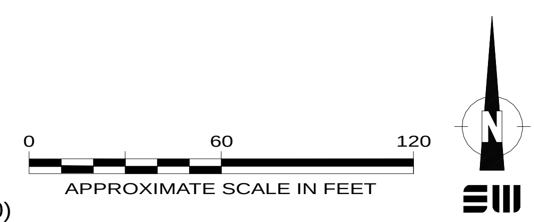
Surface Soil Sample Location, October 2000 (ENSR 2000)

Surface Water/Sediment Sample Location, October 2000 (ENSR 2000)

Surface Soil Samples Collected by Shannon & Wilson, Inc., August 7, 2004

Surface Soil Samples Collected by Shannon & Wilson, Inc., August 26, 2004

0.26 ppt TEQ dioxin concentration in parts per trillion (ppt). Calculated using the EPA method in which non-detected congeners are assigned a zero value in the TEQ calculation.



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Yakutat, Alaska

AOC H2 SITE PLAN

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Fig. 3.9-2
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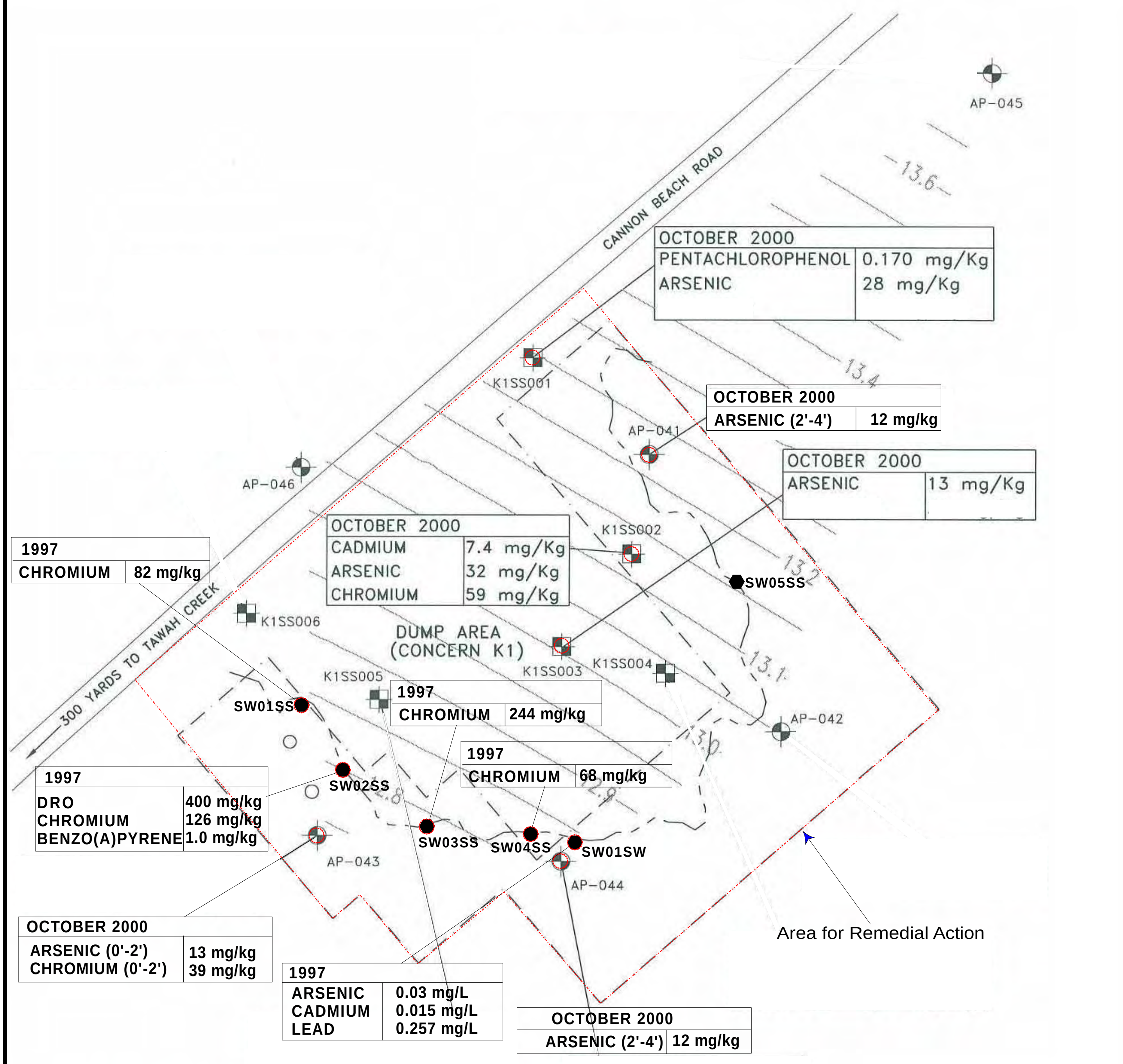

L E G E N D

- MONITORING WELL LOCATION
- SURFACE SOIL SAMPLE LOCATION
- GEOPHYSICAL SURVEY AREA
- GEOPHYSICAL ANOMALY
- GROUNDWATER ELEVATION (AMSL) MEASURED DURING WELL SAMPLING CONTOUR INTERVAL 0.05 FEET
- SURFACE SOIL/WATER SAMPLE ESTIMATED LOCATION (E&E 1998)
- Approximate location of soil or surface water impacted with COCs, based on data from E&E 1998, ENSR 2003a and ENSR 2003b. All sampling data and analytical results not shown.

NOTE: SOIL ANALYTICAL RESULTS IN mg/Kg
WATER ANALYTICAL RESULTS IN mg/L
SEE FIGURE 1-1 FOR GENERAL LOCATION
AMSL = ABOVE MEAN SEA LEVEL

SOURCE: McCLINTOCK LAND ASSOCIATES/TERRASAT

0 100 200
APPROXIMATE SCALE IN FEET

Base map prepared for USACE by ENSR and presented in "2001 Remedial Investigation Report-RI/FS, Yakutat Area, AK". Modified by Shannon & Wilson for 2010 Feasibility Study.

N

Former Yakutat Air Force Base
Yakutat, Alaska

AOC K1 SITE PLAN

July 2010 32-1-17268-002

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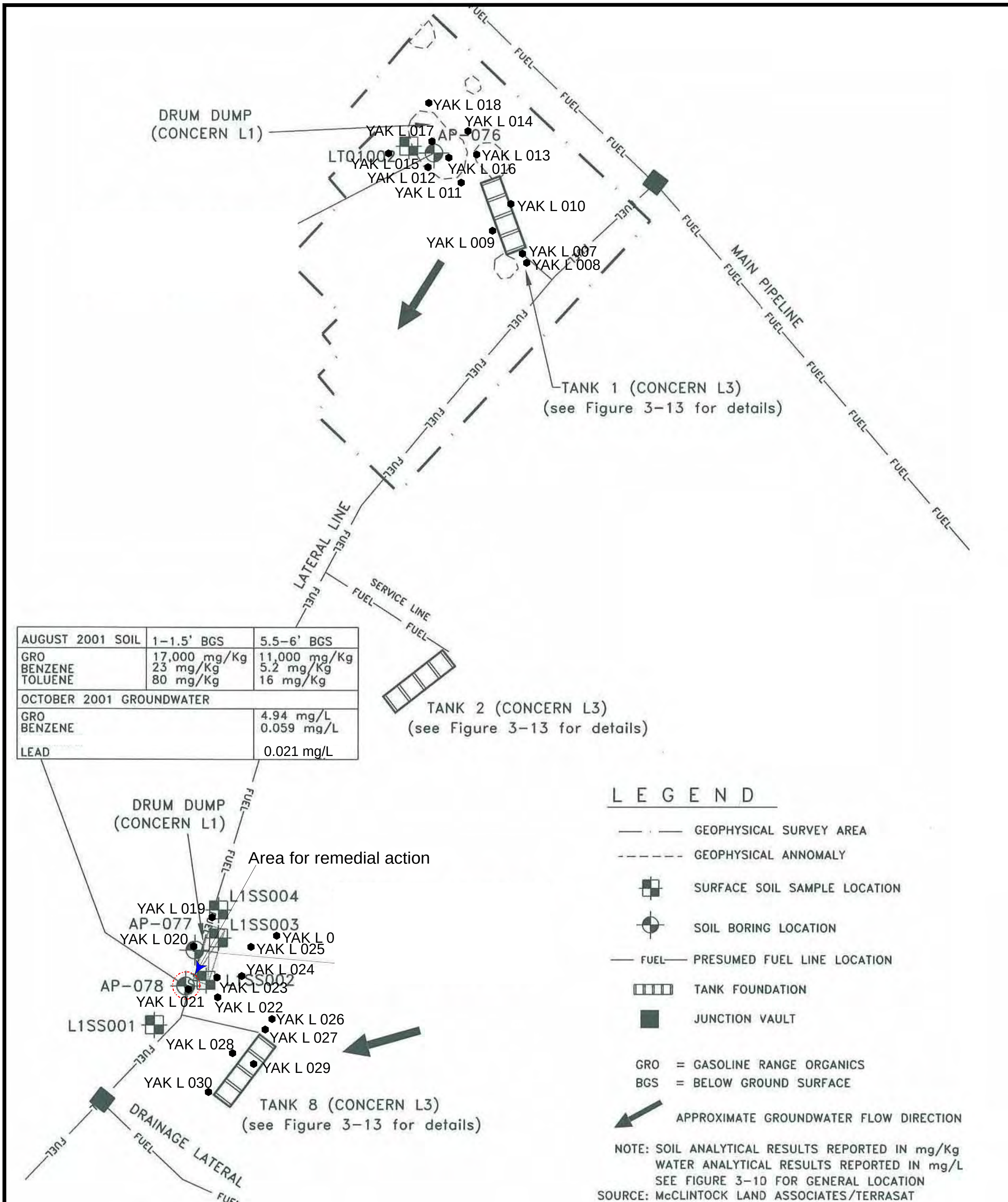
Fig. 3.10-1



AUGUST 2001 SOIL	1-1.5' BGS	5.5-6' BGS
GRO BENZENE TOLUENE	17,000 mg/Kg 23 mg/Kg 80 mg/Kg	11,000 mg/Kg 5.2 mg/Kg 16 mg/Kg
OCTOBER 2001 GROUNDWATER		
GRO BENZENE		4.94 mg/L 0.059 mg/L
LEAD		0.021 mg/L

Approximate ROST Probe Location by USACE, July 2005 (USACE 2006)

Approximate boundary of Area for Remedial Action. Used for impacted area and volume calculations and is based on data from ENSR 2003b, S&W 2006a, USACE 2006 and BC-J 2007. All sampling data and analytical results not shown.

0 100 200
APPROXIMATE SCALE IN FEET

Base map prepared for USACE by ENSR and presented in "2001 Remedial Investigation Report-Final-RI/FS, Yakutat Area, AK". Modified by Shannon & Wilson for 2010 Feasibility Study.

N

Former Yakutat Air Force Base
Yakutat, Alaska

AOC L1 SITE PLAN

July 2010 32-1-17268-002

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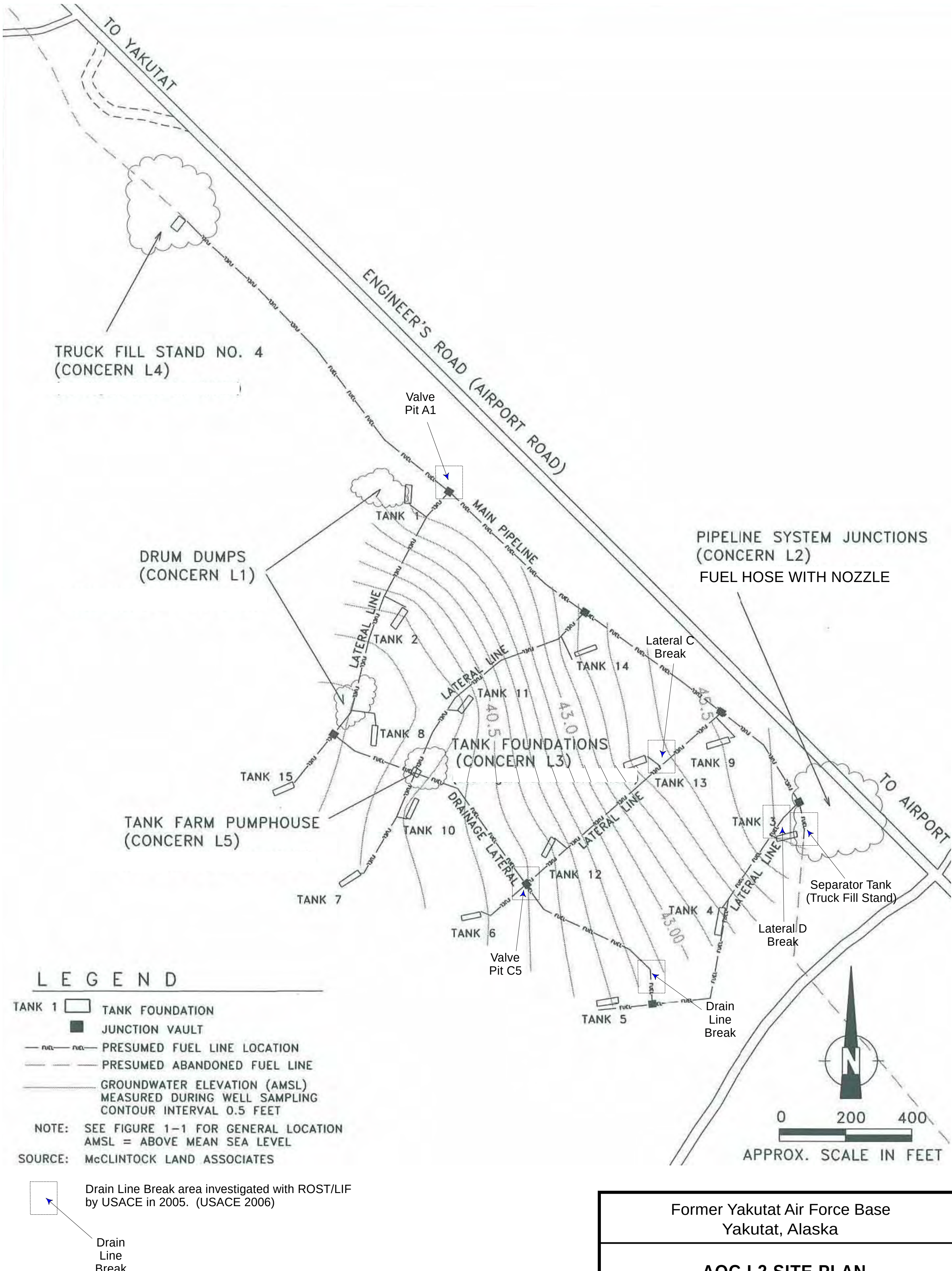
Fig. 3.11-1



Base map prepared for USACE by ENSR and presented in "2001 Remedial Investigation Report-RI/FS, Yakutat Area, AK". Modified by Shannon & Wilson for 2010 Feasibility Study.

Former Yakutat Air Force Base
Yakutat, Alaska

AOC L2 SITE PLAN

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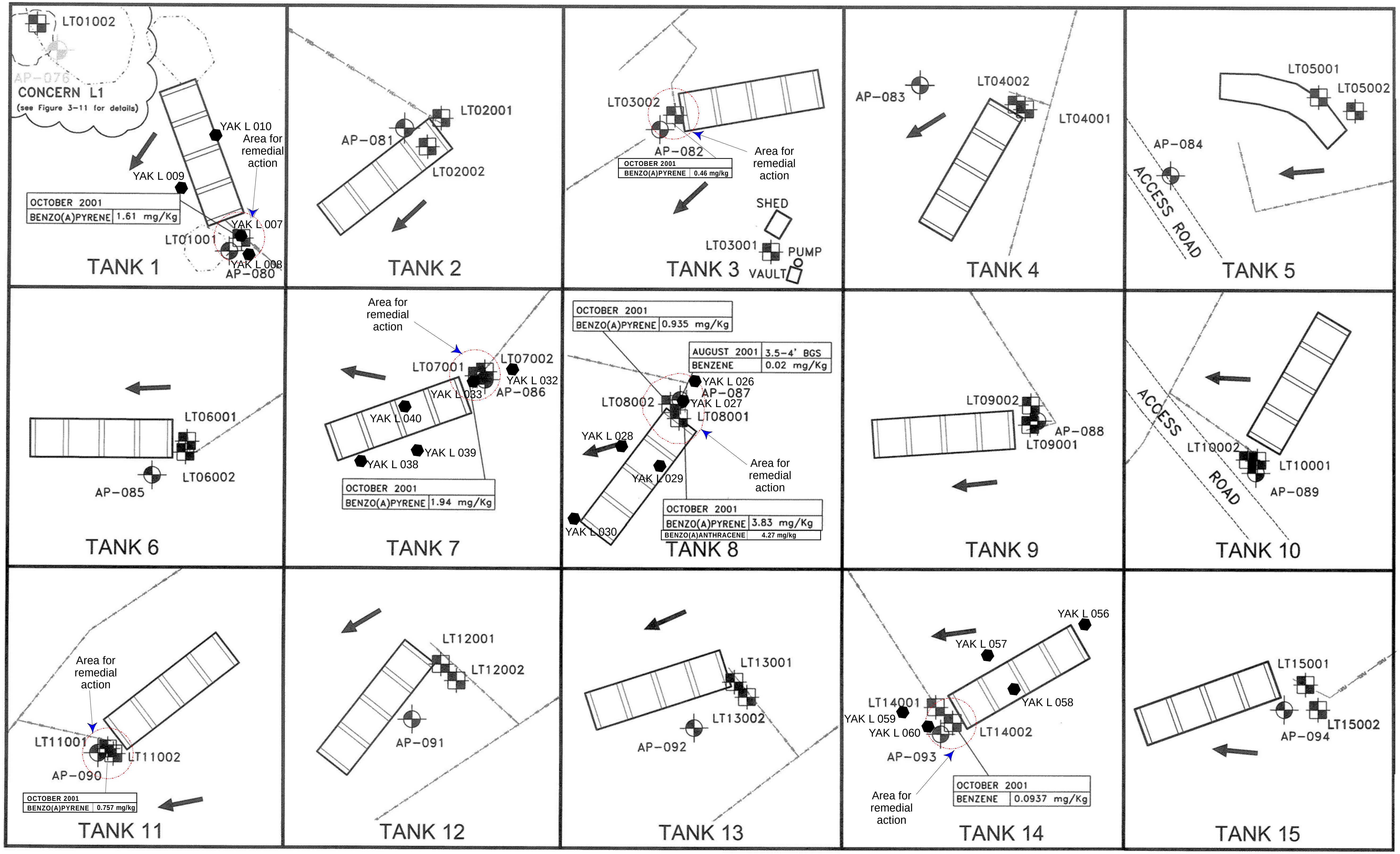
Fig. 3.11-2



LEGEND

- SURFACE SOIL SAMPLE LOCATION
- SOIL BORING LOCATION
- GRO = GASOLINE RANGE ORGANICS
- DRO = DIESEL RANGE ORGANICS
- PRESUMED FUEL LINE LOCATION
- TANK FOUNDATION (CONCERN L3)

SOURCE: McCLINTOCK LAND ASSOCIATES/TERRASAT

- GEOPHYSICAL SURVEY AREA
- GEOPHYSICAL ANOMALY
- APPROXIMATE GROUNDWATER FLOW DIRECTION

NOTE: SOIL ANALYTICAL RESULTS REPORTED IN mg/Kg
WATER ANALYTICAL RESULTS REPORTED IN mg/L
SEE FIGURE 3-10 FOR TANK FOUNDATION LOCATIONS AND GROUNDWATER CONTOURS

- Approximate ROST Probe Location by USACE, July 2005 (USACE 2006)
- Approximate boundary of Area for Remedial Action. Used for impacted area and volume calculations and is based on data from ENSR 2003b, S&W 2006a, USACE 2006 and BC-J 2007. All sampling data and analytical results not shown.

0 40 80
APPROXIMATE SCALE IN FEET

Base map prepared for USACE by ENSR and presented in "2001 Remedial Investigation Report-Final-RI/FS, Yakutat Area, AK". Modified by Shannon & Wilson for 2010 Feasibility Study.

N

Yakutat Feasibility Study
Yakutat, Alaska

AOC L3 SITE PLAN

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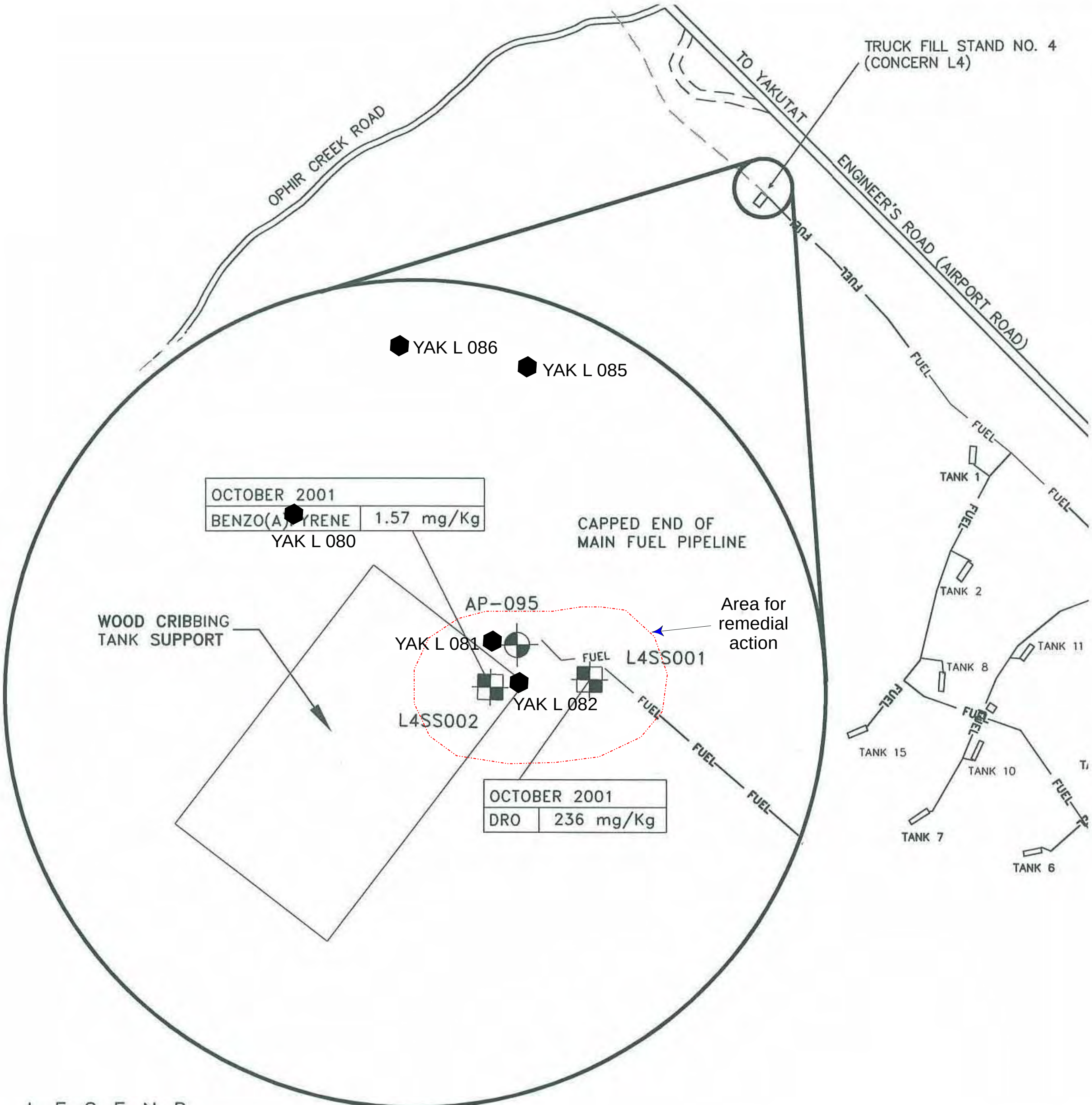
Fig. 3.11-3



L E G E N D

- MONITORING WELL LOCATION
- SURFACE SOIL SAMPLE LOCATION
- TANK FOUNDATION
- —FUEL— PRESUMED FUEL LINE LOCATION
- PRESUMED ABANDONED FUEL LINE

DRO = DIESEL RANGE ORGANICS

NOTES: SEE FIGURE 3-10 FOR GENERAL LOCATION

SOURCE: McCLINTOCK LAND ASSOCIATES

Approximate boundary of Area for Remedial Action. Used for impacted area and volume calculations and is based on data from ENSR 2003b and USACE 2006. All sampling data and analytical results not shown.

Approximate ROST Probe Location by USACE, July 2005 (USACE 2006)

Base map prepared for USACE by ENSR and is presented in "2001 Remedial Investigation Report-Final-RI/FS, Yakutat Area, AK". Modified by Shannon & Wilson for 2010 Feasibility Study.

0 20 40
APPROXIMATE INSET SCALE IN FEET

0 500 1000
APPROXIMATE SCALE IN FEET

N

Former Yakutat Air Force Base
Yakutat, Alaska

AOC L4 SITE PLAN

July 2010 32-1-17268-002

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Fig. 3.11-4
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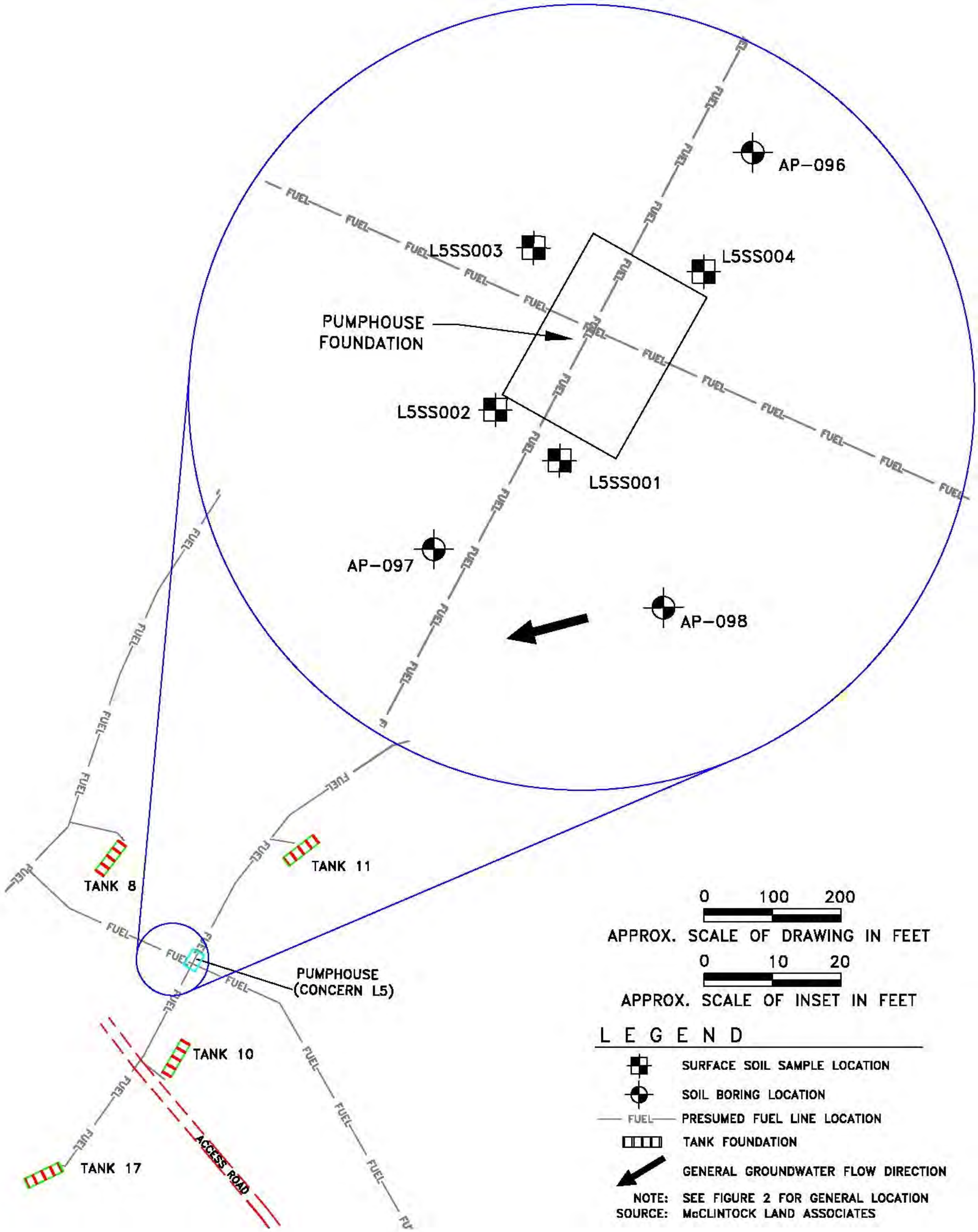

Base map prepared for USACE by ENSR and is presented in "2001 Remedial Investigation Report-Final-RI/FS, Yakutat Area, AK". Modified by Shannon & Wilson for 2010 Feasibility Study.

Former Yakutat Air Force Base
Yakutat, Alaska

AOC L5 SITE PLAN

July 2010 32-1-17268-002

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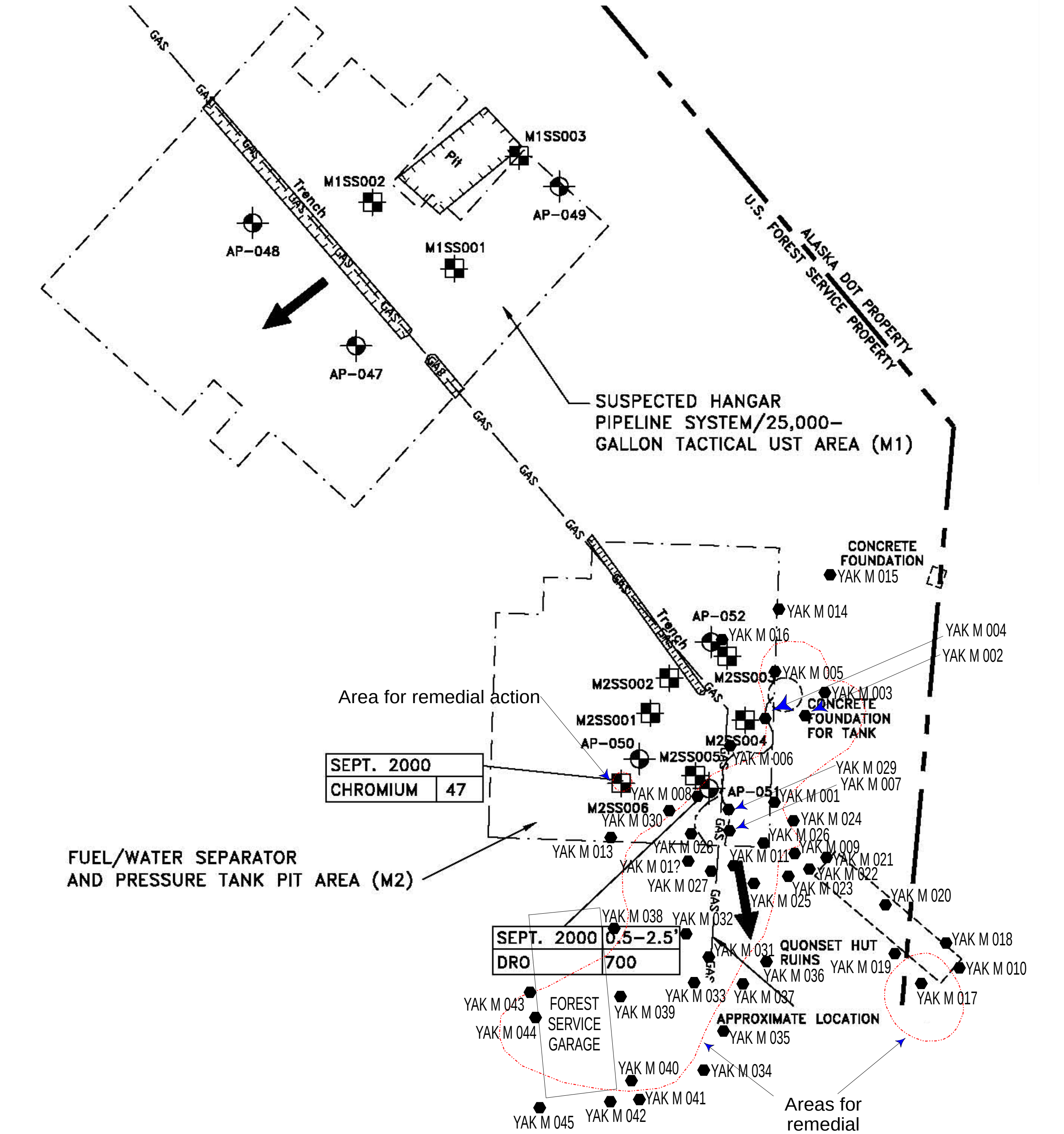
Fig. 3.11-5



LEGEND

- SURFACE SOIL SAMPLE LOCATION
- MONITORING WELL LOCATION
- DRO = DIESEL RANGE ORGANICS
- APPROXIMATE GROUNDWATER FLOW DIRECTIONS
- Approximate ROST Probe Location by USACE, July 2005 (USACE 2006)
- GEOPHYSICAL SURVEY AREA
- GEOPHYSICAL ANOMALY
- GAS — FORMER GASOLINE PIPE LINE

NOTE: AT LOCATIONS WHERE MULTIPLE SAMPLES WERE TAKEN, THE HIGHEST RESULT IS SHOWN.
ANALYTICAL SAMPLE RESULTS REPORTED IN mg/Kg
SOURCE: McCLINTOCK LAND ASSOCIATES/TERRASAT

0 80 160
APPROXIMATE SCALE IN FEET

Approximate boundary of Area for Remedial Action. Used for impacted area and volume calculations and is based on data from ENSR 2003a and USACE 2006. All sampling data and analytical results not shown.

Base map prepared for USACE by ENSR and presented in "2000 Remedial Investigation Report-RI/FS, Yakutat Area, AK". Modified by Shannon & Wilson for 2010 Feasibility Study.

Former Yakutat Air Force Base
Yakutat, Alaska

AOC M1 AND M2 SITE PLAN

July 2010 | 32-1-17268-002

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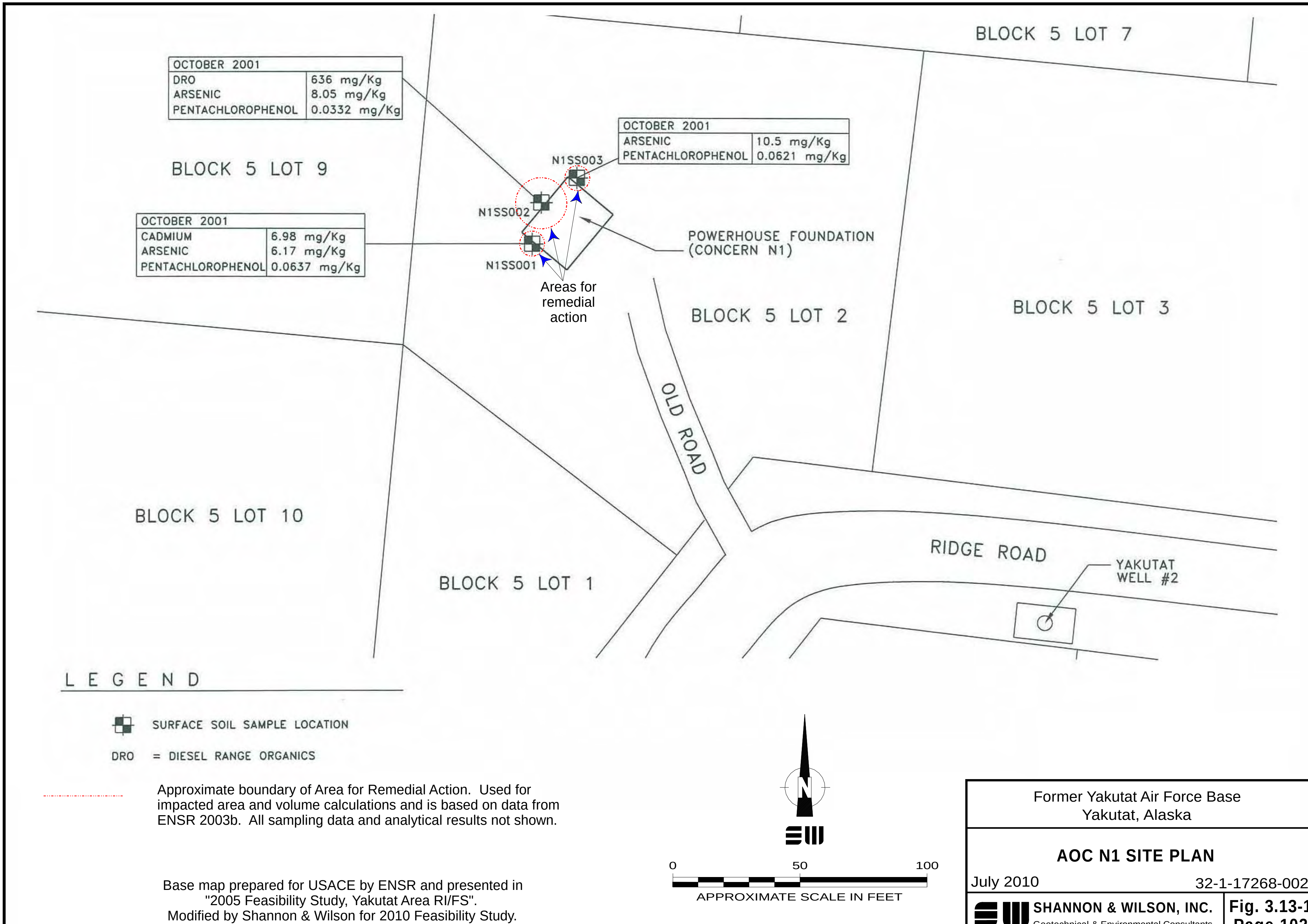
Fig. 3.12-1



LEGEND

SURFACE SOIL SAMPLE LOCATION

DRO = DIESEL RANGE ORGANICS

Approximate boundary of Area for Remedial Action. Used for impacted area and volume calculations and is based on data from ENSR 2003b. All sampling data and analytical results not shown.

Base map prepared for USACE by ENSR and presented in "2005 Feasibility Study, Yakutat Area RI/FS". Modified by Shannon & Wilson for 2010 Feasibility Study.

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Yakutat, Alaska

AOC N1 SITE PLAN

July 2010 32-1-17268-002

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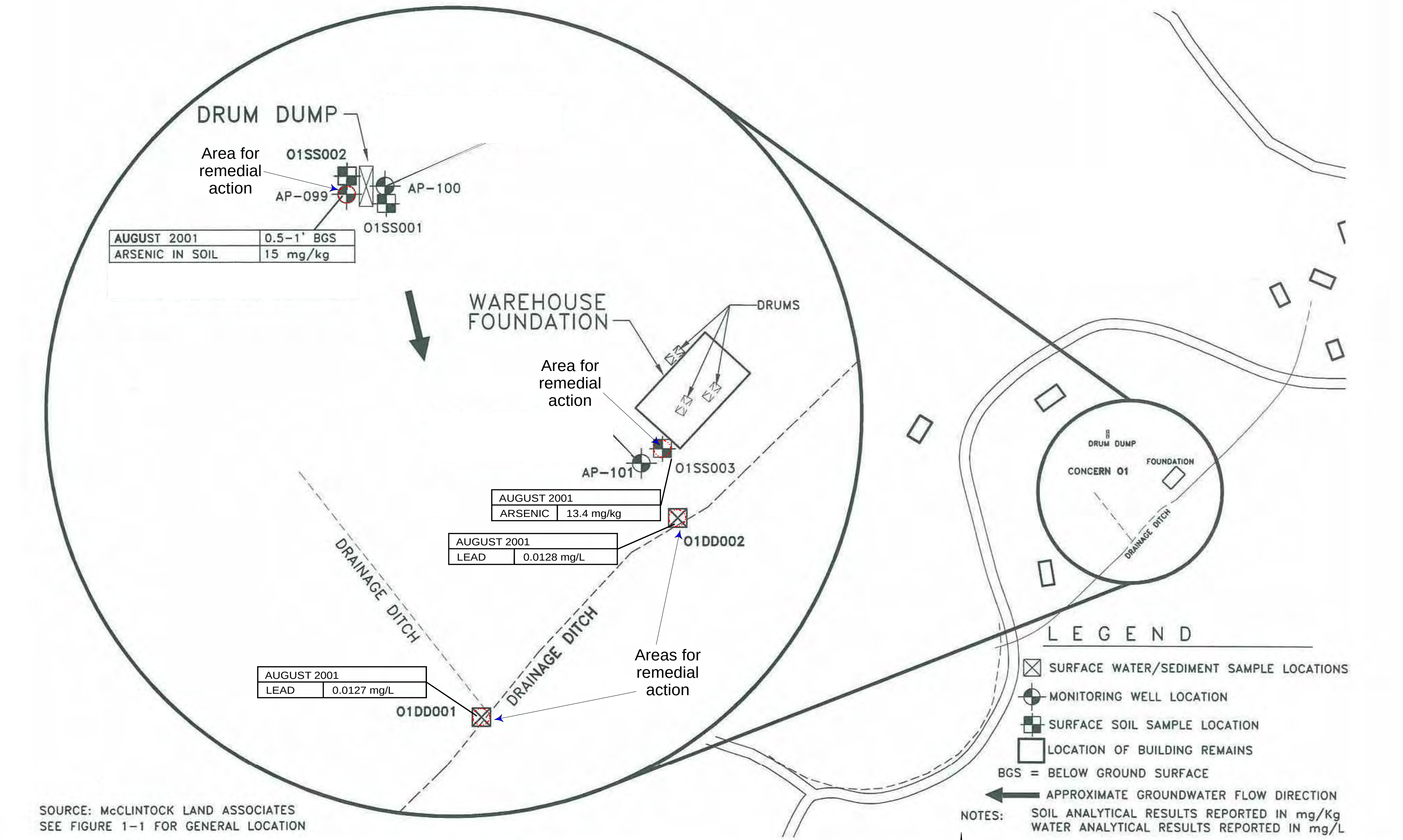
Fig. 3.13-1



Approximate boundary of Area for Remedial Action. Used for impacted area and volume calculations and is based on data from ENSR 2003b. All sampling data and analytical results not shown.

Base map prepared for USACE by ENSR and presented in "2001 Remedial Investigation Report-Final-RI/FS, Yakutat Area, AK". Modified by Shannon & Wilson for 2010 Feasibility Study.

0 80 160
APPROXIMATE INSET SCALE IN FEET

0 400 800
APPROXIMATE SCALE IN FEET

N

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Yakutat, Alaska

AOC O1 SITE PLAN

July 2010 32-1-17268-002

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Fig. 3.14-1
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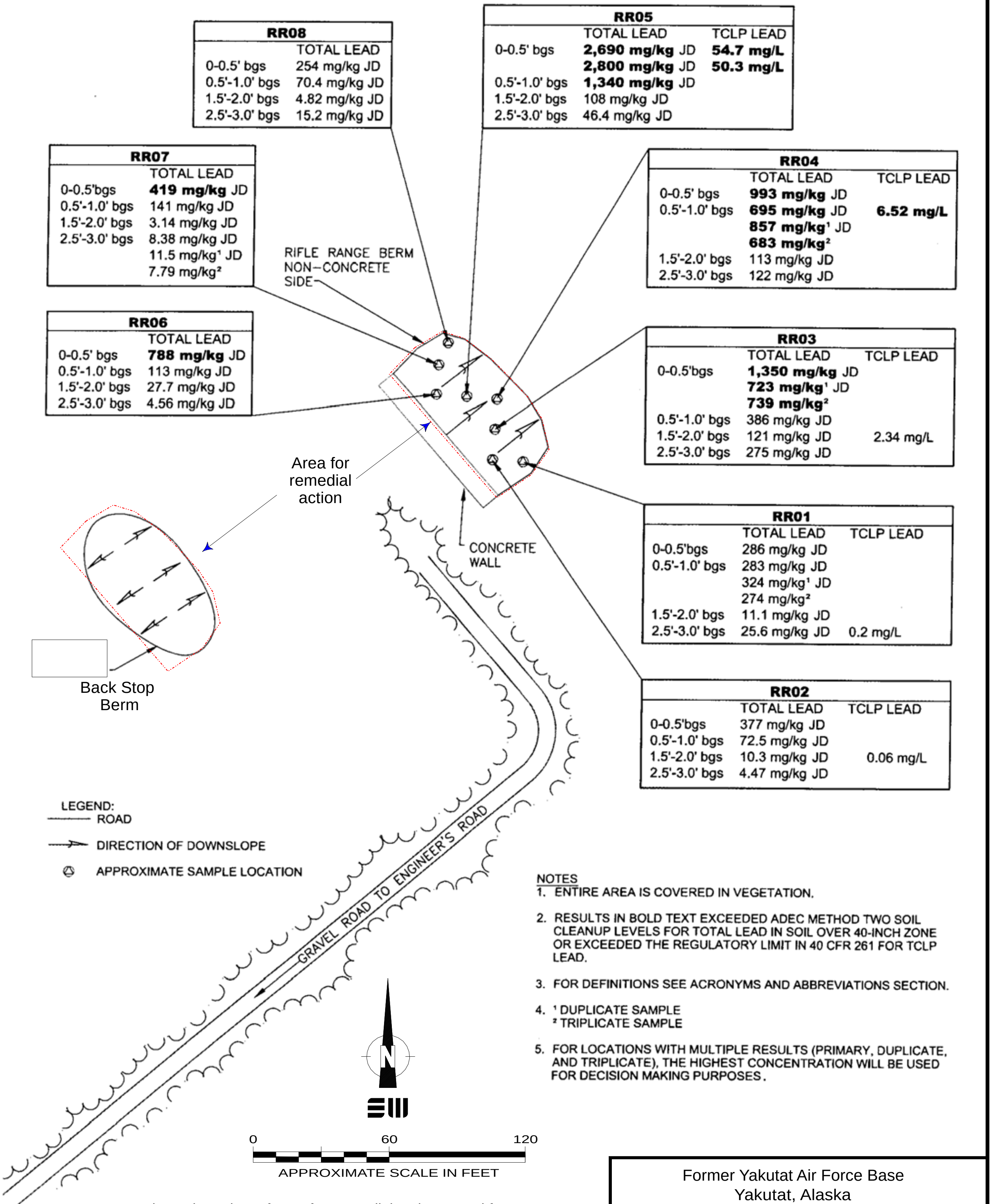

NOTES
1. ENTIRE AREA IS COVERED IN VEGETATION.
2. RESULTS IN BOLD TEXT EXCEEDED ADEC METHOD TWO SOIL CLEANUP LEVELS FOR TOTAL LEAD IN SOIL OVER 40-INCH ZONE OR EXCEEDED THE REGULATORY LIMIT IN 40 CFR 261 FOR TCLP LEAD.
3. FOR DEFINITIONS SEE ACRONYMS AND ABBREVIATIONS SECTION.
4. ¹ DUPLICATE SAMPLE
   ² TRIPLICATE SAMPLE
5. FOR LOCATIONS WITH MULTIPLE RESULTS (PRIMARY, DUPLICATE, AND TRIPLICATE), THE HIGHEST CONCENTRATION WILL BE USED FOR DECISION MAKING PURPOSES.

Approximate boundary of Area for Remedial Action. Used for impacted area and volume calculations and is based on data from BC-J 2007. All sampling data and analytical results not shown.

Base map prepared by BC Contractors and Jacobs for USACE and presented in "Former Yakutat Air Force Base Remedial Investigation Report" March 2007. Modified by Shannon & Wilson for 2010 Feasibility Study.

Former Yakutat Air Force Base
Yakutat, Alaska

AOC RIFLE RANGE SITE PLAN

July 2010 32-1-17268-002

SHANNON & WILSON, INC.
Geotechnical & Environmental Consultants

Fig. 3.17-1

4.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

The primary objective of identification and screening of technologies is to develop a range of appropriate remedial alternatives for the 28 AOCs at the former Yakutat AFB that can be analyzed more fully in the detailed analysis. Appropriate remedial alternatives satisfy the project's remedial action objectives (RAOs) of protecting human health and the environment by addressing the COC exposure pathways. RAOs may be accomplished through use of engineering and/or institutional controls, reducing the concentrations of COCs to levels below ARARs, and/or eliminating non-viable exposure pathways. A summary of the initial screening of remedial technologies is provided in Table 4.0-1.

4.1 Affected Media and COCs Summary

Based on previous investigations and site histories, 28 AOCs with one or more discrete COC-impacted areas have been identified at the former Yakutat AFB. The COCs identified at the AOCs include those chemicals that were detected at concentrations that exceed the established ARARs. Media affected by these COCs include surface soil, subsurface soil, sediment, surface water, and groundwater. The most common COCs identified are petroleum hydrocarbon constituents and include GRO, DRO, benzene, toluene, 2-methylnaphthalene, chrysene, phenanthrene, pyrene, benzo(a)pyrene, and benzo(a)anthracene. Petroleum hydrocarbon COCs were encountered in surface soil, subsurface soil, sediment, surface water, and/or groundwater. The metals arsenic, barium, cadmium, chromium, lead, mercury, and silver were also identified as COCs and were encountered in surface soil, subsurface soil, sediment, and/or surface water. In addition, a mixture of multiple COC types including DRO, pentachlorophenol, SVOCs, and/or metals were detected in surface and subsurface soil and sediment. PCBs and dioxins were identified as COCs, each at one AOC in surface water. Bis(2-ethylhexyl)phthalate was also identified as a COC but was later removed as a COC because it is also a common laboratory contaminant generated by overheating lab ware. The COCs identified and the media affected are listed in Table 4.0-1.

4.2 Remedial Action Objectives

Acceptable protection of human health and the environment at the AOCs is typically defined by risk thresholds for complete exposure pathways. Project RAOs were identified as means to protect human health and the environment by addressing the COC exposure pathways, and may be accomplished through use of engineering and/or institutional controls, reducing the concentrations of COCs to levels below ARARs, and/or research or data collection to eliminate non-viable exposure pathways. The ARARs, used as measurable criteria to assess compliance with RAOs, were developed based on risk to human health and the environment and comprise promulgated and recommended standards published by agencies and background levels for several metals.

The RAOs for surface and subsurface soil and sediment will be accomplished by reducing exposure through potential:

- ingestion and/or direct contact with soil containing COCs;
- inhalation of COCs that volatilize from soil to outdoor and indoor air; and,
- migration of COCs to groundwater or surface water.

The RAOs for surface water and groundwater will be accomplished by reducing exposure through potential:

- ingestion and/or direct contact with surface water containing COCs;
- ingestion and/or direct contact with groundwater containing COCs; and
- inhalation of COCs that volatilize from groundwater to outdoor and indoor air.

4.3 General Response Actions

General response actions were selected based on their potential for achieving the remedial action objectives and include No Action, Institutional Controls and various treatment actions. The treatment actions considered in the FS are listed by medium.

4.3.1 No Action/Institutional Controls

For each medium to be addressed at the AOCs, No Action and Institutional Controls will be considered as alternate responses to remedial action. Based on Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) guidance, the No Action option is included due to its ability to provide a baseline for comparing other alternatives.

Institutional Controls are a limited-action option that may comprise a discrete response alternative, but may also be incorporated into other integrated remedial alternatives to prevent or limit exposure to COCs. A description of Institutional Controls is provided in 18 AAC 75.375 and *Institutional Controls and Transfer of Real Property under CERCLA* (EPA 2007). In accordance with the ADEC guidance document, institutional controls may consist of fences, signs, liners, caps, easements, restrictive covenants, deed restrictions, deed notices, and/or zoning ordinances. Institutional controls may need to be implemented to increase the probability that exposure to human and environmental receptors is within protective levels and/or provide safeguards to preventing specific exposure scenarios. Institutional controls should be designed/selected to be effective in preventing human or environmental exposure to hazardous substances that remain on site above levels which allow unrestricted use. The responsible party or owner of the property must demonstrate that certain procedures are in place, or will be put in place, that will provide sufficient basis for determining that the institutional controls will perform as expected in the future. Such procedures include the means for:

- Monitoring the institutional controls' effectiveness and integrity;
- Reporting the results of such monitoring, including notice of any violation or failure of the controls; and
- Enforcing the institutional controls should such a violation or failure occur.

It is expected, for this FUDS project, that USACE, ADEC and the land owner will work together to develop the appropriate institutional controls. The cost to implement Institutional Controls is typically low relative to active remediation. Due to its ability to prevent or limit exposure to COCs remaining at an AOC and low cost, Institutional Controls will be retained as a potential remediation alternative for detailed analysis.

4.3.2 Treatment Actions

Treatment actions considered in this assessment for surface and subsurface soil and sediment are:

- Biological treatment
- Chemical treatment
- Physical removal
- Thermal treatment
- Containment
- Excavation and Disposal
- Monitored Natural Attenuation

Treatment actions considered in this assessment for surface water are:

- Monitored Natural Attenuation

Treatment actions considered in this assessment for groundwater are:

- Biological treatment
- Physical removal
- Monitored Natural Attenuation

4.4 Identification and Screening of Remedial Technologies

Potential remedial technologies identified for further evaluation are presented in Table 4.0-1. These technologies were selected based on media affected and COC type at each of the AOCs proposed for the Feasibility Study. Complete detailed descriptions of these potential remedial alternatives are provided in Appendix B. The detailed descriptions in Appendix B were obtained from the Remediation Technologies Screening Matrix and Reference Guide, Version 4.0 created for the U.S. DoD and other Federal Agencies participating in the Federal

Remediation Technology Roundtable (FRTR). The description of Passive Bioventing in Appendix B was obtained from the *Design Document for Passive Bioventing* (ESTCP 2006). Many of the AOCs have the same media affected by similar type COCs; therefore, technologies were initially screened for each medium and for each COC type that are common to more than one AOC. Potential remedial technologies listed on Table 4.0-1 were selected for screening based on our experience at other similar sites. These technologies are screened for their effectiveness, implementability, and cost to accomplish the remedial action objectives. The remedial action objectives are the reduction, destruction, or containment of COCs at the 28 AOCs in the affected media which include surface soil, subsurface soil, sediment, surface water, and groundwater. The identified remedial technologies for a given media are evaluated relative to other processes in the same media.

The effectiveness evaluation focuses on whether the individual technologies can handle the estimated areas or volumes; meet the remedial action objectives; have potential impacts to human health and the environment during construction and implementation; and whether they are reliable with respect to the contaminant properties and impacted media conditions at the AOCs.

The purpose of the implementability evaluation is to eliminate those technologies that are clearly unworkable at a site. Considerations include the availability of necessary equipment and workers to implement the technology; the availability of treatment, storage, and disposal services (including capacity); logistics; and the ability to obtain necessary permits for on or off-site actions.

The cost analysis reviews relative capital, operation, and maintenance costs between the technologies and draws conclusions based on engineering judgment as to whether costs are high, low, or medium relative to other options.

4.5 Remedial Technologies Screening for Soil and Sediment

The remedial technologies applicable to reducing, destroying, and/or containing COCs in surface and subsurface soil and sediment at the 28 AOCs are discussed in the following sections. Complete descriptions of the individual technologies presented are provided in Appendix B. Those technologies determined to be appropriate for further screening are indicated on Table 4.0-1 along with the rationale for those deemed inappropriate for further screening.

4.5.1 Enhanced Bioremediation

Enhanced bioremediation stimulates naturally occurring microbes by circulating water-based solutions through contaminated soils to speed up the biological degradation of organic contaminants. Nutrients (nitrogen, phosphate, and potassium), or other amendments may be used in the aerobic process. Aerobic bioremediation techniques have been effectively used to remediate soils contaminated with DRO, GRO, VOCs, and SVOCs. Anaerobic bioremediation may be effective to remediate soils contaminated with pentachlorophenol. Enhanced bioremediation is not effective on soils contaminated with metals. Due to lack of oxygen supply to the subsurface soil and submerged sediments, enhanced bioremediation should be considered a surface soil treatment alternative. Enhanced bioremediation, however, can work in subsurface soil as long as there is oxygen in the soil voids. Cold weather climates slow the bioremediation process. Enhanced bioremediation is a commonly used process that is readily implementable. Prior to beginning this type of treatment, additional information would be required, such as nutrient distribution in native soil and the presence of oil-degrading bacteria. Bench scale and possibly pilot scale studies are typically conducted to design the system. The cost to implement enhanced bioremediation is low to moderate.

Due to Yakutat's climate and cold temperatures that may hinder effectiveness of this technology, this option will not be retained as a discrete remediation alternative for detailed analysis. Principles of enhanced bioremediation will be retained, however, for detailed analyses in conjunction with bioventing, passive bioventing, and biopiles.

4.5.2 Bioventing

Bioventing provides oxygen to impacted, unsaturated soil to stimulate the natural, in-situ biodegradation of aerobically degradable compounds in soil by existing soil microorganisms. Forced air movement through either extraction or injection of air is used to supply oxygen. Oxygen promotes biodegradation of DRO, GRO, VOCs, and SVOCs. GRO and VOCs are also biodegraded as vapors move through biologically active soil. Bioventing is not effective on soils contaminated with metals. Bioventing is considered an appropriate technology for treating petroleum-impacted surface and subsurface soil. Bioventing is not considered appropriate for treating submerged sediment. Bioventing requires air-injection wells and a blower system at the surface. Some initial soil and oil-degrading bacteria data would be useful, as with enhanced bioremediation, and a bench scale or pilot test would be advisable. Depending on soil conditions and area to be remediated, bioventing costs may be moderate to moderately high.

Effectiveness may also be limited by cold temperatures. However, due to its advantages relative to other biological treatment technologies, bioventing will be retained as a potential remediation alternative.

4.5.3 Passive Bioventing

Passive bioventing provides oxygen to impacted, unsaturated soil to stimulate the natural, in-situ biodegradation of aerobically degradable compounds in soil by existing soil microorganisms. Passive air movement through aeration wells is used to supply oxygen to the subsurface. Passive bioventing uses the difference in gas pressure that develops between the atmosphere and the subsurface to drive air through vent wells and into the contaminated subsurface zone. Passive ventilation may be a cost-effective option, particularly for remote access sites. Oxygen promotes biodegradation of DRO, GRO, VOCs, and SVOCs. GRO and VOCs are also biodegraded as vapors move through biologically active soil. Passive bioventing is not effective on soils contaminated with metals. Passive bioventing is considered an appropriate technology for treating petroleum-impacted surface and subsurface soil. Passive bioventing is not considered appropriate for treating submerged sediment. Passive bioventing requires the installation of aeration wells/points but, unlike conventional bioventing, does not require blowers, electricity, manifold piping, or maintenance and operation. Some initial soil and oil-degrading bacteria data would be useful, as with enhanced bioremediation and active bioventing. A pilot test would be advisable to evaluate the radius of influence of aeration wells. Passive bioventing costs are low.

Effectiveness is limited by cold temperatures and the limited supply of oxygen. However, due to its low costs and potential use at remote sites, passive bioventing will be retained as a potential remediation alternative.

4.5.4 Biopiles

This is an ex-situ method in which contaminated material is removed and transported to a treatment cell. A biopile is a treatment cell in which petroleum-impacted soil is placed and moisture, heat, nutrients, oxygen, and pH can be controlled to enhance biodegradation. Excavated soil is mixed with amendments, as with enhanced bioremediation, and placed in the treatment cell that includes a leachate collection system and a method of providing oxygen. Biopile technology can be effectively used to degrade hydrocarbons in soil. Biopiles are not effective on soils contaminated with metals. The biopile process can combine aspects of enhanced bioremediation and bioventing, except that it is accomplished ex-situ. Biopiles require standard heavy equipment used for excavation and transport of soil. Excavation of impacted soil can generally be accomplished to a depth of about 15 feet bgs or to groundwater whichever occurs first. The cost to implement biopiles would be moderate.

Due to its effectiveness and implementability for treating petroleum-impacted surface soil, subsurface soil, and sediment to depths of about 15 feet bgs, biopiles will be retained as a potential remediation alternative for detailed analysis.

4.5.5 Landfarming

In landfarming, contaminated soil or sediment is excavated, placed into lined beds, and periodically turned over or tilled to aerate. Remediation is accomplished through biodegradation and volatilization. Landfarming has been an effective method to treat hydrocarbon-impacted soil at numerous locations around the world. However, a limitation in Yakutat would be the high annual precipitation, which would tend to leach nutrients from the soil, thereby requiring frequent amendments to keep the biological processes going. Landfarming is not effective on soils contaminated with metals. Landfarming is easily implemented, requiring earth moving equipment and amendments to enhance microbial activity. The cost for landfarming is low to moderate.

Due to high precipitation rates in the Yakutat area and potential difficulty to implement in cold temperatures, landfarming will not be retained as a remedial alternative for the detailed analysis.

4.5.6 Phytoremediation

Phytoremediation uses plants to remove, transfer, stabilize and destroy organic and inorganic contamination in surface soil, sediment, surface water, and groundwater. Phytoremediation can be an effective technology to remediate soil impacted by petroleum hydrocarbons and in treating soil with heavy metals by uptake through plant roots. The technology is limited by depth to which the roots can penetrate into the subsurface. Phytoremediation is easily implemented but is a long-term method. Phytoremediation for soil is relatively low cost.

Due to its long-term requirement and limited depth of effectiveness, phytoremediation will not be retained as a remedial alternative for the detailed analysis.

4.5.7 Fenton's Reagent Oxidation

Oxidation by application of Fenton's reagent is an in-situ technology that chemically converts hazardous contaminants to non-hazardous or less toxic compounds that are more stable, less mobile, and/or inert. Oxidation using hydrogen peroxide solution in the presence of ferrous iron produces Fenton's Reagent oxidation. Oxidation can result in the rapid and complete chemical destruction of many toxic organic chemicals, provided the reagent can be effectively delivered to the contaminated media. This technology can be applied to surface and sub-surface soil impacted with petroleum hydrocarbon contaminants. This technology is not being considered for water-saturated sediments. Oxidation is not effective on soils contaminated with metals. It may be necessary to install wells for delivery of the reagent to the contaminated intervals. With up to 50 percent hydrogen peroxide solution, safety is also a consideration. The cost for implementing this remedial option is moderate.

Due to its effectiveness, implementability, and moderate cost for treating petroleum-impacted surface soil and subsurface soil, Fenton's Reagent Oxidation will be retained as a potential remediation alternative for detailed analysis.

4.5.8 Dehalogenation

The dehalogenation process is achieved by either the replacement of the halogen molecules or the decomposition and partial volatilization of the contaminants. Dehalogenation is effective in chemically transforming halogenated hydrocarbons in soil to more inert compounds. For the purpose of this discussion, we assume that contaminated soil/sediment would be excavated, screened, processed with a crusher and pug mill, mixed with a reagent, and heated in a reactor to acheive dehalogenation. The only halogenated hydrocarbon present in Yakutat is pentachlorophenol, and has been detected in surface soil, subsurface soil, and sediment. Sediment would require dewatering, which would likely produce contaminated water that would require treatment and/or disposal. The dehalogenation process would require that special equipment be mobilized to the site. The necessary equipment is readily available in Alaska. A limiting factor in Yakutat, even in surface or sub-surface soil, may be the high moisture content in the soil. The cost to install and operate a dehalogenation system may be moderate to high.

Due to the potentially high moisture content of soil and sediment and the moderate to high costs to implement, dehalogenation will not be retained as a potential remediation alternative for detailed analysis

4.5.9 Soil Vapor Extraction (SVE)

With soil vapor extraction (SVE), a vacuum is applied to the subsurface to create a pressure/concentration gradient that strips volatiles from soil. This technology also is known as in situ soil venting, in situ volatilization, enhanced volatilization, or soil vacuum extraction. SVE is most effective when treating soil contaminated by volatile organics. Although some GRO and benzene contamination has been reported at the various AOCs, the majority of the hydrocarbon impact is from DRO, which have limited volatility. SVE is not effective on soils contaminated with metals. SVE may be used in conjunction with other technologies, such as air sparging, to enhance their effectiveness. The cost for installing and operating SVE systems may be moderate to high.

Due to the low volatility of the majority of site contaminants, SVE will not be retained as a discrete option for detailed analysis. SVE principles will be retained, however, in integrated alternatives with soil heating and air sparging.

4.5.10 Acid Extraction

Acid extraction is a means of separating metals from soils, thereby reducing the volume of the impacted soil that must be treated. The technology uses acid as an extracting chemical. As with soil washing, physical separation steps are often used before chemical extraction to grade the soil into coarse and fine fractions, with the assumption that the fines contain most of the contamination. Acid extraction can be effective in removing metals from soil in specific circumstances. A drawback is the need for neutralization and disposal of the metal-containing liquid. Commercial units are available to acid treat soil. Availability of these units and mobilization to Yakutat may be difficult. Costs for acid treatment can be high, decreasing with volume of soil requiring treatment.

Due to the need to dispose of the acid solution and associated high cost, acid treatment will not be retained as a potential remediation alternative for the detailed analysis.

4.5.11 Soil Washing

Soil washing is an ex-situ, fluid-based process for chemically or physically removing contaminants from soil. Soil washing processes grade soil into separate size fractions to concentrate the contamination into a smaller volume. Coarse material (gravel) can be screened from the excavated soil and may be returned to the excavation unless it contains contaminant particles, such as lead bullets or shot found at rifle and/or skeet ranges. Medium-sized particles (sand) can be concentrated into a smaller volume using water for particle size separation, gravity separation, and attrition scrubbing. Finer particles (silt) can be dissolved or suspended in a non-acidic chemical wash solution which is further treated on site with the technology(s) suitable for the contaminants or disposed of off site. Soil washing is generally considered a media transfer technology, i.e. contaminants are not destroyed, and can be effective in removing hydrocarbon and metal contaminants from soil. Soil washing can be effective with soil grain sizes ranging from fine to coarse sand (about 0.24 to 2 millimeters), but does not work well with finer grained soil such as silt and clay. One limitation is that the effectiveness of soil washing decreases the more a metal is sorbed to soil. With the appropriate chemical wash solution, however, soil washing can be effective for removing lead such as from a battery acid release to soil.

Soil washing can be an effective technology for removing lead bullets or shot from soil at a shooting range by concentrating the lead particles into a smaller volume. This is accomplished using water for particle size separation, gravity separation, attrition scrubbing and mineral jigging similar to those techniques used in sand and gravel and precious metal recovery operations.

Soil washing may be difficult to implement on the scale that would be required to treat the hydrocarbon contaminants in soil at the various AOCs in Yakutat. Excavation of metals-impacted soil and sediment can generally be accomplished to a depth of about 15 feet bgs or to groundwater whichever occurs first. The cost to implement this alternative may be high for hydrocarbon contaminants but moderate to high for metal contaminants in soil.

Due to its relative effectiveness and potentially moderate cost, soil washing will be retained as a remediation alternative for treating metals-contaminated surface soil, subsurface soil, and sediment.

4.5.12 Electrokinetic Remediation

Electrokinetic remediation is a process in which a low-intensity, direct current is applied through the soil between electrodes that are divided into a cathode array and an anode array. This mobilizes charged species, such as metal ions, ammonium ions, and positively charged organic compounds, and directs them toward the cathode. Electromigration is the main mechanism for the electrokinetic process. This is an effective method for removing metals from soils under appropriate conditions. Moisture content of less than 18% is required. Metals in the sub-surface, such as pipelines or drums or other metallic debris may hinder the effectiveness of this method. This method is most effective in low-permeability soil, such as clay. There are no major obstacles to physically implementing this technology in surface and sub-surface soil, but it could not be used for saturated sediments. The cost to implement this option may be relatively high.

Due to the limited effectiveness in surface soil and subsurface soil, the potential for excessive moisture content in soil, the inability to implement the method for sediments, and the relatively high cost, electrokinetic remediation will not be retained as a potential alternative for the detailed analysis.

4.5.13 Soil Heating

Soil heating is an in-situ method that uses heat to stimulate the volatilization of hydrocarbons. Three types of soil heating methods are typically implemented including six-phase soil heating, hot air/steam injection and thermal conduction. Heat is produced by injection of steam or hot air, or by an electrical means. If the produced heat is not excessive, biodegradation may also be enhanced. Soil heating systems are typically combined with SVE systems for vapor removal; however, under the right conditions SVE wells may not be required. Soil heating can be effective for both surface and sub-surface soil. Heterogeneous soil or soil with high carbon content may limit the effectiveness. High moisture content would enhance the performance of a soil heating system. This option is physically implementable, but would require transport of specialized equipment to the site for steam, hot air, electrical heat or electrical current generation. The cost may be moderate to high, depending on the area of contamination, the soil conditions and type of soil heating method implemented. This technology would not be appropriate for sediments. Also, soil heating is not effective on soils contaminated with metals.

Due to the effectiveness, implementability, potentially short-term duration, and the potentially moderate cost for treating petroleum-impacted surface and subsurface soil, soil heating using thermal conduction will be retained as a potential remediation alternative for detailed analysis.

4.5.14 Incineration

Incineration is an ex-situ technology that employs high temperatures to volatilize and combust organics and metals in contaminated soil. Off-gases and combustion residuals may require treatment. This is an effective method for soils impacted with petroleum constituents. Difficulties that may arise are the treatment of off-gases and frequent cleaning of the equipment when volatile metals such as arsenic are present. This method can physically be implemented; however, the necessary equipment would need to be transported to Yakutat. Excavation of impacted soil can generally be accomplished to a depth of about 15 feet bgs or to groundwater whichever occurs first. In the case of sediments, drying or other means of de-watering would likely be required. The latter may produce contaminated water, which would then require additional treatment or disposal. The cost to implement this technology at a remote site such as Yakutat would be relatively high.

Due to the high cost for treating petroleum-impacted surface soil, subsurface soil, and sediment, incineration will not be retained as a potential remediation alternative for detailed analysis.

4.5.15 Low Temperature Thermal Desorption (LTTD)

Thermal desorption is an ex-situ physical separation process. Soil is heated to between 90 °C and 320 °C (200 °F to 600 °F) to volatilize water and organic contaminants. Contaminant destruction efficiencies in the afterburners of LTTD units may be greater than 95%. LTTD is effective in treating surface soil, subsurface soil and sediment contaminated with non-halogenated hydrocarbons. It uses temperatures up to about 320˚F. This method is not designed to destroy contaminants, but rather separates them from the soil. High moisture content would limit the effectiveness of this option for sediments unless dewatering occurs first. LTTD systems and qualified personnel needed to operate the system should be available for transport and mobilization to Yakutat. Excavation of impacted soil can generally be accomplished to a depth of about 15 feet bgs or to groundwater whichever occurs first. Cost to implement LTTD is expected to be moderate if the process is conducted on site. LTTD is not effective on soils contaminated with metals.

Due to its effectiveness, implementability, and potentially moderate cost for treating petroleum-impacted surface soil, subsurface soil, and sediment to depths of about 15 feet bgs, LTTD will be retained as a potential remediation alternative for detailed analysis.

4.5.16 Solidification

Solidification/stabilization is a process that does not remove or destroy contaminants, but rather reduces the mobility of contaminants by both physical and chemical means. Solidification/stabilization techniques may be used alone or combined with other treatment and disposal methods to yield a material suitable for land disposal or retention on site.

Solidification/stabilization of soil impacted with metals can be effective in reducing the risk of migration to other media and would reduce risk to potential receptors through ingestion or inhalation. At the Yakutat AOCs, most of the excessive metals concentrations are in surface soil. Solidification/stabilization would likely effectively limit future use of considerable areas of land remediated in this way.

Solidification/stabilization may be used as a remedial option for both organics and inorganics. Implementation for surface soil would not be difficult. It would necessarily be limited to surface or near surface soil. This would not be an appropriate remedial response for sediments. Vegetation would likely need to be cleared and removed from contaminated areas prior to treatment. High precipitation may also hinder efforts to implement this option. The cost for implementing this option would be moderate for surface soil, and would increase for deeper soils, depending on the method of solidification.

Solidification/stabilization will be retained as a potential remediation alternative for the detailed analysis.

4.5.17 Capping

Capping is an in-situ process wherein an impervious cover is engineered and placed over the contaminated area to prevent direct contact by potential receptors and to act as a barrier that prevents percolation of precipitation into contaminated soil (not appropriate for sediment). Caps may be soil or concrete, and must typically achieve a permeability of 10^{-5} centimeters per second, or less. Contaminants are not destroyed by this option, and institutional controls would likely be required. Capping is an effective containment method to prevent direct contact with contaminated soil. This option is relatively simple to implement. Long-term monitoring and maintenance may be required. The cost to implement this option may be low to moderate.

Capping will be retained as a potential remediation alternative for detailed analysis.

4.5.18 Excavation and Off-Site Disposal

This is an ex-situ method in which contaminated material is removed and transported to permitted, off-site treatment and/or disposal facilities. Excavation of impacted soil can generally be accomplished to a depth of about 15 feet bgs or to groundwater whichever occurs first. The depth limitation is due to the need to slope the sidewalls of the excavation which are generally cut back at about 1 foot horizontal to 1 foot vertical. An excavation deeper than 15 feet requires significant expansion outward to maintain the 1:1 side slopes that it is generally considered impractical with respect to cost. Some pretreatment of the impacted soil (e.g. lead contaminated soil at the Rifle Range) may be required in order to meet land disposal restrictions. Excavation and disposal is an effective remedial option that has been used extensively throughout the world. Equipment and personnel needed to implement this alternative may be available in Yakutat. Appropriate off-site disposal facilities are located in Washington, Oregon, and Idaho. Costs for this option may be moderate for small sites to very high for larger sites, primarily due to transportation and disposal costs.

Due to its effectiveness and ease for implementation for treating impacted surface soil, subsurface soil, and sediment, excavation and off-site disposal will be retained as a potential remediation alternative for detailed analysis.

4.5.19 Monitored Natural Attenuation

Monitored natural attenuation does not employ active remedial actions but allows the natural attenuation processes to continue to remediate impacted soil and sediment. Long-term monitoring would be required to assess the performance of the natural attenuation processes. Petroleum COCs will degrade in the natural environment, given sufficient oxygen, nutrients, and bacterial organisms. Natural attenuation of petroleum COCs may also include physical degradation processes such as advection and diffusion. Pentachlorophenol may also biodegrade but would typically require anaerobic conditions. Metals would not normally degrade by natural processes.

Remedial actions performed with monitored natural attenuation include advancing long-term monitoring and confirmation test pits and/or soil borings. These actions are readily implemented by mobilization of the appropriate equipment and personnel to Yakutat. Institutional and/or engineering controls may also be required at AOCs using monitored natural attenuation until ARARs are achieved. The cost for monitored natural attenuation is dependent on the number of confirmation test pits and/or borings advanced and time requirements for long-term monitoring that would be necessary at each AOC. Initial costs may be low, depending on the area of contamination and the performance of the natural processes, but will increase as the time required to perform long-term monitoring lengthens.

Due to its potential effectiveness for treating petroleum-impacted soil and sediment using natural processes and relatively low cost, monitored natural attenuation will be retained as a potential remediation alternative for detailed analysis.

4.6 <u>Remedial Technologies Screening for Surface Water</u>

Surface water contamination is likely due to dissolution of adsorbed contaminants from sediment, or surface water runoff from sites with impacted surface soil. If the sediment and surface soil at each impacted location is addressed, the surface water contamination observed would likely be reduced. The remedial technologies applicable to reducing and/or containing COCs in sediment and surface soil are discussed in the previous section. Complete descriptions of the individual technologies presented are provided in Appendix B. Final determination on appropriateness of surface water treatment technologies for detailed analysis is indicated on Table 4.0-1 along with the rationale for those determinations.

4.7 Remedial Technologies Screening for Groundwater

The remedial technologies applicable to reducing and/or containing COCs in groundwater at the applicable AOCs are discussed in the following sections. Complete descriptions of the individual technologies presented are provided in Appendix B. Final determination on appropriateness of technologies for detailed analysis is indicated on Table 4.0-1 along with the rationale for those determinations.

4.7.1 Nutrient Amendment

Nutrients (nitrogen, phosphate, and potassium) may be added to groundwater to stimulate naturally occurring microbes and increase the rate of biological degradation of organic contaminants. In addition, hydrocarbon-metabolizing bacteria may also be introduced to supplement the indigenous population of bacteria. Aerobic and/or anaerobic biological degradation has been effectively used to remediate groundwater contaminated with DRO, GRO, and VOCs. This alternative may be effective, provided concentrations of contaminants are not at levels toxic to the bacteria. This alternative is readily implemented, particularly for smaller areas of contamination. Cold weather climates slow aerobic biological degradation processes. Additional groundwater data will likely be required to determine the existing conditions with regard to the biodegradation process, and to determine what amendments would be required for optimization. Additional wells may be required for adequate coverage of the contaminated groundwater plume. The cost to implement nutrient amendment is low to moderate.

Based on the USACE's experience, nutrient amendment has not contributed to the successful treatment of petroleum-impacted groundwater and will not be retained as a discrete remediation alternative for detailed analysis. Nutrient amendment will be retained, however, as an integrated component of the air sparging remedial alternative.

4.7.2 Air Sparging/Soil Vapor Extraction

Air sparging is an in-situ technology in which air is injected into a contaminated aquifer. Air movement induces volatilization of contaminants and provides oxygen to promote aerobic biodegradation of organic contaminants. Nutrient amendments and additional petroleum hydrocarbon-metabolizing organisms can also be introduced. Air sparging has been used effectively in Alaska to remediate groundwater impacted with petroleum hydrocarbons. Air is forced into the water-bearing zone soil using air-injection wells. As air moves through the saturated soil within the zone of influence of the air injection wells, volatile organic contaminants are stripped from the water. Using a SVE system in conjunction with air sparging will enhance the process by increasing flow through the groundwater, controlling gas/vapor movement through the subsurface, and capture volatiles before they escape at the surface. The drill rig used to install the air injection wells should be equipped with appropriate tools to penetrate to the depth of groundwater at AOC D. The cost to implement Air Sparging/SVE is moderate to high.

Due to its effectiveness, implementability, and potential moderate costs for treating petroleum impacted groundwater, Air Sparging/SVE will be retained as a potential remediation alternative for detailed analysis.

4.7.3 Air Stripping

Air stripping can be considered using both in-situ and ex-situ technologies. In-well air stripping is an in-situ process where air is injected into a vertical well that has been screened at two depths. The lower screen is set in the groundwater saturated zone and the upper screen is in the unsaturated zone. Air is injected into the well below the water table, aerating the water. The aerated water rises in the well, flows out of the system at the upper screen, and draws contaminated groundwater into the lower screen. VOCs vaporize within the well at the top of the water table and are drawn off by a SVE system. Ex-situ air stripping involves a process where groundwater is pumped from wells to the surface and passed through an air stripping tower to remove volatiles. Water treatment and disposal are components of an ex-situ air stripping system. For heavier, less volatile hydrocarbons such as DRO, air stripping would not be sufficient to reduce the concentrations of contaminants. Aerated groundwater would promote aerobic biodegradation of organic contaminants. This option is easily implemented and has been used effectively at other sites. Operation and maintenance on a weekly basis would likely be required. The cost to implement air stripping may be relatively high.

Due to the presence of non-volatile constituents in the groundwater such as DRO, in-well air stripping would not be effective and will not be retained as a potential remediation alternative for detailed analysis. Ex-situ air stripping at these sites has the same limitation, but has the additive disadvantage of needing process water treatment and disposal. Ex-situ air stripping will not be retained as a potential remediation alternative for detailed analysis.

4.7.4 Liquid-Phase Carbon Adsorption

Liquid-phase carbon adsorption is an ex-situ technology that involves pumping of contaminated groundwater from wells to the surface and passing it through scrubbers that contain activated carbon. Organic contaminants will preferentially adsorb to the activated carbon leaving the water clean. Carbon adsorption has been used for many years and has proven effective under specific conditions. Operation and maintenance on a weekly basis would likely be required. Cost to implement this option may be high due to disposal issues for both carbon and treated water and operation and maintenance.

Due to disposal requirements, high cost, and general effectiveness concerns associated with groundwater pump and treat systems, liquid-phase carbon adsorption will not be retained as a potential remediation alternative for detailed analysis.

4.7.5 Monitored Natural Attenuation

Monitored natural attenuation does not employ active remedial actions but allows the natural attenuation processes to continue to remediate impacted groundwater. Long-term monitoring would be required to assess the performance of the natural attenuation processes. Petroleum COCs will degrade in the natural environment, given sufficient oxygen, nutrients, and bacterial organisms. Natural attenuation of petroleum COCs may also include physical degradation processes such as advection and diffusion.

Remedial actions performed with monitored natural attenuation include advancing confirmation borings, installing new groundwater wells, and long-term monitoring. These actions are readily implemented by mobilization of the appropriate drill equipment and personnel to Yakutat. Institutional and/or engineering controls may also be required at AOCs using monitored natural attenuation until ARARs are achieved. The cost for monitored natural attenuation is dependent on the number of confirmation borings advanced, monitoring wells installed, and time requirements for long-term monitoring that would be necessary at each AOC. Initial costs may be low, depending on the area of contamination and the performance of the natural processes, but will increase as the time required to perform long-term monitoring lengthens.

Due to its potential effectiveness for treating petroleum-impacted soil, sediment, surface water, and groundwater using natural processes and relatively low cost, monitored natural attenuation will be retained as a potential remediation alternative for detailed analysis.

TABLE 4.0-1 - INITIAL SCREENING OF REMEDIAL TECHNOLOGIES

Affected Media	COC	ARARs	Remedial Action Objectives (RAOs)	General Response Action	Remedial Technology Type	Remedial Technology Process (See Appendix B)	Type	Media Addressed	COC Addressed	Selected Remedial Technology	Comments**
Surface Soil	GRO, DRO, VOCs (benzene and toluene), SVOCs (benzo(a)pyrene and benzo(a)anthracene), PCP, and metals (arsenic, cadmium, chromium, lead, and silver)	ADEC Method 2, 18 AAC 75 (October 2008), background concentrations for arsenic and chromium, and RCRA TCLP criteria for lead from Rifle Range.	1. Prevent ingestion and/or direct contact with soil containing COCs.	No Action	-	-	-	-	-	Y	Does not meet the RAOs; does not achieve ARARs; presented as a baseline for comparison purposes
				Institutional Controls	Institutional Controls	Institutional Controls	Ex-Situ	SS, S, Sd	DRO, GRO, VOCs, SVOCs, PCP, Metals	Y	Technically effective, low cost, limits future use of land; does not achieve ARARs
				Treatment/ Containment	Biological Treatment	Enhanced Bioremediation	In-Situ	SS	DRO, GRO, VOCs, SVOCs	N*	Low cost but uncertain effectiveness and may be difficult to implement due to cold temperatures
						Bioventing	In-Situ	SS, S	DRO, GRO, VOCs, SVOCs	Y	Moderately effective in subsurface soil; moderate cost
						Passive Bioventing	In-Situ	SS, S	DRO, GRO, VOCs, SVOCs	Y	Moderately effective in subsurface soil; low cost
						Biopiles	Ex-Situ	SS, S, Sd	DRO, GRO, VOCs, SVOCs	Y	Biopile management allows increased effectiveness relative to in-situ treatment but limited by excavation depth; moderate cost
						Landfarming	Ex-Situ	SS, S, Sd	DRO, GRO, VOCs, SVOCs	N	Climate (rainfall) reduces effectiveness; shallow water table, where present, may render this technology impractical
						Phytoremediation	In-Situ	SS, Sd	DRO, GRO, VOCs, SVOCs, Metals	N	Limited depth of effectiveness
Sub-surface Soil	GRO, DRO, VOCs (benzene and toluene), and metals (arsenic and chromium)	ADEC Method 2, 18 AAC 75 (October 2008) and background concentrations for arsenic and chromium.	2. Prevent inhalation of COCs that volatilize from soil to outdoor and indoor air.		Chemical Treatment	Fenton's Reagent Oxidation	In-Situ	SS, S	DRO, GRO, VOCs, SVOCs	Y	Technically effective; potentially moderate cost
						Dehalogenation	Ex-Situ	SS, S, Sd	PCP	N	Technically effective; limited by excavation depth; moderate cost but difficult to implement with fine sediment and high soil moisture content
					Physical Removal	Soil Vapor Extraction	In-Situ	S	DRO, GRO, VOCs, SVOCs	N*	Technically effective for volatiles in subsurface soil, but few volatile constituents at site
						Acid Extraction	Ex-Situ	SS, S, Sd	Metals	N	Technically effective; limited by excavation depth; high cost for disposal of chemicals
						Soil Washing	Ex-Situ	SS, S, Sd	Metals	Y	Technically effective; limited by excavation depth; potentially moderate cost
						Electrokinetic Remediation	In-Situ	SS, S	Metals	N	Limited effectiveness in subsurface soil and by potential high soil moisture content; high cost
					Thermal Treatment	Soil Heating	In-Situ	SS, S	DRO, GRO, VOCs, SVOCs	Y	Technically effective in surface and subsurface soil; potentially moderate cost
						Incineration	Ex-Situ	SS, S, Sd	DRO, GRO, Metals	N	Technically effective; limited by excavation depth, but cost not justified with other available alternatives
Sediment	DRO, SVOCs (chrysene, phenanthrene, and pyrene), PCP, and metals (arsenic, cadmium, chromium, and mercury)	SQuiRT values and background concentrations for arsenic and chromium or ADEC Method 2, 18 AAC 75 (October 2008), if a SQuiRT value for a COC is not given.	3. Prevent migration of COCs to groundwater or surface water.			Low-Temperature Thermal Desorption	Ex-Situ	SS, S, Sd	DRO, GRO, VOCs, SVOCs	Y	Technically effective; limited by excavation depth; moderate cost if conducted on site
					Containment	Solidification	In-Situ	SS, S	DRO, GRO, VOCs, SVOCs, Metals	N	Limits future use of land; limited by excavation depth
						Capping	In-Situ	SS, S	DRO, GRO, VOCs, SVOCs, PCP, Metals	Y	Limits future use of land; does not achieve ARARs
					Excavation and Disposal	Excavation and Off-Site Disposal	Ex-Situ	SS, S, Sd	DRO, GRO, VOCs, SVOCs, PCP, Metals	Y	Technically effective in completely removing contaminants, limited by excavation depth; high cost
					Natural Attenuation	Monitored Natural Attenuation	In-Situ	SS, S, Sd	DRO, GRO, VOCs, SVOCs	Y	Technically effective; low cost to implement initially but cost for long-term monitoring may be high

TABLE 4.0-1 - INITIAL SCREENING OF REMEDIAL TECHNOLOGIES

Affected Media	COC	ARARs	Remedial Action Objectives (RAOs)	General Response Action	Remedial Technology Type	Remedial Technology Process (See Appendix B)	Type	Media Addressed	COC Addressed	Selected Remedial Technology	Comments**
Surface Water	SVOCs (bis(2-ethylhexyl)phthalate~ and 2-methylnaphthalene), PCBs, dioxins, and metals (arsenic, barium, cadmium and lead)	Most stringent criteria between the SQuiRT values, AWQS, and EPA MCLs. If no SQuiRT value, AWQS, or EPA MCL established, Table C, 18 AAC 75.345 will be used.	Prevent ingestion or direct contact with surface water containing COCs.	No Action	-	-	-	-	-	Y	Does not meet the RAOs. Presented as a baseline for comparison purposes
				Institutional Controls	Institutional Controls	Institutional Controls	Ex-Situ	SW	SVOCs, PCBs, Dioxins, Metals	Y	Technically effective; relatively low cost, but may limit future use of surface water
				Treatment	Natural Attenuation	Monitored Natural Attenuation	Ex-Situ	SW	SVOCs, PCBs, Dioxins, Metals	Y	Technically effective; low cost to implement initially but cost for long-term monitoring may be high
Groundwater	DRO, GRO, and VOCs (benzene)	Table C, 18 AAC 75.345 (October 2008)	1. Prevent ingestion and/or direct contact with groundwater containing COCs. 2. Prevent Inhalation of COCs that volatilize from groundwater to outdoor and indoor air.	No Action	-	-	-	-	-	Y	Does not meet the RAOs. Presented as a baseline for comparison purposes
				Institutional Controls	Institutional Controls	Institutional Controls	Ex-Situ	GW	DRO, GRO, VOCs	Y	Technically effective; relatively low cost but may limit future use of groundwater
				Treatment***	Biological Treatment	Nutrient Amendment	In-Situ	GW	DRO, GRO, VOCs	N*	Technically effective and low cost but may be difficult to implement due to cold temperatures
						Air Sparging/Soil Vapor Extraction	In-Situ	GW	DRO, GRO, VOCs	Y	Technically effective; moderate to high cost
					Physical Removal	Air Stripping	In-Situ & Ex-Situ	GW	DRO, GRO, VOCs	N	Limited to volatile COCs; water disposal may reduce implementability; high cost
						Liquid-Phase Carbon Adsorption	Ex-Situ	GW	DRO, GRO, VOCs	N	Water disposal may reduce implementability; high cost
					Natural Attenuation	Monitored Natural Attenuation	In-Situ	GW	DRO, GRO, VOCs	Y	

KEY	DESCRIPTION
ADEC	Alaska Department of Environmental Conservation
AOC	Area of Concern
ARARs	Applicable or Relevant and Appropriate Requirements (See Table 3.1-1)
AWQS	Alaska Water Quality Standards listed in 18 AAC 70 and guidance manual referenced therein
COC	Chemical of Concern
DRO	Diesel range organics
EPA	Environmental Protection Agency
GRO	Gasoline range organics
GW	Groundwater
MCLs	Maximum Contaminant Levels for drinking water
PCBs	Polychlorinated Biphenyls
PCP	Pentachlorophenol
RCRA	Resource Conservation and Recovery Act criteria listed in 40 CFR 261.24, Table 1
S	Subsurface Soil
Sd	Sediment
SS	Surface Soil
SW	Surface Water
SQuiRT	National Oceanic and Atmospheric Administration's (NOAA) screening quick reference tables (SQuiRT)
SVOCs	Semi-volatile organic compounds
VOCs	Volatile organic compounds
*	These technologies were not retained as discrete, stand-alone remedial alternatives, but were incorporated into other remedial alternatives.
**	Qualitative comparisons of effectiveness and costs are relative to other technologies in the corresponding Remedial Technology Type classification.
***	Treatment (disturbance) of the groundwater at Concern D could inadvertently cause a release into the drinking water wells.
~	Bis(2-ethylhexyl)phthalate is a common laboratory contaminant.

5.0 DEVELOPMENT AND SCREENING OF REMEDIAL ALTERNATIVES

Remedial technologies were identified by evaluating COCs and affected media at each of the AOCs proposed for the Feasibility Study. The technologies were evaluated on their ability to meet the project's RAOs, and screened based on qualitative comparisons of effectiveness, implementability, and cost. Based on this evaluation, a decision was made as to whether the remedial technology would be incorporated into remedial alternative(s) for additional consideration in the Feasibility Study.

5.1 Development of Remedial Alternatives

Many of the AOCs have the same media affected by similar type COCs; therefore, the following ten specific media and COC type scenarios were identified for the 28 AOCs:

- Petroleum COCs in Surface Soil (<2 feet bgs)
- Petroleum COCs in Subsurface Soil (<15 feet bgs)
- Petroleum COCs in Subsurface Soil (>15 feet bgs)
- Petroleum COCs in Sediment
- Metals in Soil and Sediment
- Lead in Soil
- Multiple COC Types in Soil and Sediment
- Multiple COC Types in Landfill Cover Material
- COCs in Surface Water
- Petroleum Contaminated Groundwater.

The remedial alternatives considered in the detailed analysis were constructed by integrating these media and COC scenarios with the general response actions and technologies/processes discussed in Section 4.0. Based on the technology screening, the following technologies are considered as discrete actions and/or in combination with integrated alternatives:

- Monitored Natural Attenuation (Soil, Sediment, Surface Water, and Groundwater)
- Enhanced Bioremediation (Soil)
- Bioventing (Soil)
- Passive Bioventing (Soil)
- Biopiles (Soil and Sediment)
- Fenton's Reagent Oxidation (Soil)
- Soil Vapor Extraction (Soil)
- Soil Washing (Soil and Sediment, metals only)
- Solidification (Soil)
- Soil Heating (Soil)

- Low Temperature Thermal Desorption (LTTD) (Soil and Sediment)
- Capping (Soil)
- Excavation and Off-Site Disposal (Soil and Sediment)
- Nutrient Amendment (Groundwater)
- Air Sparging/Soil Vapor Extraction(Groundwater)

In addition, General Response Actions retained as discrete alternatives are:

- No Action (Soil, Sediment, Surface Water, and Groundwater)
- Institutional Controls (Soil, Sediment, Surface Water, and Groundwater).

5.2 Screening of Remedial Alternatives

Based on previous experience and preliminary discussion with the USACE, solidification and capping were eliminated from further consideration due to the degree of land use limitations that would likely accompany these options. A preliminary list of remedial technologies selected for detailed analyses was submitted to the USACE for review. Comments received from the USACE are provided in Appendix D. Three technologies (enhanced bioremediation, soil vapor extraction, and nutrient amendment) were not retained as discrete, stand-alone remedial alternatives, but were incorporated into other remedial alternatives. Enhanced bioremediation processes are incorporated in the bioventing, passive bioventing, and biopiles alternatives; soil vapor extraction is combined with the soil heating and air sparging alternatives; and, nutrient amendment is integrated as a component of air sparging alternative. After eliminating these five potential remedial alternatives as discrete, stand-alone remedial alternatives, a total of eleven remedial alternatives remained. Upon further input from the USACE PM, capping was retained as a remedial alternative for AOC K1 which has a scenario of multiple COC types in landfill cover material. In addition, passive bioventing was added as a remedial alternative. These thirteen remedial alternatives identified for detailed analysis are listed on Table 5.2-1. Note that institutional controls are retained as a discrete alternative; however, institutional controls may also be integrated into the selected alternative(s) to be identified in the project decision document.

5.3 Alternatives for Petroleum COCs in Surface Soil (<2 feet bgs)

Petroleum COCs were encountered in only surface soil at 8 AOCs. The COCs include DRO, benzene, benzo(a)anthracene, and benzo(a)pyrene. The AOCs include D-AST2, L3-Tank 1, L3-Tank 3, L3-Tank 7, L3-Tank 8, L3-Tank 11, L3-Tank 14, and L4. The remedial alternatives applicable to only surface soil impacted with DRO, VOCs, and SVOCs at the 8 AOCs are indicated on Table 5.2-1 and include:

- No Action
- Institutional Controls
- Monitored Natural Attenuation
- In-Situ Fenton's Reagent Oxidation
- In-Situ Soil Heating
- Biopiles
- Excavation and On-Site Low-Temperature Thermal Desorption
- Excavation and Off-Site Disposal.

5.4 Alternatives for Petroleum COCs in Subsurface Soil (<15 feet bgs)

Petroleum COCs were encountered in subsurface soil at depths less than 15 feet bgs, with or without petroleum-impacted surface soil, at 15 AOCs. The COCs include DRO, GRO, benzene, toluene, 2-methylnaphthalene, benzo(a)anthracene, and benzo(a)pyrene. The AOCs include C2, C4, C6, D-AST1, D-AST1 (downslope), D-AST3, D-AST4 (north), D-AST4 (south), D-AST5, D-AST6, D-AST7, D-AST8, L1-South Dump, M2 (tank) and M2 (quonset hut). Note that AOCs D-AST1, D-AST1 (downslope), D-AST5, D-AST6, D-AST7 and D-AST8 also have petroleum-impacted soil that extends greater than 15 feet bgs. The remedial alternatives applicable to subsurface soil, with or without surface soil, impacted with DRO, GRO, VOCs and SVOCs to depths less than 15 feet bgs at the 15 AOCs are indicated on Table 5.2-1 and include:

- No Action
- Institutional Controls
- Monitored Natural Attenuation
- In-Situ Fenton's Reagent Oxidation
- In-Situ Soil Heating
- Bioventing
- Passive Bioventing
- Biopiles
- Excavation and On-Site Low-Temperature Thermal Desorption
- Excavation and Off-Site Disposal.

5.5 Alternatives for Petroleum COCs in Subsurface Soil (>15 feet bgs)

DRO was encountered in subsurface soil at depths greater than 15 feet, with or without petroleum-impacted surface soil, at 6 AOCs. The AOCs include D-AST1, D-AST1 (downslope), D-AST5, D-AST6, D-AST7 and D-AST8. The remedial alternatives applicable to subsurface soil greater than 15 feet, with or without surface soil, impacted with DRO at the 6 AOCs are indicated on Table 5.2-1 and include:

- No Action
- Institutional Controls
- Monitored Natural Attenuation
- In-Situ Fenton's Reagent Oxidation
- In-Situ Soil Heating
- Bioventing
- Passive Bioventing

5.6 Alternatives for Petroleum COCs in Sediment

DRO was encountered in sediment at AOCs C2 and C4. The remedial alternatives applicable to sediment impacted with DRO at AOCs C2 and C4 are indicated on Table 5.2-1 and include:

- No Action
- Institutional Controls
- Monitored Natural Attenuation
- Biopiles
- Excavation and On-Site Low-Temperature Thermal Desorption
- Excavation and Off-Site Disposal.

5.7 Alternatives for Metals in Soil and Sediment

Metals were encountered in surface soil, subsurface soil, and/or sediment at 7 AOCs. The metals include arsenic, cadmium, chromium, lead, mercury, and silver. The AOCs include C1, C2, C4, C7, E1 (drum dump), M2, and O1. Note that the chromium concentration in surface soil is assumed to be hexavalent chromium (Cr6+), a known carcinogen. All the sites with elevated chromium are recommended to be retested to determine if the chromium concentration is due to hexavalent chromium or trivalent chromium (Cr3+). The cleanup level for trivalent chromium is 124,000 mg/kg. If it is determined that the chromium concentration in surface soil is actually trivalent chromium, then some sites, for example AOC C1, have no COCs.

The remedial alternatives applicable to surface soil, subsurface soil, and/or sediment impacted with metals at the 7 AOCs are indicated on Table 5.2-1 and include:

- No Action
- Institutional Controls
- Excavation and Off-Site Disposal
- Soil Washing.

5.8 Alternatives for Lead in Soil

Lead was encountered in surface soil at the Rifle Range. The remedial alternatives applicable to the lead-impacted surface soil at the Rifle Range are indicated on Table 5.2-1 and include:

- No Action
- Institutional Controls
- Excavation and Off-Site Disposal
- Soil Washing.

5.9 Alternatives for Multiple COC Types in Soil and Sediment

A mixture of multiple COC types including DRO, pentachlorophenol, SVOCs, and/or metals were detected in surface and subsurface soil and sediment at 4 AOCs. DRO, cadmium, and mercury were encountered in sediment at AOC C2. DRO, arsenic, and chromium were encountered in surface and subsurface soil at AOC E1 (drum dump). DRO, pentachlorophenol, arsenic, cadmium, chromium, and mercury were encountered in sediment at AOC E1 (drainage ditch). DRO, chrysene, phenanthrene, pyrene, arsenic, cadmium, chromium, and mercury were encountered in sediment at AOC G4. The remedial alternatives applicable to surface and subsurface soil and sediment impacted with multiple COC types, including DRO, pentachlorophenol, SVOCs, and/or metals, at the 4 AOCs are indicated on Table 5.2-1 and include:

- No Action
- Institutional Controls
- Excavation and Off-Site Disposal.

5.10 Alternatives for Multiple COC Types in Landfill Cover Material

A mixture of multiple COC types including DRO, pentachlorophenol, SVOCs, and/or metals were detected in the landfill cover material at AOC K1. DRO, pentachlorophenol, benzo(a)pyrene, arsenic, cadmium and chromium were encountered in surface soil and near surface soil (2 to 4 feet bgs) at AOC K1. The remedial alternatives applicable to surface and subsurface soil in landfill cover material impacted with multiple COC types, including DRO, pentachlorophenol, SVOCs, and/or metals, at AOC K1 are indicated on Table 5.2-1 and include:

- No Action
- Institutional Controls
- Excavation and Off-Site Disposal
- Capping.

5.11 Alternatives for COCs in Surface Water

Dioxins were encountered in surface water at AOC C1. PCBs, SVOCs (bis(2-ethylhexyl)phthalate and 2-methylnaphthalene), and lead were encountered in surface water at AOC C2. Barium was encountered in surface water at AOC G4. Arsenic, cadmium and lead were encountered in surface water at AOC K1. Lead was encountered in surface water at AOC O1. The remedial alternatives applicable to surface water impacted with PCBs, SVOCs, and/or metals at the 5 AOCs are indicated on Table 5.2-1 and include:

- No Action
- Institutional Controls
- Monitored Natural Attenuation.

5.12 Alternatives for Petroleum COCs in Groundwater

Petroleum COCs were encountered in groundwater at 3 AOCs. The COCs include DRO at AOCs C6 and D-AST7 and GRO and benzene at AOC L1-South Drum Dump. The remedial alternatives applicable to groundwater impacted with DRO, GRO, and benzene at the 3 AOCs are indicated on Table 5.2-1 and include:

- No Action
- Institutional Controls
- Monitored Natural Attenuation
- Air Sparging/Soil Vapor Extraction.

TABLE 5.2-1 - AOC-SPECIFIC REMEDIAL ALTERNATIVES IDENTIFIED FOR DETAILED ANALYSES

				Remedial Alternative												
Area of Concern	**Description of AOC**	**Chemical of Concern**	**Affected Media**	Alternative 1 - No Action	Alternative 2 - Institutional Controls	Alternative 3 - Monitored Natural Attenuation	Alternative 4 - In-Situ Fenton's Reagent Oxidation	Alternative 5 - In-Situ Soil Heating	Alternative 6 - Bioventing	Alternative 7 - Passive Bioventing	Alternative 8 - Biopiles	Alternative 9 - Excavation and On-Site Low-Temperature Thermal Desorption	Alternative 10 - Excavation and Off-Site Disposal	Alternative 11 - Soil Washing	Alternative 12 - Capping	Alternative 13 - Air Sparging/Soil Vapor Extraction
C1	Point Carrew - Ankau Bridge Garbage/Drum Dump	chromium	SS	X	X								X	X		
C1	Point Carrew - Ankau Bridge Garbage/Drum Dump	dioxins	SW	X	X	X										
C2	Point Carrew - Garrison Area Drum Dump	diesel range organics	SS, S (<15 ft)	X	X	X	X	X	X	X	X	X	X			
C2	Point Carrew - Garrison Area Drum Dump	diesel range organics	Sd	X	X	X					X	X	X			
C2	Point Carrew - Garrison Area Drum Dump	silver	SS	X	X								X	X		
C2	Point Carrew - Garrison Area Drum Dump	diesel range organics, cadmium, mercury	Sd	X	X								X			
C2	Point Carrew - Garrison Area Drum Dump	PCBs, bis(2-ethylhexyl)phthalate, lead	SW	X	X	X										
C4	Point Carrew - Garrison Area Surface Debris	diesel range organics	SS, S (<15 ft)	X	X	X	X	X	X	X	X	X	X			
C4	Point Carrew - Garrison Area Surface Debris	diesel range organics	Sd	X	X	X					X	X	X			
C4	Point Carrew - Garrison Area Surface Debris	chromium	SS	X	X								X	X		
C6	Point Carrew - 50,000-Gallon Fuel Tank	diesel range organics	SS, S (<15 ft)	X	X	X	X	X	X	X	X	X	X			
C6	Point Carrew - 50,000-Gallon Fuel Tank	diesel range organics	GW	X	X	X										X
C7	Point Carrew - Powerhouse No. 1093	arsenic, chromium	SS	X	X								X	X		
D-AST1	Army Dock Area - Former AST No. 1	diesel range organics	S (< 15 ft)	X	X	X	X	X	X	X	X	X	X			
D-AST1	Army Dock Area - Former AST No. 1	diesel range organics	S (> 15 ft)	X	X	X	X	X	X	X						
D-AST1 (downslope)	Army Dock Area - Former AST No. 1	diesel range organics	S (< 15 ft)	X	X	X	X	X	X	X	X	X	X			
D-AST1 (downslope)	Army Dock Area - Former AST No. 1	diesel range organics	S (> 15 ft)	X	X	X	X	X	X	X						
D-AST2	Army Dock Area - Former AST No. 2	diesel range organics, benzene	SS	X	X	X	X	X			X	X	X			
D-AST3	Army Dock Area - Former AST No. 3	diesel range organics, benzene	SS, S (<15 ft)	X	X	X	X	X	X	X	X	X	X			
D-AST4 (north)	Army Dock Area - Former AST No. 4	diesel range organics	SS, S (<15 ft)	X	X	X	X	X	X	X	X	X	X			
D-AST4 (south)	Army Dock Area - Former AST No. 4	diesel range organics	S (< 15 ft)	X	X	X	X	X	X	X	X	X	X			
D-AST5	Army Dock Area - Former AST No. 5	diesel range organics	SS, S (<15 ft)	X	X	X	X	X	X	X	X	X	X			
D-AST5	Army Dock Area - Former AST No. 5	diesel range organics	S (>15 ft)	X	X	X	X	X	X	X						
D-AST6	Army Dock Area - Former AST No. 6	diesel range organics	SS, S (<15 ft)	X	X	X	X	X	X	X	X	X	X			
D-AST6	Army Dock Area - Former AST No. 6	diesel range organics	S (>15 ft)	X	X	X	X	X	X	X						
D-AST7	Army Dock Area - Former AST No. 7	diesel range organics	SS, S (< 15 ft)	X	X	X	X	X	X	X	X	X	X			
D-AST7	Army Dock Area - Former AST No. 7	diesel range organics, 2- methylnaphthalene	S (> 15 ft)	X	X	X	X	X	X	X						
D-AST7	Army Dock Area - Former AST No. 7	diesel range organics	GW	X	X	X										X
D-AST8	Army Dock Area - Former AST No. 8	diesel range organics	S (<15 ft)	X	X	X	X	X	X	X	X	X	X			
D-AST8	Army Dock Area - Former AST No. 8	diesel range organics	S (>15 ft)	X	X	X	X	X	X	X						
E1	Northwest Drum Dump/Quartermaster Loop Area	diesel range organics, arsenic, chromium	SS, S (<15 ft)	X	X								X			
E1	Northwest Drum Dump/Quartermaster Loop Area	arsenic, chromium	SS	X	X								X	X		
E1	Drainage Ditch/Quartermaster Loop Area	diesel range organics, pentachlorophenol, arsenic, cadmium, chromium, mercury	Sd	X	X								X			

TABLE 5.2-1 - AOC-SPECIFIC REMEDIAL ALTERNATIVES IDENTIFIED FOR DETAILED ANALYSES

				Remedial Alternative												
Area of Concern	**Description of AOC**	**Chemical of Concern**	**Affected Media**	Alternative 1 - No Action	Alternative 2 - Institutional Controls	Alternative 3 - Monitored Natural Attenuation	Alternative 4 - In-Situ Fenton's Reagent Oxidation	Alternative 5 - In-Situ Soil Heating	Alternative 6 - Bioventing	Alternative 7 - Passive Bioventing	Alternative 8 - Biopiles	Alternative 9 - Excavation and On-Site Low-Temperature Thermal Desorption	Alternative 10 - Excavation and Off-Site Disposal	Alternative 11 - Soil Washing	Alternative 12 - Capping	Alternative 13 - Air Sparging/Soil Vapor Extraction
G4	Seaplane Base - Seaplane Slough	diesel range organics, chrysene, phenanthrene, pyrene, arsenic, cadmium, chromium, mercury	Sd	X	X								X			
G4	Seaplane Base - Seaplane Slough	barium	SW	X	X	X										
K1	Solid Waste Disposal Dump No. 4 Area	arsenic	S (2-4 ft)	X	X								X		X	
K1	Solid Waste Disposal Dump No. 4 Area	diesel range organics, pentachlorophenol, arsenic, cadmium, chromium, benzo(a)pyrene	SS	X	X								X		X	
K1	Solid Waste Disposal Dump No. 4 Area	arsenic, cadmium, lead	SW	X	X	X										
L1	Air Corps Operations Reserve Tank Farm - South Drum Dump	gasoline range organics, benzene, toluene	SS, S (<15 ft)	X	X	X	X	X	X	X	X	X	X			
L1	Air Corps Operations Reserve Tank Farm - South Drum Dump	gasoline range organics, benzene	GW	X	X	X										X
L3	Air Corps Operations Reserve Tank Farm - Tank Foundations (Tank 1)	benzo(a)pyrene	SS	X	X	X	X	X			X	X	X			
L3	Air Corps Operations Reserve Tank Farm - Tank Foundations (Tank 3)	benzo(a)pyrene	SS	X	X	X	X	X			X	X	X			
L3	Air Corps Operations Reserve Tank Farm - Tank Foundations (Tank 7)	benzo(a)pyrene	SS	X	X	X	X	X			X	X	X			
L3	Air Corps Operations Reserve Tank Farm - Tank Foundations (Tank 8)	benzo(a)pyrene, benzo(a)anthracene	SS	X	X	X	X	X			X	X	X			
L3	Air Corps Operations Reserve Tank Farm - Tank Foundations (Tank 11)	benzo(a)pyrene	SS	X	X	X	X	X			X	X	X			
L3	Air Corps Operations Reserve Tank Farm - Tank Foundations (Tank 14)	benzene	SS	X	X	X	X	X			X	X	X			
L4	Air Corps Operations Reserve Tank Farm - Truck Fill Stand No. 4	diesel range organics, benzo(a)pyrene	SS	X	X	X	X	X			X	X	X			
M2	Post Powerhouse - Fuel/water Separator	chromium	SS	X	X								X	X		
M2 (Tank)	Post Powerhouse - Fuel/water Separator	diesel range organics	S (<15 ft)	X	X	X	X	X	X	X	X	X	X			
M2 (Quonset Hut)	Post Powerhouse - Fuel/water Separator	diesel range organics	S (<15 ft)	X	X	X	X	X	X	X	X	X	X			
O1	Air Corps Warehouse Group No. 2 - Suspected Drum Dump	arsenic	SS	X	X								X	X		
O1	Air Corps Warehouse Group No. 2 - Suspected Drum Dump	lead	SW	X	X	X										
RR	Rifle Range - Target Pits	lead	SS	X	X								X	X		

KEY	DESCRIPTION
AOC	Area of Concern
AST	Above ground storage tank
DRO	Diesel range organics
GRO	Gasoline range organics
GW	Groundwater
PCBs	Polychlorinated Biphenyls
S	Subsurface Soil
Sd	Sediment
SS	Surface Soil
SVOCs	Semi-volatile organic compounds
SW	Surface Water
VOCs	Volatile organic compounds

6.0 DETAILED ANALYSES OF ALTERNATIVES

The remedial alternatives analyzed in detail in this section were developed for discrete media and COC scenarios using technology processes selected for their potential to achieve the RAOs. The technologies/processes incorporated into the remedial alternatives are discussed in Section 6.1. A comparative analysis of the integrated remedial alternatives applicable for each of the ten COC/affected media scenarios is presented in Section 6.2. Site-specific considerations to identify limitations for selecting remedial alternatives at each site are provided in Section 6.3. A summary of the remedial alternatives analyses is provided in Table 6.0-1.

6.1 Technologies/Processes Comprising Media-Specific Alternatives

Criteria used for detailed evaluation of the selected alternatives are those defined in the EPA document *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final*, EPA/540/G-89/004, OSWER Directive 9355.3-01 (EPA 1988). The criteria are:

1. Overall Protection of Human Health and the Environment;
2. Compliance with ARARs;
3. Long-Term Effectiveness and Permanence;
4. Reduction of Toxicity, Mobility, or Volume Through Treatment;
5. Short-Term Effectiveness;
6. Implementability; and
7. Cost.

Two additional criteria, State Acceptance and Community Acceptance, will be evaluated following review of this document by the USACE, the ADEC, and the public.

The presented remedial alternatives represent a range of distinct strategies that address the human health and environmental concerns associated with various AOCs. In general, the discussions will apply to each AOC with similar COC and media. If there are particular concerns for a given AOC, they are discussed, as necessary in Section 6.3. Although each selected alternative will be further refined as necessary during the pre-design phase, the description of the alternatives and the analysis with respect to the seven criteria presented above, reflect the fundamental components of the various alternative approaches being considered.

Rough order of magnitude (ROM) costs for implementing the remedial alternatives at the individual AOCs are provided in Table 6.0-2 for soil and sediment and Table 6.0-3 for surface water and groundwater. Because estimated volumes of impacted soil and/or sediment at the various AOCs range from about 7 cy to 28,000 cy, and unit costs for treatment are volume-dependent, the cost to implement each remedial alternative was developed on a per cubic yard basis for representative 20 cy, 2,000 cy, and 20,000 cy sites. The resulting 3-point curve established by plotting these unit costs per cubic yard was used to develop the AOC-specific soil treatment costs (excluding mobilization/demobilization) shown in Table 6.0-2. The data used to develop the unit costs per cubic yard basis for each remedial alternative for a 20 cy, 2,000 cy, and 20,000 cy site, and graphical representation, are presented in Appendix C. As shown on the Appendix C graphs, the unit costs to treat impacted soil are highest with low volumes and then steeply decrease and eventually flatten out as the treatment volumes increase. The ROM cost estimates presented in the tables are intended to be within -30 percent (%) and +50% (i.e. actual costs may be 30% lower to 50% higher). The total cost, including mobilization/demobilization, for implementing a given remedial alternative at the applicable AOCs is the sum of the costs per individual AOC plus the mobilization/demobilization costs. The mobilization/demobilization costs are also shown at the top of Table 6.0-2. The cost per cubic yard for implementing a given remedial alternative at the applicable AOCs is shown at the bottom of Table 6.0-2.

As shown in Appendix C, the ROM costs for soil and sediment, provided in Table 6.0-2, and for surface water and groundwater, provided in Table 6.0-3, were estimated based on present worth costs as described in *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA 2000). The present worth costs include mobilization, capital, O&M, and future capital costs. Mobilization/demobilization costs are for making the necessary equipment and labor available in Yakutat to implement the remedial alternative. Capital costs are for field treatability studies, installation of treatment components, and fencing. The O&M cost is for treatment monitoring, maintenance, and energy use. Future capital costs are for advancement of confirmation borings and decommissioning treatment components, monitoring wells, and fencing. Note that minimum amounts of soil are required to implement Alternatives 9 and 11 as these alternatives require mobilization of large commercial remediation units.

Tables 6.0-2 and 6.0-3 summarize the ROM costs for a remedial alternative applicable to the AOC listed. The ROM costs for a combination of remedial alternatives, if desired, can also be estimated using the costs shown in Tables 6.0-2 and 6.0-3. For example, the costs to excavate and treat the approximately 13,000 cy of impacted soil at AOC C6 with the on-site LTTD are estimated at $4.1 million as shown on Table 6.0-2. Assuming that all impacted soil at AOC C6 is removed and treated, additional costs would be incurred to implement monitored natural attenuation of impacted groundwater. The present worth costs for monitored natural attenuation of impacted groundwater at AOC C6 are estimated at $409,000 as shown on Table 6.0-3. The combined mobilization/demobilization costs to implement excavation and on-site LTTD ($278,000) and monitored natural attenuation of groundwater ($49,000) are estimated at $327,000 which may be shared with remedial actions at other AOCs. Institutional controls may be required at AOC C6 until COCs have been reduced to concentrations below ARARs. As shown on Tables 6.0-3, the cost to implement institutional controls at AOC C6 have been estimated at $13,000. Therefore, the total cost to remediate AOC C6 using on-site LTTD to remediate soil and monitored natural attenuation and institutional controls for impacted groundwater, including mobilization costs, is estimated at $4.8 million.

6.1.1 Alternative 1 - No Action

The No Action remedial alternative applies to each AOC regardless of the affected media or the COC type. For this alternative, no active remediation or action is taken to reduce the potential for exposure. The No Action remedial alternative provides a baseline for comparing other alternatives.

Overall Protection of Human Health and the Environment

No Action when COCs are present does not provide additional anthropogenic protection of human health and the environment. However, if pathways to potential receptors are not complete, or likely to become complete, no action may be justified. In areas of surface soil or sediment contamination, or impacted subsurface soil in close proximity to the groundwater table, possible migration to surface water or leaching to groundwater may occur.

Compliance with ARARs

Compliance with ARARs would not be achieved with the No Action alternative, with the exception of petroleum COCs, and non-petroleum COCs in surface water, which may eventually degrade with natural attenuation processes. The time required to achieve ARARs for petroleum-impacted soil will depend on the magnitude of COC concentrations, soil conditions (permeability, oxygen and nutrient availability, presence of bacteria, etc.), and temperature. For the purposes of this FS, it is assumed that concentrations will not change with the No Action alternative. Natural attenuation processes would not reduce concentrations of metals or pentachlorophenol in soil or sediment.

Long-Term Effectiveness and Permanence

Conditions would likely not change for the practical long term with the No Action alternative. No controls would be implemented to protect human health and the environment and the site would not be reviewed every 5 years, as typically is required with institutional controls. Although natural attenuation processes should reduce petroleum COC concentrations and non-petroleum COCs in surface water, over time, for the purposes of this FS it is assumed that concentrations will not change with the No Action alternative.

Reduction in Toxicity, Mobility, or Volume through Treatment

With No Action, there would be little to no reduction in toxicity and mobility of the COCs or volume of affected media. COCs are still present 60 years after introduction to the environment and future effectiveness of natural attenuation processes is considered minimal for petroleum COCs and non-existent for metals or pentachlorophenol. Although the toxicity, mobility, and volume of COCs in surface water would also be reduced through natural attenuation processes such as dilution and volatilization, for the purpose of this FS it is assumed that no reduction of these factors is made with the No Action alternative.

Short-Term Effectiveness

With No Action, construction and implementation of a remedial alternative does not occur. Therefore, there would likely be no additional risks to workers, the community, or the environment as a result of No Action. If the population of Yakutat grows, there would be a potential for encroachment on individual AOCs by residential, commercial, and/or industrial development and pressure on the USACE to implement active remediation. Although it may require 30 years or more before petroleum COCs are reduced through natural degradation to concentrations less than ARARs, for the purposes of this FS it is assumed that concentrations will not change with the No Action alternative. Concentrations of metal COCs and pentachlorophenol may not be reduced.

Implementability

With No Action, implementation is immediate.

Costs

The present worth and capital cost for the No Action alternative would be $0.

6.1.2 Alternative 2 - Institutional Controls

Institutional Controls are considered for each AOC. Institutional Controls are a limited-action remedial alternative that may or may not be used in conjunction with other long-term remedial alternatives to prevent or limit exposure to COCs. They are physical and/or administrative measures designed to prevent or limit exposure to COCs left in place at a site. Institutional Controls could consist of fences, signs, liners, and caps to physically prevent future potential occupant exposure or deed restrictions, deed notices, easements, restrictive covenants, or zoning ordinances that would require appropriate measures be implemented to address excavation of impacted soil and sediment or construction over impacted media to prevent future potential occupant exposure. ADEC and the local Yakutat authority would need to review plans to install drinking water wells to prevent exposure to contaminated groundwater in areas of soil and groundwater contamination. In addition, areas of surface soil and/or sediment contamination would need to be identified to prevent harvesting of food from these areas.

Overall Protection of Human Health and the Environment

The Institutional Controls may be effective in preventing human or environmental exposure to COCs that remain on sites.

Compliance with ARARs

Compliance with ARARs would not be achieved with the Institutional Controls alternative. COCs are still present 60 years after introduction to the environment. Depending on the magnitude of COC concentrations and soil conditions, it would likely require at least another 30 years before petroleum COCs are reduced through natural degradation to below ARARs. Concentrations of metal COCs and pentachlorophenol would not be reduced through natural degradation processes except for these COCs in impacted surface water. For the purposes of this FS, it is assumed that concentrations will not change with the Institutional Controls alternative. The presence of lead concentrations at the Rifle Range above RCRA hazardous waste levels may require more than Institutional Controls be implemented.

Long-Term Effectiveness and Permanence

Oversight, monitoring and appropriate enforcement mechanisms are required to protect human health and the environment. The status of the chosen institutional control would be reviewed every year. Potential risks are not reduced. Periodic, long-term monitoring may be advisable to assess possible changes in conditions. Institutional Controls over the long term may become less desirable as it is expected that the population of Yakutat would grow. This could result in potential encroachment on individual AOCs by residential, commercial, and/or industrial development and pressure on the USACE to implement active remediation. Long-term monitoring would be required because it may take at least 30 years or more for the petroleum COCs to naturally degrade. For the purposes of this FS, it is assumed that concentrations will not change with the Institutional Controls alternative. A review would need to be conducted annually to assess the status of the chosen institutional control.

Reduction in Toxicity, Mobility, or Volume through Treatment

Institutional Controls reduce potential exposure. There would be little to no reduction of toxicity, mobility, or volume of the COCs other than through natural degradation of petroleum COCs. Natural degradation of metals and pentachlorophenol would not occur. Although the toxicity, mobility, and volume of COCs in surface water would also be reduced through natural attenuation processes such as dilution and volatilization, for the purpose of this FS it is assumed that no reduction of these factors is made with the Institutional Controls alternative.

Short-Term Effectiveness

Institutional Controls are effective immediately upon implementation. Since construction is not required to implement Institutional Controls, no additional risk to workers, the community, or the environment would result. Although it may require 30 years or more before petroleum COCs are reduced through natural degradation to below ARARs, for the purpose of this FS it is assumed that concentrations will not change with the Institutional Controls alternative. Concentrations of metal COCs and pentachlorophenol may not be reduced.

Implementability

Institutional Controls such as deed restrictions, deed notices, easements, restrictive covenants, or zoning ordinances can be implemented following acceptance by ADEC, EPA and the local community.

Costs

As shown on Tables 6.0-2 and 6.0-3, the 30-year present worth cost for the Institutional Control alternative for an individual AOC is estimated at $13,000. The total cost to implement the Institutional Control alternative for impacted soil and sediment at the applicable AOCs is estimated at about $575,000 for about 90,000 cubic yards or about $6 per cubic yard. As shown on Table C.2 in Appendix C, the estimated capital cost is $5,000 and the estimated O&M cost is $8,000. The capital cost is for initially establishing deed restrictions, deed notices, easements, restrictive covenants, or zoning ordinances. The annual O&M cost is primarily for oversight, monitoring, and enforcement and assumes no groundwater monitoring.

6.1.3 Alternative 3 - Monitored Natural Attenuation

Monitored Natural Attenuation applies to the AOCs with media affected by petroleum COCs including GRO, DRO, VOCs, and SVOCs and, in surface water impacted with metals and PCBs. Natural processes such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials may reduce contaminant concentrations over time to acceptable levels. Consideration of this option usually requires modeling and evaluation of contaminant degradation rates and pathways and predicting contaminant concentration at down gradient receptor points, especially if a plume is still expanding/migrating. In addition, long-term monitoring of soil, sediment, surface water, and groundwater, consisting of the collection and analyses of samples must be conducted to evaluate whether COC degradation is proceeding at rates consistent with meeting cleanup objectives. The interval for collection and analyses of samples will be negotiated between the ADEC and the USACE; however, for costing purposes for this FS, a five year interval is assumed. The Monitored Natural Attenuation process may include engineering controls, such as fencing, to limit access and exposure to COCs at sites with impacted soil and sediment and no enhanced bioremediation processes.

Overall Protection of Human Health and the Environment

Institutional and engineering controls would need to be implemented to prevent human and environmental exposure to COCs that remain on site above unrestricted use. Engineering controls, such as fencing can be implemented to limit access to sites with impacted soil and sediment to limit exposure during the Monitored Natural Attenuation process.

Compliance with ARARs

Monitored Natural Attenuation would not likely achieve ARARs within at least about 30 years for petroleum-impacted AOCs. The time required to achieve ARARs, will depend on the magnitude of COC concentrations, soil conditions (permeability, oxygen and nutrient availability, presence of bacteria, etc.), and temperature. Institutional and engineering controls may be required until ARARs are met. Natural attenuation processes would not reduce concentrations of metals or PCP to comply with ARARs. Dioxins, PCBs and metals in surface water would likely be reduced through natural attenuation processes such as dilution and dispersion as long as the source of the COCs is removed. Natural attenuation may achieve ARARs for petroleum-impacted hot spots.

Long-Term Effectiveness and Permanence

Without continuing or new sources of contamination, natural attenuation processes should continue to reduce petroleum COC concentrations over long term but not metals or PCP. Reduction of risks to receptors to acceptable levels may take years to achieve. To remain effective during the natural attenuation process, institutional and engineering controls would need to be maintained to prevent direct contact with impacted surface soil, sediment, and surface water. Long-term monitoring would be required because it may take at least 30 years or more for the petroleum COCs to naturally degrade. A review would need to be conducted about every 5 years to assess whether COC degradation is occurring and that institutional and engineering controls are being maintained to adequately protect human health and the environment.

Reduction in Toxicity, Mobility, or Volume through Treatment

Attenuation of petroleum COCs by natural processes may eventually reduce toxicity, mobility, and volume to acceptable, risk-based levels. Attenuation of metals and pentachlorophenol would not occur. The toxicity, mobility, and volume of dioxins, PCBs and metals in surface water may also be reduced through natural attenuation processes such as dilution and dispersion.

Short-Term Effectiveness

Monitored Natural Attenuation may not provide protection to on-site workers or visitors where direct exposure to contaminated soil is possible. A temporary increase of risk to workers, the community and the environment may occur due to VOC emissions during installation of monitoring wells and fencing or advancement of confirmation borings. These risks may be mitigated using dust control measures and personal protective equipment (PPE). It may require 30 years or more before petroleum COCs are reduced through natural degradation to below ARARs. Concentrations of metal COCs and pentachlorophenol may not be reduced.

Implementability

Within about 6 months of a decision to use Monitored Natural Attenuation, institutional and engineering controls could be implemented to prevent exposure. There is no remedial action to be implemented; however, additional monitoring wells will likely need to be installed, and long-term monitoring may be required. No special materials, labor, or techniques would be required during installation of monitoring wells and fencing or advancement of confirmation borings. A nationwide permit to disturb surface soil in a wetland or drainage channel may be required but can typically be obtained within about 30 days.

Costs

The 30-year present worth costs for the Monitored Natural Attenuation alternative are shown on Tables 6.0-2 and 6.0-3. The total present worth cost including mobilization demobilization to implement the Monitored Natural Attenuation alternative for soil at the applicable AOCs is estimated at about $1.6 million for about 82,000 cubic yards or about $19 per cubic yard. The total present worth cost including mobilization demobilization to implement the Monitored Natural Attenuation alternative for the 3 sites with contaminated groundwater plumes, C6, D-AST7, and L1(South Dump), is estimated to be $840,000. The total present worth cost to implement the Monitored Natural Attenuation alternative for the 4 sites with contaminated surface water, C2, G4, K1, and O1, is estimated to be $130,000. As shown on Tables 3A, 3B, and 3C in Appendix C, the present worth costs include capital costs, O&M costs, and future capital costs. Capital costs are for installation of monitoring wells and fencing. The O&M cost is for monitoring. Future capital costs are for advancement of confirmation borings and decommissioning fencing and monitoring wells.

6.1.4 Alternative 4 - In-Situ Fenton's Reagent Oxidation

In-Situ Fenton's Reagent Oxidation applies to the AOCs with surface soil and subsurface soil impacted by petroleum COCs including GRO, DRO, VOCs, and SVOCs. In-Situ Oxidation with Fenton's Reagent uses hydrogen peroxide solution in the presence of ferrous iron. Hydrogen peroxide and ferrous iron delivery systems employ vertical and/or horizontal injection wells to pressure-inject chemicals into the subsurface. Vertical injection wells would extend to the depth of groundwater and have an assumed radius of influence of about 10 feet.

A field treatability study would be performed to evaluate the radius of influence for the injection wells and to collect parameters to evaluate biodegradation potential. These parameters include nitrogen, phosphorus, potassium, heterotrophic and oil degrading bacteria, and grainsize. Vertical and horizontal piping to deliver chemicals to the subsurface and the batch tank would be constructed of stainless steel. An electrical supply would be required at the sites to pressure-inject hydrogen peroxide and ferrous iron solutions. A chain-link fence would be constructed around the treatment areas to protect/prevent trespassers from having contact with the concentrated hydrogen peroxide solution. Sufficient chemicals would need to be on hand to complete the entire treatment process. The time required for chemical treatment may be about 2 months. Coverage of the entire impacted area may not be obtained therefore areas not remediated with the chemical oxidation process will rely on biodegradation. Following oxidation, residual oxygen and nutrient amendments may enhance biodegradation of remaining COCs. Oil degrading bacteria may need to be re-introduced. Screening test pits would be advanced about 2 years after the oxidation process has been initiated. Confirmation borings would be advanced about 3 years after the oxidation process has been completed.

Overall Protection of Human Health and the Environment

Risk to human and ecological receptors may be reduced to acceptable levels after completion of the oxidation and biodegradation processes.

Compliance with ARARs

ARARs can be achieved with Fenton's Reagent Oxidation followed by biodegradation of remaining COCs from residual oxygen and introduced nutrients. The time required to achieve ARARs will depend on the magnitude of COC concentrations, soil conditions (permeability, oxygen and nutrient availability, presence of bacteria, etc.), and temperature.

Long-Term Effectiveness and Permanence

Strong oxidants rapidly degrade organic compounds achieving permanent and irreversible results. The oxidation approach is used to obtain rapid reduction in the source area and may not completely eliminate all contamination or reduce COC concentrations to less than ARARs. Multiple applications of Fenton's Reagent Oxidation may be required. Following oxidation, the residual oxygen remaining will enhance biodegradation. The contaminant zone treated by oxidation would require confirmation sampling at the end of treatment. This alternative should not require a 5-year review as residual risks to human and ecological receptors should be reduced before that time to acceptable levels after completion of the oxidation and biodegradation processes.

Reduction in Toxicity, Mobility, or Volume through Treatment

Fenton's Reagent Oxidation is an irreversible treatment process that may reduce the toxicity of petroleum-impacted soil. Introduction of a chemical oxidant into the subsurface transforms soil contaminants into non-hazardous and/or less toxic compounds. Biodegradation of contaminants may occur after oxidation is complete, providing a residual benefit. Oil degrading bacteria may need to be re-introduced.

Short-Term Effectiveness

Hydrogen peroxide solution persists in soil for minutes to hours and reacts immediately upon contact with contaminants. Application of oxidant may be necessary either short or long-term, depending on soil conditions, the method of delivery, and distribution throughout the sub-surface. Engineering controls (e.g. chain-link fence) would reduce exposure to the community and environment during the treatment process. Highly concentrated hydrogen peroxide may be a fire hazard if high levels of oxygen are released. Additional risks to workers may result from handling large quantities of hazardous oxidizing chemicals and possible ingestion or inhalation of impacted soil during placement of injection wells and manifold piping. These additional risks can be mitigated through training and the use of PPE. About 2 months of Fenton's Reagent Oxidation and about 3 years of enhanced biodegradation may be required to reduce the petroleum COCs to levels below ARARs.

Implementability

This alternative is technically and administratively feasible, and has been used effectively at other sites. Vertical injection wells and confirmation borings would be installed/advanced using similar drilling equipment as used previously at the site. Excavating equipment, available in Yakutat, would be needed for installing the horizontal injection pipes. The most difficult part of implementation is the uniform or targeted distribution of oxidant to the impacted soil. Heterogeneities producing preferential pathways could limit effective delivery and distribution of oxidant. A nationwide permit to disturb surface soil in a wetland or drainage channel may be required. Possible special concerns include shipping/handling hydrogen peroxide solution, batch tank mixing, and electrical requirements at remote locations.

Costs

The 2-year present worth costs for the Fenton's Reagent Oxidation alternative are shown on Table 6.0-2. The total present worth cost including mobilization demobilization to implement the Fenton's Reagent Oxidation alternative at the applicable AOCs is estimated at about $15 million for about 82,000 cubic yards or about $179 per cubic yard. The present worth costs include capital costs, O&M costs, and future capital costs. Capital costs are for the field treatability study and installation of injection wells and fencing. The O&M cost is for treatment. Future capital costs are for advancement of screening and confirmation borings and decommissioning fencing and monitoring wells.

6.1.5 Alternative 5 - In-Situ Soil Heating

In-Situ Soil Heating using thermal conduction applies to the AOCs with surface and subsurface soil impacted by petroleum COCs including GRO, DRO, VOCs, and SVOCs. This alternative uses thermally enhanced soil vapor extraction technology to increase the volatilization rate of petroleum COCs and facilitate extraction. Thermal wells consisting of vertical metal rods are installed within the treatment area and are heated so that heat flows from the thermal wells out into the soil and volatilizes the petroleum COCs. Likewise, a thermal blanket is constructed over the site surface to treat impacted surface soil. SVE is typically implemented to collect vapors. Thermal conductive soil heating uses heaters electrically powered with on-site portable generators to heat impacted soil to target treatment temperatures (typically 325 °C for semi-volatile constituents). The thermal wells are positioned such that heat fronts from each well overlap to provide coverage of the impacted-soil zone. The thermal wells typically extend throughout the depth of contaminated soil and have an assumed radius of influence of about 5 feet. Temperature and pressure monitoring well points are installed within the thermal well network to monitor the subsurface heat distribution. Vapor extraction wells are positioned to remove volatiles and steam produced during the soil heating process. The vapor is passed through a treatment system typically composed of a heat exchanger, oil-water separator, knockout drum and water treatment unit. A vapor cap may be placed on the site surface.

A field treatability study would be performed to evaluate the radius of influence for the thermal and vapor extraction wells. Vertical and horizontal piping used for extraction wells would be constructed of stainless steel. An chain-link fence would be constructed around the treatment areas to protect/prevent trespassers. The time required for soil heating treatment may be about 6 months to 1 year. Confirmation borings would be advanced immediately after the soil heating process has been completed.

Overall Protection of Human Health and the Environment

Risk to human and ecological receptors may be reduced, primarily through volatilization of petroleum hydrocarbons.

Compliance with ARARs

ARARs can be achieved with soil heating. The time required to achieve ARARs will depend on the magnitude of COC concentrations, soil conditions (permeability, moisture content, etc.), temperature, and degradation rates.

Long-Term Effectiveness and Permanence

Contaminants are permanently removed by volatilization and extraction. The contaminant zone treated by soil heating would require confirmation sampling at the end of treatment. This alternative should not require a 5-year review as residual risks to human and ecological receptors should be reduced before that time to acceptable levels after completion of the soil heating process.

Reduction in Toxicity, Mobility, or Volume through Treatment

Soil heating is an irreversible treatment process that reduces the concentrations of COCs therefore reducing the toxicity, mobility and volume of contaminants.

Short-Term Effectiveness

Volatile constituents are typically mobilized during operation of a soil heating system, with capture and treatment (if necessary) of volatile emissions at the surface. Engineering controls (e.g. chain-link fence) would reduce exposure to the community and environment during the treatment process. Precautions, in the form of PPE, are needed to prevent ingestion or inhalation during placement of thermal wells, extraction wells, monitoring points and manifold piping. It is estimated that about 6 months to 1 year of active soil heating may be required to reduce the petroleum COCs to levels below ARARs.

Implementability

This alternative is technically and administratively feasible, and has been used effectively at other sites. Vertical wells and confirmation borings would be installed/advanced using similar drilling equipment as used previously at the sites. Excavating equipment, available in Yakutat, would be needed for installing the horizontal extraction pipes. A nationwide permit to disturb surface soil in a wetland or drainage channel may be required.

Costs

The 2-year present worth costs for the Soil Heating alternative are shown on Table 6.0-2. The total present worth cost including mobilization demobilization to implement the Soil Heating alternative at the applicable AOCs is estimated at about $32 million for about 82,000 cubic yards or about $391 per cubic yard. The present worth costs include capital costs, O&M

costs, and future capital costs. Capital costs are for the field treatability study and installation of thermal probes, electrical service, extraction wells, and fencing. The O&M cost is for treatment. Future capital costs are for advancement of screening and confirmation borings and decommissioning fencing, thermal probes, extraction wells, and monitoring wells.

6.1.6 Alternative 6 - Bioventing

Bioventing applies to the AOCs with subsurface soil impacted by petroleum COCs including GRO, DRO, VOCs, and SVOCs. This alternative is also applicable to surface soil underlain by impacted subsurface soil but not impacted surface soil only. In bioventing, forced air movement (either extraction or injection of air) provides oxygen to impacted, unsaturated soil to stimulate biodegradation. Oxygen promotes degradation of adsorbed fuel. Volatile compounds are also stripped and degraded as vapors move through biologically active soil. The increased surface air flow created by combining injection and extraction of air simultaneously can decrease the time for remediation. Vertical and horizontal injection and/or extraction wells are installed within the treatment area. The vertical wells would extend throughout the depth of contaminated soil and have an assumed radius of influence of about 25 feet.

A field treatability study would be performed to evaluate the radius of influence for the injection and/or extraction wells and to collect parameters to evaluate biodegradation potential. These parameters include nitrogen, phosphorus, potassium, heterotrophic and oil degrading bacteria, and grainsize. Vertical and horizontal piping used for the injection and/or extraction wells would be constructed of polyvinyl chloride (PVC). A chain-link fence would be constructed around the above-ground portion of the treatment components for protection. The time required for Bioventing treatment may be about 10 years. Screening test pits and/or borings would be advanced at 5 years and confirmation borings would be advanced at 10 years after the bioventing process has been initiated.

Overall Protection of Human Health and the Environment

Risk to human and ecological receptors may be reduced, as long as sufficient bacteria and nutrient amendments are present and/or provided and effectively distributed to metabolize the petroleum contaminants.

Compliance with ARARs

ARARs can be achieved with bioventing. The time required to achieve ARARs will depend on the magnitude of COC concentrations, soil conditions (permeability, oxygen and nutrient availability, presence of bacteria, etc.), temperature, and degradation rates.

Long-Term Effectiveness and Permanence

With bioventing, contaminants may be permanently altered to non-hazardous compounds through bacterial metabolic processes, and to some extent, volatilization of lighter hydrocarbons. The contaminant zone treated by bioventing would require confirmation sampling at the end of treatment to evaluate whether residual risks to human and ecological receptors have been reduced to acceptable levels. This alternative may require a 5-year review.

Reduction in Toxicity, Mobility, or Volume through Treatment

Biodegradation through use of the bioventing alternative is an irreversible treatment process that reduces the concentration of COCs within the radius of influence of the biovent wells.

Short-Term Effectiveness

Volatile constituents may be mobilized during operation of a bioventing system and may escape into the atmosphere at AOCs containing volatile COCs. This can be minimized or reduced with the use of SVE in conjunction with bioventing, and capture and treatment (if necessary) of volatile emissions at the surface. Precautions, in the form of PPE, are needed to prevent ingestion or inhalation during placement of injection and/or extraction wells and manifold piping. This alternative may take about 10 years to achieve goals, depending on soil conditions, available bacteria, distribution of amendments and degradation rates. The length of treatment time is also dependent on the type of fuel to be treated. GRO-impacted soil typically reaches cleanup quicker than DRO-impacted soil which typically reaches cleanup quicker than RRO-impacted soil.

Implementability

This alternative is technically and administratively feasible, and has been used effectively at other sites. Vertical wells and confirmation borings would be installed/advanced using similar drilling equipment as used previously at the sites. Excavating equipment, available in Yakutat, would be needed for installing the horizontal injection/extraction pipes. A nationwide permit to disturb surface soil in a wetland or drainage channel may be required. Possible special concerns include electrical requirements at remote locations.

Costs

The 10-year present worth costs for the Bioventing alternative are shown on Table 6.0-2. The total present worth cost including mobilization demobilization to implement the Bioventing alternative at the applicable AOCs is estimated at about $11 million for about 81,000 cubic yards or about $133 per cubic yard. The present worth costs include capital costs, O&M costs, and future capital costs. Capital costs are for the field treatability study and installation of injection wells, manifold piping, electrical service, and fencing. The O&M cost is for treatment. Future capital costs are for advancement of screening and confirmation borings and decommissioning fencing, injection wells, extraction wells, and monitoring wells.

6.1.7 Alternative 7 - Passive Bioventing

Passive bioventing applies to the AOCs with subsurface soil impacted by petroleum COCs including GRO, DRO, VOCs, and SVOCs. This alternative is also applicable to surface soil underlain by impacted subsurface soil but not impacted surface soil only. In passive bioventing, air movement through aeration wells/points provides oxygen to impacted, unsaturated soil to stimulate biodegradation. Passive bioventing uses the difference in gas pressure that develops between the atmosphere and the subsurface to drive air through vent wells and into the contaminated subsurface zone. Oxygen promotes degradation of adsorbed fuel. Volatile compounds may also be degraded as vapors move through biologically active soil. Vertical and horizontal aeration wells are installed within the treatment area. The vertical wells would extend throughout the depth of contaminated soil and have an assumed radius of influence of about 5 feet.

A field treatability study would be performed to evaluate the radius of influence for passive aeration wells and to collect parameters to evaluate biodegradation potential. These parameters include nitrogen, phosphorus, potassium, heterotrophic and oil degrading bacteria, and grainsize. Vertical and horizontal piping used for the aeration wells would be constructed of PVC. A chain-link fence would be constructed around the above-ground portion of the treatment components for protection. Passive bioventing does not require blowers, electricity, manifold piping, or maintenance and operation. The time required for passive bioventing treatment may be about 30 years. Screening test pits and/or borings would be advanced at 5 year intervals and confirmation borings would be advanced at 20 years after the passive bioventing process has been initiated.

Overall Protection of Human Health and the Environment

Risk to human and ecological receptors may be reduced, as long as sufficient bacteria and nutrient amendments are present and/or provided and effectively distributed to metabolize the petroleum contaminants.

Compliance with ARARs

ARARs can be achieved with passive bioventing. The time required to achieve ARARs will depend on the magnitude of COC concentrations, soil conditions (permeability, oxygen and nutrient availability, presence of bacteria, etc.), temperature, and degradation rates.

Long-Term Effectiveness and Permanence

With passive bioventing, contaminants may be permanently altered to non-hazardous compounds through bacterial metabolic processes, and to some extent, volatilization of lighter hydrocarbons. The contaminant zone treated by passive bioventing would require confirmation sampling at the end of treatment to evaluate whether residual risks to human and ecological receptors have been reduced to acceptable levels. This alternative may require a 5-year review.

Reduction in Toxicity, Mobility, or Volume through Treatment

Biodegradation through use of the passive bioventing alternative is an irreversible treatment process that reduces the concentration of COCs within the radius of influence of the aeration wells.

Short-Term Effectiveness

Volatile constituents may be mobilized during installation of a passive bioventing system and may escape into the atmosphere at AOCs containing volatile COCs. Precautions, in the form of PPE, are needed to prevent ingestion or inhalation during placement of aeration wells and manifold piping. This alternative may take about 20 years to achieve goals, depending on soil conditions, available bacteria, distribution of amendments and degradation rates. The length of treatment time is also dependent on the type of fuel to be treated. GRO-impacted soil typically reaches cleanup quicker than DRO-impacted soil which typically reaches cleanup quicker than RRO-impacted soil.

Implementability

This alternative is technically and administratively feasible, and has been used effectively at other sites. Vertical wells and confirmation borings would be installed/advanced using similar drilling equipment as used previously at the sites. Excavating equipment, available in Yakutat, would be needed for installing the horizontal aeration pipes. A nationwide permit to disturb surface soil in a wetland or drainage channel may be required.

Costs

The 20-year present worth costs for the Passive Bioventing alternative are shown on Table 6.0-2. The total present worth cost including mobilization demobilization to implement the Passive Bioventing alternative at the applicable AOCs is estimated at about $6.7 million for about 81,000 cubic yards or about $82 per cubic yard. The present worth costs include capital costs and future capital costs. Capital costs are for the field treatability study and installation of vent wells and fencing. Future capital costs are for advancement of screening and confirmation borings and decommissioning fencing, vent wells, and monitoring wells.

6.1.8 Alternative 8 - Biopiles

Biopiles apply to AOCs with surface soil, subsurface soil, and sediment impacted by petroleum COCs up to depths of about 15 feet bgs or to groundwater, whichever occurs first. For biopile treatment, excavated soil is mixed with nutrient amendments and placed in a treatment cell that includes a leachate collection and aeration system. Concentrations of petroleum constituents in excavated soils are reduced through biodegradation processes by controlling moisture, nutrients, and oxygen.

Biopiles would be constructed at a designated Treatment Area in Yakutat for petroleum contaminated soil. A rectangular area sufficient to store the estimated quantity of petroleum-impacted soil would be identified for the Treatment Area. An approximate 100 feet long by 50 feet wide area would be enclosed within a soil berm over which a 20-mil petroleum resistant membrane would be extended to form an individual biopile. We estimate that the usable area of the biopile, inside the perimeter of the berm, would be about 90 feet by 40 feet and that the sides of the biopile would slope at 1.5 to 1. Approximately 1,100 cubic yards of petroleum-impacted soil and/or sediment can be placed in a maximum 16-foot high biopile with these dimensions. Additional 20-mil petroleum resistant membranes would be used to construct additional biopiles, as necessary.

Once excavation activities are initiated, petroleum-impacted soil would be transported to the biopiles. The anticipated rate of excavation is approximately 400 cubic yards per day. Confirmation samples would be collected from the final excavations. An air injection system, consisting of 4-inch slotted PVC pipe and manifold piping would be laid horizontally over layers of soil on 10-foot centers in the biopile. With the use of blowers, air will be circulated through the PVC pipe to aerate the soil. A 10-mil petroleum resistant membrane would be used to cover the materials in the biopile to prevent accumulation of rainwater in the bottom of the biopile. The cover material for an individual biopile would extend outside the bermed area to shed rainwater away from the cell and be held down with anchor material. Rainwater accumulation on the cover would be removed by hand with buckets or by pumping prior to uncovering the biopile. The bottom of the biopile would be sloped to drain to a leachate collection system at one corner and water that accumulates would be pumped back into the soil in the biopile through the aeration piping.

A field treatability study would be performed to collect parameters to evaluate biodegradation potential. These parameters include nitrogen, phosphorus, potassium, heterotrophic and oil degrading bacteria, and grainsize. A chain-link fence would be constructed around the Treatment Area to protect/prevent trespassers. The time required for biopiles treatment may be about 5 years. Screening test pits would be advanced into the biopiles at 2, 3, and 4 years after the biopile process has been initiated and confirmation test pits or hand auger borings would be advanced and multi-incremental soil sampling would be conducted at 5 years after the biopile process has been initiated.

Following removal of the treated soil and 20-mil petroleum resistant liner, confirmation samples would be collected from the surface soil underlying the former biopile footprints to document that petroleum-impacted materials were not released at the Treatment Area.

Overall Protection of Human Health and the Environment

Risk to human and ecological receptors may be reduced, as long as sufficient bacteria and nutrient amendments are present and/or provided to metabolize the petroleum contaminants.

Compliance with ARARs

ARARs can be achieved with biopiles through biodegradation of petroleum COCs as a result of nutrient amendments and oxygen supplied by the aeration system. The time required to achieve ARARs for the petroleum-impacted soil in the biopile depends on volume, initial COC concentrations, soil conditions, available bacteria, and degradation rates.

Long-Term Effectiveness and Permanence

Petroleum COCs may be permanently altered to harmless constituents through bacterial metabolic processes, and to some extent, volatilization of lighter hydrocarbons. Monitoring would be required during the operation of the biopiles. The biopile soil would require confirmation sampling at the end of treatment to evaluate whether residual risks to human and ecological receptors have been reduced to acceptable levels. When ARARs have been achieved, the treated soil can be re-used as backfill material. This alternative may or may not require a 5-year review, depending on the initial COC concentrations and rate of biodegradation in the biopiles.

Reduction in Toxicity, Mobility, or Volume through Treatment

Biodegradation through use of the biopile alternative is an irreversible treatment process that reduces the concentration of COCs in soil removed for treatment.

Short-Term Effectiveness

Volatile constituents may be mobilized during excavation, transport, and filling of biopiles, and may escape into the atmosphere. Excavation of impacted soil would be accomplished in the short-term. Precautions, in the form of PPE, are needed to prevent ingestion or inhalation during excavation and placement of soil and aeration and manifold piping. Additional risks to the community may result from transporting large quantities of impacted soil to the Treatment Area. This alternative may take about 5 years to achieve goals, depending on initial COC concentrations, soil conditions, available bacteria, and degradation rates. GRO-impacted soil typically reaches cleanup quicker than DRO-impacted soil which typically reaches cleanup quicker than RRO-impacted soil.

Implementability

Biopiles are technically and administratively feasible, and have been used effectively at other sites. Excavating equipment and trucks, potentially available in Yakutat, would be needed to remove the petroleum-impacted soil to depths of 15 feet and transport the impacted soil to the Treatment Area. A nationwide permit to disturb surface soil in a wetland or drainage channel may be required. Biopiles can be constructed at a Treatment Area where soil can be transported from the various impacted AOCs. The blower(s) to aerate the Biopiles can be used for multiple biopiles if co-located in the Treatment Area.

Costs

The 5-year present worth costs for the Biopiles alternative are shown on Table 6.0-2. The total present worth cost including mobilization demobilization to implement the Biopiles alternative at the applicable AOCs is estimated at about $18 million for about 38,000 cubic yards or about $460 per cubic yard. The present worth costs include capital costs, O&M costs, and future capital costs. Capital costs are for the field treatability study, construction of the biopiles, and installation of fencing. The O&M cost is for treatment. Future capital costs are for advancement of screening and confirmation test pits and decommissioning fencing and biopiles.

6.1.9 Alternative 9 - Excavation and On-Site LTTD

Excavation and LTTD applies to AOCs with surface soil, subsurface soil, and sediment impacted by petroleum COCs up to depths of about 15 feet bgs or to groundwater, whichever occurs first. Thermal desorption is a physical separation process and is not designed to destroy organics. Impacted soil is heated to volatilize water and organic contaminants. A carrier gas or vacuum system transports volatilized water and organics to a gas treatment system. The bed temperatures and residence times designed into these systems may volatilize selected contaminants but would typically not oxidize them. Contaminants removed from soil would be disposed of appropriately.

In Yakutat, contaminated soil would be excavated, placed in long-term stockpiles, and treated when an LTTD unit is available. Treated soil can be re-used as backfill material. The long-term stockpiles would be constructed at a designated Treatment Area in Yakutat for petroleum-contaminated soil. An approximate 100 feet long by 50 feet wide area would be enclosed within a soil berm over which a 20-mil petroleum resistant membrane would be extended to form an individual long-term stockpile. Once excavation activities are initiated, petroleum-impacted soil would be transported to the Treatment Area. The anticipated rate of excavation is approximately 400 cubic yards per day. Confirmation samples would be collected from the final excavations. A 10-mil petroleum resistant membrane would be used to cover the materials in the long-term stockpiles to prevent accumulation of rainwater in the bottom. Water that accumulates in the bottom of the long-term stockpile would need to be treated. A chain-link fence would be constructed around the Treatment Area to protect/prevent trespassers. The time required for on-site low temperature thermal desorption may be about 1 to 12 months depending on quantity of impacted soil and/or sediment. Confirmation samples would be obtained from the treated soil after processing. Treated soil can be used to backfill subsequent excavations.

Overall Protection of Human Health and the Environment

Risk to human and ecological receptors may be reduced with Excavation and LTTD by physical separation of the COCs from soil.

Compliance with ARARs

Contaminated media would be removed from the site; therefore, ARARs may be achieved with this process. The time required to achieve ARARs for the petroleum-impacted soil depends on volume, initial COC concentrations, soil type, and moisture concentration.

Long-Term Effectiveness and Permanence

The removal of contaminants from soil is a permanent solution at the site. Long-term monitoring would not be required during the operation of the LTTD. The treated soil would require confirmation sampling to evaluate whether residual risks to human and ecological receptors have been reduced to acceptable levels. When ARARs have been achieved, the treated soil can be re-used as backfill material. This alternative may not require a 5-year review as residual risks to human and ecological receptors should be reduced to acceptable levels within several weeks to months with the LTTD process.

Reduction in Toxicity, Mobility, or Volume through Treatment

The concentration of contaminants may be reduced to levels that reduce the potential for mobility or toxicity.

Short-Term Effectiveness

Volatile constituents may be mobilized during excavation, transport, and filling of long-term stockpiles, and may escape into the atmosphere. Excavation of impacted soil would be accomplished in the short-term. Precautions, in the form of PPE, are needed to prevent ingestion or inhalation during excavation and placement of soil in the long-term stockpiles. Dry, dusty conditions may create an inhalation hazard (unlikely in Yakutat); however, watering treated soil and exposed surfaces can mitigate potential risk. Additional risks to the community may result from transporting impacted soil and/or sediment to the Treatment Area. Use of the Excavation and LTTD alternative can be completed in several weeks to months, depending on availability of equipment and volume of impacted soil and/or sediment.

Implementability

This alternative is technically and administratively feasible, and has been used effectively at other sites. The long-term stockpiles can be constructed at a Treatment Area where soil can be transported from the various impacted AOCs. Excavating equipment and trucks, potentially available in Yakutat, would be needed to remove the petroleum-impacted soil up to depths of 15 feet and transport the impacted soil to the Treatment Area. A nationwide permit to disturb surface soil in a wetland or drainage channel may be required. Time to completion may be affected by the availability of the LTTD unit. A minimum amount of impacted soil and sediment would be required to mobilize an LTTD unit to Yakutat. An ADEC *Soil Remediation Unit General Permit* may likely be required for operating the LTTD unit.

Costs

The 1-year present worth costs for the Excavation and LTTD alternative are shown on Table 6.0-2. The total present worth cost including mobilization demobilization to implement the Excavation and LTTD alternative at the applicable AOCs is estimated at about $17 million for about 38,000 cubic yards or about $445 per cubic yard. The present worth costs include capital costs for processing contaminated soil and sediment and installation of fencing. There would be no annual O&M cost or future capital costs.

6.1.10 Alternative 10 - Excavation and Off-Site Disposal

Excavation and Off-Site Disposal applies to surface soil, subsurface soil, and sediment impacted by petroleum, metals, and multiple-type COCs up to depths of about 15 feet bgs or to groundwater whichever occurs first. With this alternative, contaminated material is removed and transported to permitted, off-site treatment and/or disposal facilities. Some pretreatment of the contaminated materials may be required in order to meet land disposal restrictions.

Contaminated soil would be excavated, segregated based on COC type, placed in containment cells, and shipped off site. The containment cells would be constructed at a designated Containment Area in Yakutat for contaminated soil. An approximate 100 feet long by 50 feet wide area would be enclosed within a soil berm over which a 20-mil petroleum resistant membrane would be extended to form an individual containment cell. Once excavation activities are initiated, impacted soil would be placed into 5-cy lift-liner bags and transported to the Containment Area. This disposal method is assumed for costing purposes in this FS;

however, there are other, excavation and disposal methods that may be employed. The anticipated rate of excavation is approximately 100 cubic yards per day. Confirmation samples would be collected from the final excavations. A 10-mil petroleum resistant membrane would be used to cover the materials in the containment cells to prevent accumulation of rainwater in the bottom. Water that accumulates in the bottom of the containment cells would need to be treated. A chain-link fence would be constructed around the Containment Area to protect/prevent trespassers. The time required for Excavation and Off-Site Disposal may be several weeks to months, depending on availability of excavating equipment and contaminated soil transportation off site. Confirmation samples would be obtained from the treated soil after processing.

Overall Protection of Human Health and the Environment

Risk to human and ecological receptors may be reduced by disposal of contaminated soil at a permitted, off-site treatment and/or disposal facility.

Compliance with ARARs

Contaminated materials would be removed from the site; therefore, ARARs may be achieved with this process. The time required to achieve ARARs is dependent on the rate of excavation and disposal.

Long-Term Effectiveness and Permanence

The removal of contaminated soil is a permanent solution at the site. Long-term monitoring would not be required. The excavation and off-site disposal alternative may not require a 5-year review as residual risks to human and ecological receptors should be reduced to acceptable levels within several weeks to months.

Reduction in Toxicity, Mobility, or Volume through Treatment

The toxicity, mobility, and volume of impacted soil at the applicable AOCs should be reduced by the excavation process.

Short-Term Effectiveness

Volatile constituents may be mobilized during excavation, transport, and filling of lift-liner bags, and may escape into the atmosphere. Excavation of impacted soil would be accomplished in the short-term. Precautions, in the form of PPE, are needed to prevent ingestion or inhalation during excavation and placement of soil in the lift-liner bags. Dry, dusty conditions may create an inhalation hazard (unlikely in Yakutat); however, watering exposed surfaces can mitigate potential risk. Additional risks to the community may result from transporting impacted soil and/or sediment to the Containment Area and/or off-site. Use of the Excavation and Off-Site

Disposal alternative can be completed in several weeks to months, depending on availability of excavating equipment and contaminated soil transportation off site.

Implementability

Excavation and Off-Site Disposal is technically and administratively feasible, and has been used effectively at other sites. The containment cells can be constructed at a Containment Area where soil can be transported from the various impacted AOCs and be staged for shipping. Excavating equipment and trucks, potentially available in Yakutat, would be needed to remove the impacted soil up to depths of 15 feet and transport impacted soil to the Containment Area. A nationwide permit to disturb surface soil in a wetland or drainage channel may be required.

Costs

The 1-year present worth costs for the Excavation and Off-Site Disposal alternative are shown on Table 6.0-2. The total present worth cost including mobilization demobilization to implement the Excavation and Off-Site Disposal alternative at the applicable AOCs is estimated at about $49 million for about 46,000 cubic yards or about $1,058 per cubic yard. The present worth costs include capital costs for excavation and disposal of contaminated soil and sediment and installation of fencing. There would be no annual O&M cost or future capital costs.

6.1.11 Alternative 11 - Soil Washing

Soil washing applies to surface soil, subsurface soil, and sediment impacted by metal COCs. The metals addressed by this alternative include arsenic, cadmium, chromium, lead, and silver. Soil washing is a water-based process for scrubbing soils ex situ to remove contaminants. The process removes contaminants from soils in one of the following two ways. The first method is by dissolving or suspending contaminants in the wash solution which can be sustained by chemical manipulation of pH for a period of time. The second method involves concentrating contaminants into a smaller volume of soil through particle size separation, gravity separation, attrition scrubbing and mineral jigging similar to those techniques used in sand and gravel and precious metal recovery operations.

Contaminated soil would be excavated, placed in long-term stockpiles, and treated with a Soil Washing unit. The contaminated water or chemical solution generated from the soil washing will be shipped to an off-site treatment/disposal facility. Treated soil can be re-used as backfill material. The long-term stockpiles would be constructed at a designated Treatment Area in Yakutat for metals-contaminated soil. An approximate 100 feet long by 50 feet wide area would be enclosed within a soil berm over which a 20-mil petroleum resistant membrane would be extended to form an individual long-term stockpile. Once excavation activities are initiated, metals-impacted soil would be transported to the Treatment Area. The anticipated rate of excavation is approximately 400 cubic yards per day. Confirmation samples would be collected from the final excavations. A 10-mil petroleum resistant membrane would be used to cover the materials in the long-term stockpiles to prevent accumulation of rainwater in the bottom. Water that accumulates in the bottom of the long-term stockpile may need to be treated.

A bench scale study would be performed to collect parameters to evaluate soil washing potential. These parameters include COC concentration, grain size, moisture content, cation exchange and buffering capacity, and pH. It is assumed that the Treatment Area can be constructed inside the security fence at the Rifle Range. Otherwise, a chain-link fence would need to be constructed around the Treatment Area to protect/prevent trespassers. The time required for Soil Washing may be about several weeks to 6 months depending on quantity of impacted soil and/or sediment. Confirmation samples would be obtained from the treated soil after processing. Treated soil can be used to backfill subsequent excavations.

Overall Protection of Human Health and the Environment

Risks to human and ecological receptors may be reduced by removing metals from soil and/or sediment either to acceptable levels or to background concentrations.

Compliance with ARARs

Metals in the soil would be removed from the site; therefore, ARARs may be achieved with this process. The time required to achieve ARARs for the metals-impacted soil and/or sediment depends on volume, initial COC concentrations, soil properties, and moisture content.

Long-Term Effectiveness and Permanence

The removal of contaminants from soil and/or sediment is a permanent solution. Long-term monitoring would not be required during the soil washing process. The treated soil would require confirmation sampling to evaluate whether residual risks to human and ecological receptors have been reduced to acceptable levels. When ARARs have been achieved, the treated soil can be re-used as backfill material. This alternative may not require a 5-year review as residual risks to human and ecological receptors should be reduced to acceptable levels within about 6 months with soil washing.

Reduction in Toxicity, Mobility, or Volume through Treatment

Soil washing results in reduction of the metals concentrations and is an irreversible treatment process. The concentration of contaminants is reduced by soil washing to levels that reduce the potential for mobility and toxicity.

Short-Term Effectiveness

Excavation of impacted soil would be accomplished in the short-term. Precautions, in the form of PPE, are needed to prevent ingestion or inhalation during excavation. Dry, dusty conditions may create an inhalation hazard (unlikely in Yakutat); however, watering exposed surfaces can mitigate potential risk. Additional risks to the community may result from transporting impacted soil and/or sediment to the Treatment Area and the water/liquid residue off site. Use of the soil washing alternative can be completed in several weeks to months, depending on availability of excavating equipment, volume, initial COC concentrations, soil properties, and moisture content.

Implementability

Soil washing is a tested and effective alternative that has been utilized at many sites to remove metals from soil. Excavating equipment and trucks, potentially available in Yakutat, would be needed to remove and transport the impacted soil and/or sediment to the Treatment Area. The equipment used in the soil washing process would need to be mobilized to the site. A minimum amount of impacted soil and sediment would be required to mobilize a soil washing unit to Yakutat. A nationwide permit to disturb surface soil in a wetland or drainage channel may be required.

Costs

The 1-year present worth costs for the Soil Washing alternative are shown on Table 6.0-2. The total present worth cost including mobilization demobilization to implement the Soil Washing alternative at the applicable AOCs is estimated at about $645,000 for about 540 cubic yards or about $1,200 per cubic yard. Since the minimum volume of impacted soil and/or sediment required to mobilize a soil washing unit to Yakutat is 300 to 400 cy, a range of costs for implementing the Soil Washing alternative was not developed. The present worth costs include capital costs for excavation and processing contaminated soil and sediment and collection of confirmation samples. There would be no annual O&M cost or future capital costs.

6.1.12 Alternative 12 - Capping

Capping applies to soil in the landfill cover material at AOC K1 impacted by multiple COC types. For this FS, capping is being considered as a remedial alternative only for AOC K1. AOC K1 is the location of a former debris dump covering an estimated 82,150 square foot area. The COCs at AOC K1 (DRO, pentachlorophenol, benzo(a)pyrene, arsenic, cadmium and chromium) are present at ten discrete surface soil and near surface soil (2 to 4 feet bgs) locations. For the purpose of this FS, it is assumed that the 2-feet thick landfill cover material throughout the former debris dump area at AOC K1 is impacted by multiple COC types.

Capping is an in situ technology in which an impervious cover is engineered and placed over the contaminated area to prevent direct contact by potential receptors and to act as a barrier that prevents percolation of precipitation into contaminated soil.

The debris dump area at AOC K1 is assumed to be equivalent to a Class I municipal solid waste landfill. Closure standards for a Class I municipal solid waste landfill are presented in 18 AAC 60.395. Based on these standards, the final cover must be designed and constructed to:

(1) have a permeability no greater than 1 x 10^{-5} centimeters per second;

(2) minimize infiltration through the landfill by use of an infiltration layer that contains a minimum of 18 inches of earthen material; and

(3) minimize erosion of the final cover by use of an erosion layer that contains a minimum of six inches of earthen material capable of sustaining native plant growth.

Reportedly a 2-foot thick layer of gravelly sand was placed over the debris dump in 1984 as a capping material. Vegetation, including spruce trees, has since regrown over the area. The vegetation will be cleared from the former dump area. After clearing the vegetation and smoothing the surface soil, a geotextile liner will be placed as a marker material and barrier between the original granular 1984 capping material and the new infiltration layer. The infiltration layer soil will be placed in six-inch lifts and compacted to meet the design requirements of a minimum of 18 inch thickness and a permeability of no greater than 1 x 10^{-5} centimeters per second. After placement of the infiltration layer, a minimum 6-inch thick erosion layer will be placed and seeded with native plants. The cap will be graded to minimize ponding of surface water. It is assumed a leachate collection system will not be required.

Post closure care requirements for a Class I municipal solid waste landfill are addressed in 18 AAC 60.397. Per these requirements, post-closure care must be maintained for at least 30 years. At a minimum, the integrity and effectiveness of the final cover must be maintained. Groundwater and gas monitoring must be implemented, if applicable. It is assumed that a groundwater and gas monitoring program will not be required. The post-closure care period may be decreased if the owner or operator demonstrates that the reduced period is sufficient to protect public health and the environment.

Contaminants are not destroyed by this option, and institutional controls would likely be required. Institutional controls, in the form of a deed restriction, will need to be in place to inform future users of the property that impacted soil is on site, and that proper handling and disposal of the contaminated material will be required if disturbed. Additional drawbacks include: long term liability associated with residual contamination; uncertain costs related to future assessment, cleanup and disposal needs; and the landowner would need to agree to the remedy, the institutional controls and maintenance of the cap.

Overall Protection of Human Health and the Environment

Risk to human and ecological receptors may be reduced by capping the contaminated soil at AOC K1. The physical barrier of the capping material limits access to COCs, and therefore, exposure. The integrity of the cap must be maintained in order to sustain the limited exposure.

Compliance with ARARs

Compliance with ARARs would not be achieved with the capping alternative.

Long-Term Effectiveness and Permanence

With capping, reduced risk to human and ecological receptors is maintained through the presence of the infiltration and erosion capping materials. The integrity of the cap must be maintained for long-term effectiveness, therefore, long-term monitoring would be required. In addition, precautions, in the form of institutional controls such as deed restrictions, would need to be taken to assume the integrity of the cap is not compromised by land use activities and to inform future users of the property that impacted soil is on site, and that proper handling and disposal of the contaminated material will be required if disturbed.

Reduction in Toxicity, Mobility, or Volume through Treatment

Capping does not reduce the toxicity, mobility, or volume of COCs, but does mitigate migration by limiting the vertical entry of water into the landfill. The cap does not prevent the horizontal flow of groundwater through the impacted soil.

Short-Term Effectiveness

A temporary increase of risk to workers, the community and the environment may occur due to exposure to COCs during the construction of the cap. These risks may be mitigated using dust control measures and PPE. Capping does not reduce the concentrations of COCs.

Implementability

This alternative is technically and administratively feasible, and has been used effectively at other sites. Earthwork equipment, available in Yakutat, would be needed for installing the capping materials. A nationwide permit to disturb surface soil in a wetland or drainage channel may be required.

Costs

The 1-year present worth costs for the Capping alternative are shown on Table 6.0-2. The total present worth cost including mobilization demobilization to implement the Capping alternative at AOC K1 is estimated at about $500,000 for about 7,000 cubic yards of soil impacted with multiple COCs or about $71 per cubic yard. The present worth costs include capital costs for installation of the cap. There would be no annual O&M cost or future capital costs.

6.1.13 Alternative 13 - Air Sparging/Soil Vapor Extraction

Air Sparging/Soil Vapor Extraction applies to groundwater impacted by petroleum COCs at 3 sites, including AOCs C6, D-AST7, and L1(South Dump). The COCs addressed by the following alternatives include DRO, GRO, and benzene. Air sparging is an in situ technology in which air is injected into a petroleum-impacted water bearing zone. Injected air travels horizontally and/or vertically through the saturated soil column, creating an underground stripper that removes contaminants by volatilization. The volatile contaminants are carried upward by the injected air into the unsaturated zone and removed by a vapor extraction system. Oxygen supplied to the petroleum-impacted water bearing zone and vadose zone soils enhances biodegradation of the non-volatile contaminants below and above the water table. Vertical injection wells and vertical and horizontal extraction wells are installed within the treatment area. The vertical injection wells would extend throughout the depth of contaminated water bearing zone soil and have an assumed radius of influence of about 10 feet.

A field treatability study would be performed to evaluate the radius of influence for the injection and extraction wells and to collect parameters to evaluate biodegradation potential. These parameters include nitrogen, phosphorus, potassium, heterotrophic, and iron/oil degrading bacteria, and grain size. Vertical and horizontal piping used for injection and extraction wells would be constructed of PVC. A chain-link fence would be constructed around the above ground portions of the treatment components to protect/prevent trespassers. The time required for Air Sparging/Soil Vapor Extraction may be about 10 years. Groundwater samples from the on-site monitoring wells would be collected and analyzed each subsequent year after the Air Sparging/Soil Vapor Extraction process has been initiated.

Overall Protection of Human Health and the Environment

This alternative results in physical removal of volatile constituents and biodegradation of heavier petroleum hydrocarbons. Used effectively, this alternative can reduce risk to acceptable levels.

Compliance with ARARs

Removal of volatile constituents and reduction of heavier petroleum hydrocarbon concentrations through biodegradation as a result of oxygen supplied by the injection wells and introduced nutrients may achieve ARARs. The time required to achieve ARARs depends on

COC concentrations, extent of the groundwater plume, soil and groundwater conditions, available bacteria, distribution of amendments and degradation rates.

Long-Term Effectiveness and Permanence

With Air Sparging/Soil Vapor Extraction, contaminants would be removed through volatilization and extraction of lighter hydrocarbons and permanent alteration of heavier hydrocarbons to non-hazardous compounds through bacterial metabolic processes. Risk through exposure or ingestion of groundwater may be permanently reduced, as long as there is not a new or continuing source of contamination. Long-term monitoring would be required to evaluate whether residual risks to human and ecological receptors have been reduced to acceptable levels. This alternative would require reviewing groundwater contaminant concentrations on a yearly basis.

Reduction in Toxicity, Mobility, or Volume through Treatment

Extraction of lighter hydrocarbons and biodegradation of heavier hydrocarbons through use of the Air Sparging/Soil Vapor Extraction alternative is an irreversible treatment process. The concentration of contaminants is reduced by extraction and biodegradation to levels that reduce the potential for mobility and toxicity.

Short-Term Effectiveness

Volatile constituents may be mobilized during operation of an Air Sparging/Soil Vapor Extraction and may escape into the atmosphere. This can be minimized through treatment (if necessary) of volatile emissions at the surface. Precautions, in the form of PPE, are needed to prevent ingestion or inhalation during placement of extraction/injection wells and manifold piping. Although unlikely, pressure applied to the sparging wells may need to be adjusted to prevent potential mobilization of contaminants in groundwater off site. This alternative may take about 10 years to achieve goals, depending on soil and groundwater conditions, available bacteria, distribution of amendments, and degradation rates.

Implementability

This alternative is technically and administratively feasible, and has been used effectively at other sites. Vertical wells and confirmation borings would be installed/advanced using similar drilling equipment as used previously at the sites. Excavating equipment, available in Yakutat, would be needed for installing horizontal pipes. A nationwide permit to disturb surface soil in a wetland or drainage channel may be required.

Costs

The 10-year present worth costs for the Air Sparging/Soil Vapor Extraction alternative are shown on Table 6.0-3. The present worth cost for the Air Sparging/Soil Vapor Extraction alternative for the 3 sites with contaminated groundwater plumes, C6, D-AST7, and L1(South Dump), are estimated to be $1.4 million, $1.35 million, and $270,000, respectively. These costs assume that only the Air Sparging component for this alternative will be installed and that the Bioventing alternative for soil, discussed in a previous section, will be used as the Soil Vapor Extraction component for each of these 3 sites. The present worth costs include capital costs, O&M costs, and future capital costs. Capital costs are for the field treatability study, installation of sparging wells, manifold piping, monitoring wells and fencing. The O&M cost is for groundwater treatment and monitoring. Future capital costs are for decommissioning air sparging wells, fencing and monitoring wells.

6.2 Comparative Analysis

The remedial alternatives that have been analyzed are compared in the following discussion to identify the relative advantages and disadvantages in context of the specific media applicable to the AOCs.

Tables 6.2-1 through 6.2-10 present the alternatives analyzed for each COC and media scenario present at the AOCs. Each alternative is given a score for each criterion evaluated. The scores are based on best judgment considering the COCs and the affected media, potential constraints posed by the individual AOCs, and other considerations. The alternative(s) that best meets the specific criterion is given the lowest score of 1. Alternatives are then incrementally scored higher in the order in which they address the criterion. The scores given to each criterion are added to get the overall score for each alternative considered for the specific scenario. The alternative(s) with the lowest overall score theoretically best meets the seven evaluation criteria used in the FS process. The scores are not intended as the ultimate selection criterion, but rather as an additional tool to assist decision-makers in the selection process.

The volume of impacted soil (cubic yards) or the area of impacted groundwater (square feet) for each of the ten scenarios are presented on Tables 6.2-1 through 6.2-10. The aerial extent of impacted surface water cannot be estimated based on available data and is uncertain. The total present worth costs shown on Tables 6.2-1 through 6.2-10 to implement a given remedial alternative are based on the volume of impacted soil or area of impacted groundwater at the applicable AOCs. The present worth costs for implementing a given remedial alternative at one of the ten scenarios can be estimated using the costs shown on Tables 6.2-1 through 6.2-10. For example, the present worth costs to excavate and treat the approximately 254 cy of petroleum impacted surface soil at the 8 AOCs listed on Table 6.2-1 with the on-site LTTD are estimated at $390,000. The present worth costs to treat the approximately 43,000 cy of petroleum impacted soil at depths less than 15 feet bgs at the 15 AOCs listed on Table 6.2-2 with the on-site LTTD are estimated at $16 million. Note that the total cost for implementing a given remedial alternative at the applicable AOCs, shown on Tables 6.2-1 through 6.2-10, does not include mobilization/demobilization costs as these costs can be shared while implementing remedial alternatives at other AOCs. Minimum amounts of soil are required to implement Alternatives 9 and 11 as these alternatives require mobilization of large commercial remediation units.

6.2.1 Alternatives for Petroleum COCs in Surface Soil (<2 feet bgs)

DRO, benzene, benzo(a)anthracene, and benzo(a)pyrene were encountered in only surface soil at D-AST2, L3-Tank 1, L3-Tank 3, L3-Tank 7, L3-Tank 8, L3-Tank 11, L3-Tank 14, and L4. The remedial alternatives applicable to only surface soil impacted with DRO, VOCs, and SVOCs at the 8 AOCs are indicated on Table 6.2-1 and include:

- Alternative 1 - No Action
- Alternative 2 - Institutional Controls
- Alternative 3 - Monitored Natural Attenuation
- Alternative 4 - In-Situ Fenton's Reagent Oxidation
- Alternative 5 - In-Situ Soil Heating
- Alternative 8 - Biopiles
- Alternative 9 - Excavation and On-Site Low-Temperature Thermal Desorption
- Alternative 10 - Excavation and Off-Site Disposal.

Overall Protection of Human Health and the Environment

All the alternatives, except the No Action and Institutional Controls alternatives, can provide adequate protection of human health and the environment. Risks through direct contact with impacted surface soil and potential ingestion of impacted groundwater are addressed with Alternatives 8, 9, and 10 by removal of the COCs from the environment. Alternative 10 mitigates the risk more quickly than Alternatives 8 and 9 through off-site treatment of the excavated impacted soil as opposed to on-site treatment. Alternatives 4 and 5 reduce the risk of direct contact with impacted surface soil and potential ingestion of impacted groundwater with time through in-situ treatment and monitoring. Engineering controls, such as fencing, are implemented to limit access to sites with impacted surface soil to limit exposure while COCs are reduced with Alternatives 3, 4, 5, 8, and 9. Risks through potential ingestion of impacted groundwater are addressed with Alternative 3 through long-term monitoring. Alternative 2 would neither prevent nor reduce the risk of direct contact with impacted surface soil. Deed restrictions can be implemented under Alternative 2 to reduce risks associated with potential ingestion of impacted groundwater by prohibiting installation of drinking water wells and to reduce risk of direct contact with soil. Risks through direct contact with impacted surface soil and potential ingestion of impacted groundwater are not addressed with Alternative 1.

Compliance with ARARs

Each alternative can achieve ARARs, however, for the purposes of this FS, we assume that ARARs are not achieved with Alternatives 1 and 2. Alternatives 9 and 10 can achieve ARARs the quickest by removal of the COCs from the environment followed by short-term on-site treatment or off-site disposal. Alternative 8 can also achieve ARARs by removal of the COCs from the environment followed by medium-term on-site treatment. COCs are not removed from the environment with Alternatives 4 and 5 but are destroyed and/or reduced to ARARs by implementing medium-term in-situ treatment. Alternative 3 achieves ARARs over the long term through natural biodegradation processes. Compliance with ARARs is reviewed periodically with Alternative 3 through long-term monitoring.

Long-Term Effectiveness and Permanence

All of the alternatives can be effective in the long-term, however, for the purposes of this FS, we assume that Alternatives 1 and 2 do not reduce the hazards posed by the COCs. Alternatives 9 and 10 would be more reliable to reduce the hazards posed by the COCs in the impacted surface soil and excavation wastes. Alternative 8 is a reliable technology to reduce the hazards posed by the COCs in the impacted surface soil but is less reliable than Alternatives 9 and 10 in treating excavation wastes. Alternatives 4 and 5 are less reliable than Alternatives 8, 9 and 10 in reducing the hazards posed by the COCs in the impacted surface soil. Alternatives 4 and 5 are reliable technologies to reduce the hazards posed by the COCs in the impacted surface soil and are effective over the medium term. Alternative 3 is the least reliable in reducing the hazards posed by the COCs in the impacted surface soil over the long-term, however, the long-term effectiveness is monitored with Alternative 3.

Reduction in Toxicity, Mobility, or Volume through Treatment

Alternatives 9 and 10 achieve complete reduction in toxicity, mobility, and volume of contaminants through excavation and treatment/disposal of impacted surface soil. Alternative 8 removes impacted surface soil from the environment by excavation and achieves reduction in toxicity, mobility, and volume of contaminants through ex-situ treatment. Alternatives 4 and 5 do not remove impacted surface soil from the environment but can achieve reduction in toxicity, mobility, and volume of contaminants a little quicker than the excavation wastes under Alternative 8 are treated. Alternative 3 relies on natural biodegradation processes over the long term to eventually achieve reduction in toxicity, mobility, and volume of contaminants. The reduction in toxicity, mobility, and volume of contaminants is reviewed periodically with Alternative 3 through long-term monitoring. Alternatives 1 and 2 are assumed to not reduce the toxicity, mobility or volume of COCs.

Short-Term Effectiveness

Alternatives 1 and 2 do not pose risks to workers, the community, and the environment during implementation. Alternative 2 poses less risk to workers, the community, and the environment because no action is taken with Alternative 1 in the short term to reduce exposure to COCs. Of the remaining technologies, Alternative 3 poses the least risk to workers, the community, and the environment during the installation and decommissioning of potential monitoring wells and fencing and advancement of confirmation borings. The risks to workers, the community, and the environment posed by Alternative 5 is higher than Alternative 3 due to the soil heating process and installation of the system components. The risks to workers, the community, and the environment during implementation of Alternative 4 are slightly higher than Alternative 5 due to the handling of hydrogen peroxide and installation/decommissioning of the oxidant delivery system. Alternatives 8, 9, and 10 require the use of large excavation equipment and transport trucks to move impacted soil and/or sediment on Yakutat roads and pose the greatest risks to workers, the community, and the environment during implementation.

Alternatives 9 and 10 require the least time and are the most effective at achieving ARARs. The time required to achieve ARARs with Alternative 5 is about 1 year which is less than Alternative 4 which may be about 2 years. Alternative 8 may require about 5 years to achieve ARARs. The least effective at achieving ARARs is Alternative 3 which may require up to 30 years or more. Alternatives 1 and 2 are assumed to not achieve ARARs.

Implementability

Alternative 1 would be the simplest to implement as no action is required. Alternative 2 is also simple to implement although acceptance by ADEC, EPA and the local community is an unknown. The construction tasks associated with Alternative 3, including installation and decommissioning of potential monitoring wells, fencing, advancement of confirmation borings, and monitoring, require additional on-site efforts to implement. Evaluating treatment with Alternative 3 and the unknown length of time required for long-term monitoring make implementation more complex. Although more complex than Alternative 3, mobilization of equipment, excavation, and soil transportation requirements for Alternatives 9 and 10 are fairly common tasks in Alaska and can be successfully implemented with a high degree of certainty. Implementing excavation and construction of the biopiles under Alternative 8 can be fairly simple but evaluating the effectiveness of treatment would be more difficult than Alternatives 9 and 10. Installing and decommissioning the oxidant delivery system, potential monitoring wells, and fencing, and advancement of confirmation borings for Alternative 4 are common tasks in Alaska. Likewise, installing and decommissioning the components required for a conductive soil heating system and fencing, and advancement of confirmation borings for Alternative 5 are common tasks in Alaska. Operation of the soil heating system for Alternative 5 and the oxidant delivery system for Alternative 4 would be more complex than Alternative 8. Handling hydrogen peroxide and evaluating treatment with Alternative 4 would be more complex than operation of the soil heating system with Alternative 5.

Cost

As indicated on Table 6.2-1, Alternative 1 would have no cost to implement. Alternative 2 would have low cost to implement and, with the exception of Alternative 1, would have the least present worth costs. Of the active remedial alternatives, Alternative 3 is estimated to have the lowest capital costs but due to the continual monitoring requirements for an estimated 30 years, would have high O&M costs. The present worth costs of Alternative 3, however, would still be lower than Alternatives 4, 5, 8, 9, and 10. The costs to implement Alternative 9 are estimated to be less than those for Alternative 4 which are lower than those for Alternatives 5, 8, and 10. Alternative 5 is estimated to have lower costs than Alternative 10. The costs to implement Alternative 10 are estimated to be less than Alternative 8 making Alternative 8 the most costly option for remediation of petroleum-impacted surface soil due to the low volume of impacted soil.

6.2.2 Alternatives for Petroleum COCs in Subsurface Soil (<15 feet bgs)

Petroleum COCs were encountered in subsurface soil at depths less than 15 feet bgs, with or without petroleum-impacted surface soil, at 15 AOCs. The COCs include DRO, GRO, benzene, toluene, 2-methylnaphthalene, benzo(a)anthracene, and benzo(a)pyrene. The AOCs include C2, C4, C6, D-AST-1, D-AST1 (downslope), D-AST3, D-AST4 (north) D-AST4 (south), D-AST5, D-AST6, D-AST7, D-AST8, L1-South Dump, M2 (tank) and M2 (quonset hut). Note that AOCs D-AST1, D-AST1 (downslope), D-AST5, D-AST6, D-AST7 and D-AST8 also have petroleum-impacted soil that extends greater than 15 feet bgs. The remedial alternatives applicable to subsurface soil, with or without surface soil, impacted with DRO, GRO, VOCs and SVOCs at the 15 AOCs are indicated on Table 6.2-2 and include:

- Alternative 1 - No Action
- Alternative 2 - Institutional Controls
- Alternative 3 - Monitored Natural Attenuation
- Alternative 4 - In-Situ Fenton’s Reagent Oxidation
- Alternative 5 - In-Situ Soil Heating
- Alternative 6 - Bioventing
- Alternative 7 - Passive Bioventing
- Alternative 8 - Biopiles
- Alternative 9 - Excavation and On-Site Low-Temperature Thermal Desorption
- Alternative 10 - Excavation and Off-Site Disposal.

Overall Protection of Human Health and the Environment

All the alternatives, except the No Action and Institutional Controls alternatives, provide adequate protection of human health and the environment for AOCs where impacted surface soil overlies impacted subsurface soil. With the exception of the No Action alternative, each alternative can provide adequate protection of human health and the environment for AOCs where impacted subsurface soil only is present. Risks through direct contact with impacted surface and subsurface soil and potential ingestion of impacted groundwater are addressed with Alternatives 8, 9, and 10 by removal of the COCs from the environment. Alternatives 4, 5, 6 and 7 reduce the risk of direct contact with impacted surface and subsurface soil and potential ingestion of impacted groundwater with time through in-situ treatment and monitoring. The reduction of risk, however, will take longer with Alternative 7. Engineering controls, such as fencing, can be implemented to limit access to sites with impacted surface and subsurface soil to limit exposure while COCs are reduced with Alternative 3. Risks through potential ingestion of impacted groundwater are addressed with Alternative 3 through long-term monitoring. Alternative 2 would neither prevent nor reduce the risk of direct contact with impacted surface soil. Deed restrictions can be implemented under Alternative 2 to reduce risks associated with direct contact of impacted subsurface soil and potential ingestion of impacted groundwater by prohibiting excavation below a depth of 2 feet bgs and installation of drinking water wells, respectively. Risks through direct contact with impacted surface and subsurface soil and potential ingestion of impacted groundwater are not addressed with Alternative 1.

Compliance with ARARs

Each alternative can achieve ARARs, however, for the purposes of this FS, it is assumed that ARARs are not achieved with Alternatives 1 and 2. Alternatives 9 and 10 would achieve ARARs the quickest by removal of the COCs from the environment followed by short-term on-site treatment or off-site disposal. Alternative 8 can also achieve ARARs by removal of the COCs from the environment followed by medium-term on-site treatment. COCs are not removed from the environment with Alternatives 4, 5, and 6 but are reduced to ARARs by implementing medium-term in-situ treatment. Alternative 7 implements long-term in-situ treatment to reduce COCs to ARARS. Alternative 3 achieves ARARs over the long term through natural biodegradation processes.

Long-Term Effectiveness and Permanence

All of the alternatives can be effective in the long-term, however, for the purposes of this FS, it is assumed that Alternatives 1 and 2 are not effective in the long term. Alternatives 9 and 10 would be more reliable to reduce the hazards posed by the COCs in the impacted surface and subsurface soil and excavation wastes. Alternative 8 is a reliable technology to reduce the hazards posed by the COCs in the impacted surface and subsurface soil but is less reliable than

Alternatives 9 and 10 in treating excavation wastes. Alternatives 4, 5, and 6 are less reliable than Alternatives 8, 9 and 10 in reducing the hazards posed by the COCs in the impacted surface soil. Alternatives 4, 5, and 6, however, are reliable technologies to reduce the hazards posed by the COCs in the impacted surface and subsurface soil and are effective over the medium term. Alternative 7 is less reliable that Alternatives 4, 5 and 6 in reducing the hazards. Alternative 3 is the least reliable in reducing the hazards posed by the COCs in the impacted surface and subsurface soil over the long term.

Reduction in Toxicity, Mobility, or Volume through Treatment

Alternatives 9 and 10 achieve complete reduction in toxicity, mobility, and volume of contaminants through excavation and treatment/disposal of impacted surface and subsurface soil. Alternative 8 removes impacted surface and subsurface soil from the environment by excavation and achieves reduction in toxicity, mobility, and volume of contaminants through ex-situ treatment. Alternatives 4 and 5 do not remove impacted surface and subsurface soil from the environment but do achieve reduction in toxicity, mobility, and volume of contaminants in less time than the excavation wastes under Alternative 8 are treated. Alternative 6 requires a longer time frame to achieve reduction in toxicity, mobility, and volume of contaminants compared to Alternatives 4, 5, and 8. Alternative 7 requires a longer time than Alternative 6. Alternative 3 relies on natural biodegradation processes over the long term to eventually achieve reduction in toxicity, mobility, and volume of contaminants. Alternatives 1 and 2 are assumed to not reduce the toxicity, mobility or volume of COC.

Short-Term Effectiveness

Alternatives 1 and 2 do not pose risks to workers, the community, and the environment during implementation, because there is no disturbance of contaminated media to implement either alternative. Since no action is taken with Alternative 1 to reduce exposure to COCs, Alternative 2 poses less risk to workers, the community, and the environment. Of the remaining technologies, Alternative 3 poses the least risk to workers, the community, and the environment during the installation and decommissioning of potential monitoring wells and fencing and advancement of confirmation borings. Alternative 7 poses a slightly higher risk to workers, the community, and the environment than Alternative 3 due to the potential for exposure to volatiles released during the passive treatment. The risks to workers, the community, and the environment posed by Alternative 5 are slightly higher than Alternative 6 due to soil heating and those posed by Alternative 4 are slightly higher than Alternative 5 due to the handling of hydrogen peroxide. Alternatives 8, 9, and 10 require the use of large excavation equipment and transport trucks to move impacted soil and/or sediment on Yakutat roads and pose the greatest risks to workers, the community, and the environment during implementation.

Alternatives 9 and 10 require the least time and are the most effective at achieving ARARs. The time required to achieve ARARs with Alternative 5 is about 6 months to 1 year which is less than Alternative 4 which requires about 2 years. Alternative 8 may require about 5 years to achieve ARARs which is more effective than Alternative 6 which may require about 10 years. The least effective at achieving ARARs are Alternatives 3 and 7 which may require up to 30 years or more. Alternative 7 is considered more effective than Alternative 3 since a remedial treatment is being implemented even though the two alternatives may take the same length of time to achieve ARARs. Alternatives 1 and 2 are assumed to not achieve ARARs.

Implementability

Alternative 1 would be the simplest to implement as no action is required. Alternative 2 is also simple to implement although acceptance by ADEC, EPA and the local community of the necessary deed restrictions is an unknown. The construction tasks associated with Alternative 3, including installation and decommissioning of potential monitoring wells, fencing, advancement of confirmation borings, and monitoring, could easily be implemented. Evaluating treatment with Alternative 3 and the unknown length of time required for long-term monitoring make implementation more complex. Alternative 7 would require similar construction and monitoring tasks as Alternative 3 but would be more complex due to the number of aeration wells and possible installation of horizontal manifold piping. Although more complex than Alternatives 3 and 7, mobilization of equipment, excavation, and soil transportation requirements for Alternatives 9 and 10 are fairly common tasks in Alaska and can be successfully implemented with a high degree of certainty. Implementing excavation and construction of the biopiles under Alternative 8 can be fairly simple but the effectiveness of treatment would be more difficult to evaluate than Alternatives 9 and 10. Installing and decommissioning the air injection/extraction, oxidant delivery and soil heating systems, potential monitoring wells, and fencing, and advancement of confirmation borings for Alternatives 4, 5, and 6 are common tasks in Alaska. Evaluating the effectiveness of treatment with Alternatives 4, 5, and 6 would be more difficult than Alternative 8. Soil heating with Alternative 5 is more complex to implement than Alternative 6 and handling hydrogen peroxide with Alternative 4 would be more complex than Alternative 5.

Cost

Alternative 1 would have no cost to implement as indicated on Table 6.2-2. Alternative 2 would have low cost to implement and, with the exception of Alternative 1, would have the least O&M costs. Of the remaining remedial alternatives, Alternative 3 is estimated to have the lowest capital costs but due to the continual monitoring requirements for an estimated 30 years, would have high O&M costs. The present worth costs of Alternative 3, however, would still be lower than Alternatives 4, 5, 6, 7, 8, 9, and 10. The costs to implement Alternative 7 are estimated to be less than those for Alternative 6 which are lower than those for Alternatives 4, 5, 8, 9, and 10. Alternative 4 is estimated to have lower costs than Alternatives 8 and 9. The costs to implement Alternatives 8 and 9 are about the same. The treatment costs for Alternative 5 are greater than those for Alternatives 8 and 9 but lower than those for Alternatives 10. Alternative 10 is the most costly option for remediation of petroleum-impacted surface and subsurface soil due to the off-site disposal component.

6.2.3 Alternatives for Petroleum COCs in Subsurface Soil (>15 feet bgs)

DRO was encountered in subsurface soil at depths greater than 15 feet, with or without petroleum-impacted surface soil, at D-AST1, D-AST1 (downslope), D-AST5, D-AST6, D-AST7 and D-AST8. The remedial alternatives applicable to subsurface soil greater than 15 feet, with or without surface soil, impacted with DRO at the 6 AOCs are included on Table 6.2-3 and include:

- Alternative 1 - No Action
- Alternative 2 - Institutional Controls
- Alternative 3 - Monitored Natural Attenuation
- Alternative 4 - In-Situ Fenton's Reagent Oxidation
- Alternative 5 - In-Situ Soil Heating
- Alternative 6 - Bioventing
- Alternative 7 - Passive Bioventing

Overall Protection of Human Health and the Environment

All the alternatives, except the No Action and Institutional Controls alternatives, provide adequate protection of human health and the environment for AOCs where impacted surface soil overlies impacted subsurface soil. With the exception of the No Action alternative, each alternative can provide adequate protection of human health and the environment for AOCs where impacted subsurface soil only is present. Risks through direct contact with impacted surface and subsurface soil and potential ingestion of impacted groundwater are addressed with Alternatives 4, 5, 6, and 7 through in-situ treatment and monitoring although Alternative 7 takes longer to achieve adequate protection. Engineering controls, such as fencing, can be implemented to limit access to sites with impacted surface and subsurface soil to limit exposure while COCs are reduced with Alternative 3. Risks through potential ingestion of impacted groundwater are addressed with Alternative 3 through long-term monitoring. Alternative 2 would neither prevent nor reduce the risk of direct contact with impacted surface soil. Deed restrictions can be implemented under Alternative 2 to reduce risks associated with direct contact of impacted subsurface soil and potential ingestion of impacted groundwater by prohibiting excavation below a depth of 2 feet bgs and installation of drinking water wells, respectively. Risks through direct contact with impacted surface and subsurface soil and potential ingestion of impacted groundwater are not addressed with Alternative 1.

Compliance with ARARs

Each alternative can achieve ARARs, however, for the purposes of this FS, it is assumed that ARARs are not achieved with Alternatives 1 and 2. Of the seven remedial alternatives applicable to subsurface soil greater than 15 feet deep, Alternatives 4 and 5 would achieve ARARs the quickest by implementing medium-term in-situ treatment. Alternative 5 would achieve ARARs within 6 months to 1 year while Alternative 4 would require about 2 years. Alternative 6 would also achieve ARARs by implementing medium-term in-situ treatment but requires a longer time frame than Alternatives 4 and 5. COCs are not removed from the environment with Alternatives 4, 5, and 6 but are reduced to ARARs by implementing medium-term in-situ treatment. Alternative 7 would achieve ARARs by implementing long-term in-situ treatment which requires a longer time than Alternative 6. Alternative 3 achieves ARARs over the long term through natural biodegradation processes.

Long-Term Effectiveness and Permanence

All of the alternatives can be effective in the long-term, however, for the purposes of this FS, it is assumed that Alternatives 1 and 2 are not effective in the long term. The effectiveness of Alternatives 4, 5 and 6 is dependent on the ability to distribute the oxidation reagent (hydrogen peroxide solution), heat or oxygen, respectively, within the contaminated media. Soil heterogeneity, moisture content, and COC depth each affect the ability to effectively distribute the treatment agent at a site thus the effectiveness of the alternative. Each of Alternatives 4, 5 and 6 can be used to treat contaminated soil at depths of greater than 15 feet bgs through the installation of wells placed at strategic depths to deliver the treatment agent. Alternatives 4 and 5 would be more reliable to reduce the hazards posed by the COCs in the impacted surface soil and subsurface soil greater than 15 feet deep. Alternative 6 is a reliable technology to reduce the hazards posed by the COCs in the impacted surface and subsurface soil but is less reliable than Alternatives 4 and 5. Alternative 7 is less reliable than Alternative 6 as it is dependent on the ability to distribute oxygen passively within the subsurface. Alternative 3 is the least reliable in reducing the hazards posed by the COCs in the impacted surface and subsurface soil over the long term.

Reduction in Toxicity, Mobility, or Volume through Treatment

Alternatives 4, 5, 6 and 7 achieve reduction in toxicity, mobility, and volume of contaminants through in-situ treatment. Alternative 6 requires a longer time frame to achieve reduction in toxicity, mobility, and volume of contaminants compared to Alternatives 4 and 5. Alternative 7 requires a longer time frame than Alternative 6. Alternative 3 relies on natural biodegradation processes over the long term to eventually achieve reduction in toxicity, mobility, and volume of contaminants. Alternatives 1 and 2 are assumed to not reduce the toxicity, mobility or volume of COC.

Short-Term Effectiveness

Alternatives 1 and 2 do not pose risks to workers, the community, and the environment during implementation. Alternative 2 poses less risk to workers, the community, and the environment because no action is taken with Alternative 1 in the short term to reduce exposure to COCs. Of the remaining technologies, Alternative 3 poses the least risk to workers, the community, and the environment during the installation and decommissioning of potential monitoring wells and fencing and advancement of confirmation borings. Alternative 7 poses a slightly higher risk to workers, the community, and the environment than Alternative 3 due to the potential for exposure to volatiles released during the passive treatment. Alternative 6 poses risks to workers, the community, and the environment during installation/decommissioning of the air injection/extraction system, potential monitoring wells, and fencing; and advancement of confirmation borings. The risks to workers, the community, and the environment posed by Alternative 5 are slightly higher than Alternative 6 due to soil heating and those posed by Alternative 4 are slightly higher than Alternative 5 due to the handling of hydrogen peroxide.

The time required to achieve ARARs with Alternative 5 is about 6 months to 1 year while Alternative 4 requires about 2 years. Alternative 6 may require about 10 years. The least effective at achieving ARARs are Alternatives 3 and 7 which may require up to 30 years or more. Alternative 7 is considered more effective than Alternative 3 since a remedial treatment is being implemented even though the two alternatives may take the same length of time to achieve ARARs. Alternatives 1 and 2 are assumed to not achieve ARARs.

Implementability

Alternative 1 would be the simplest to implement as no action is required. Alternative 2 is also simple to implement although acceptance by ADEC, EPA and the local community of the necessary deed restrictions is an unknown. The construction tasks associated with Alternative 3, including installation and decommissioning of potential monitoring wells, fencing, advancement of confirmation borings, and monitoring, could easily be implemented. Evaluating treatment with Alternative 3 and the unknown length of time required for long-term monitoring make implementation more complex. Alternative 7 would require similar construction and monitoring tasks as Alternative 3 but would be more complex due to the number of aeration wells. Although more complex than Alternatives 3 and 7, installing and decommissioning the air injection/extraction, oxidant delivery and soil heating systems, potential monitoring wells, and fencing, and advancement of confirmation borings for Alternatives 4, 5, and 6 are common tasks in Alaska. Alternative 6 would require the installation of air injection/extraction wells in the subsurface to distribute oxygen within the contaminated soil zone. In addition to the installation of heat distribution points throughout the contaminated soil zone, Alternative 5 would also require operation of specialty equipment on site to generate the required heat. Alternative 5 also may require the installation of vapor extraction wells to remove vapors produced during the soil heating treatment. Soil heating with Alternative 5 is therefore more complex to implement than Alternative 6. Alternative 4 requires the handling of hydrogen peroxide solution along with its injection into the contaminated subsurface soil through oxidant delivery wells. Migration of the oxidant reagent in the subsurface must be controlled, especially in areas with drinking water wells. The handling of hydrogen peroxide with Alternative 4 would be more complex than Alternatives 5 and 6.

Cost

As indicated on Table 6.2-3, Alternative 1 would have no cost to implement. Alternative 2 would have low cost to implement and, with the exception of Alternative 1, would have the least O&M costs. Of the remaining remedial alternatives, Alternative 3 is estimated to have the lowest capital costs but due to the continual monitoring requirements for an estimated 30 years, would have high O&M costs. The present worth costs of Alternative 3, however, would still be lower than Alternatives 4, 5, 6, and 7. The present worth costs for Alternative 7 are estimated to be less than Alternative 6. The present worth costs for Alternative 4 are less than Alternative 5 but greater than Alternative 6 making Alternative 5 the most costly option for remediation of petroleum-impacted subsurface soil greater than 15 feet deep.

6.2.4 Alternatives for Petroleum COCs in Sediment

DRO was encountered in sediment at AOCs C2 and C4. The remedial alternatives applicable to sediment impacted with DRO at AOCs C2 and C4 are indicated on Table 6.2-4 and include:

- Alternative 1 - No Action
- Alternative 2 - Institutional Controls
- Alternative 3 - Monitored Natural Attenuation
- Alternative 8 - Biopiles
- Alternative 9 - Excavation and On-Site Low-Temperature Thermal Desorption
- Alternative 10 - Excavation and Off-Site Disposal.

Overall Protection of Human Health and the Environment

All the alternatives, except the No Action and Institutional Controls alternatives, provide adequate protection of human health and the environment. Risks through direct contact with impacted sediment and potential ingestion of impacted groundwater are addressed with Alternatives 8, 9, and 10 by removal of the COCs from the environment. Engineering controls, such as fencing, can be implemented to limit access to sites with impacted sediment to limit exposure while COCs are reduced with Alternative 3. Risks through potential ingestion of impacted groundwater are addressed with Alternative 3 through long-term monitoring.

Alternative 2 would neither prevent nor reduce the risk of direct contact with impacted sediment. Deed restrictions can be implemented under Alternative 2 to reduce risks associated with potential ingestion of impacted groundwater by prohibiting installation of drinking water wells. Risks through direct contact with impacted sediment and potential ingestion of impacted groundwater are not addressed with Alternative 1.

Compliance with ARARs

Each alternative can achieve ARARs, however, for the purposes of this FS, it is assumed that ARARs are not achieved with Alternatives 1 and 2. Alternatives 9 and 10 would achieve ARARs the quickest by removal of the COCs from the environment followed by short-term on-site treatment or off-site disposal. Alternative 8 would also achieve ARARs by removal of the COCs from the environment followed by medium-term on-site treatment. Alternative 3 achieves ARARs over the long term through natural biodegradation processes.

Long-Term Effectiveness and Permanence

All of the alternatives can be effective in the long-term, however, for the purposes of this FS, it is assumed that Alternatives 1 and 2 are not effective in the long term. Alternatives 9 and 10 would be more reliable to reduce the hazards posed by the COCs in the impacted sediment and excavation wastes. Alternative 8 is a reliable technology to reduce the hazards posed by the COCs in the impacted sediment but is less reliable than Alternatives 9 and 10 in treating excavation wastes. Alternative 3 is the least reliable in reducing the hazards posed by the COCs in the impacted sediment over the long term.

Reduction in Toxicity, Mobility, or Volume through Treatment

Alternatives 9 and 10 achieve complete reduction in toxicity, mobility, and volume of contaminants through excavation and treatment/disposal of impacted sediment. Alternative 8 removes impacted sediment from the environment by excavation and achieves reduction in toxicity, mobility, and volume of contaminants through ex-situ treatment. Alternative 3 relies on natural biodegradation processes over the long term to eventually achieve reduction in toxicity, mobility, and volume of contaminants. Alternatives 1 and 2 are assumed to not reduce the toxicity, mobility or volume of COC.

Short-Term Effectiveness

Alternatives 1 and 2 do not pose risks to workers, the community, and the environment during implementation. Alternative 2 poses less risk to workers, the community, and the environment because no action is taken with Alternative 1 in the short term to reduce exposure to COCs. Of the remaining technologies, Alternative 3 poses the least risk to workers, the community, and the environment during the installation and decommissioning of potential monitoring wells and fencing and advancement of confirmation borings. Alternatives 8, 9, and 10 require the use of excavation equipment and transport trucks to move impacted soil and/or sediment on Yakutat roads and pose the greatest risks to workers, the community, and the environment during implementation.

Alternatives 9 and 10 require the least time and are the most effective at achieving ARARs. Alternative 8 may require about 5 years to achieve ARARs. The least effective at achieving ARARs is Alternative 3 which may require up to 30 years or more. Alternatives 1 and 2 are assumed to not achieve ARARs.

Implementability

Alternative 1 would be the simplest to implement as no action is required. Alternative 2 is also simple to implement although acceptance by ADEC, EPA and the local community is an unknown. The construction tasks associated with Alternative 3, including installation and decommissioning of potential monitoring wells, fencing, advancement of confirmation borings, and monitoring, could easily be implemented. Evaluating treatment with Alternative 3 and the unknown length of time required for long-term monitoring make implementation more complex. Although more complex than Alternative 3, mobilization of equipment, excavation, and soil transportation requirements for Alternatives 9 and 10 are fairly common tasks in Alaska and can be successfully implemented with a high degree of certainty. Implementing excavation and construction of the biopiles under Alternative 8 would be fairly simple but the effectiveness of treatment would be more difficult to evaluate than Alternatives 9 and 10. It is assumed that excavated sediment will be placed on a plastic membrane adjacent to the excavation and allowed to drain excess water for Alternatives 8, 9 and 10. Best management practices would be used to filter particulates and contaminants from the leachate prior to allowing discharge back into the excavation. A nationwide permit to disturb surface soil in a wetland or drainage channel may be required, but can typically be obtained within about 30 days. Operation of earthwork equipment may need to be scheduled for mid-winter when surface and subsurface materials are frozen.

Cost

Alternative 1 would have no cost to implement as indicated on Table 6.2-4. Alternative 2 would have low cost to implement and, with the exception of Alternative 1, would have the least O&M costs. Of the remaining remedial alternatives, Alternative 3 is estimated to have the lowest capital costs but due to the continual monitoring requirements for an estimated 30 years, would have the highest O&M costs. The present worth costs of Alternative 3, however, would still be lower than Alternatives 8, 9, and 10. Alternatives 8, 9, and 10 would have the same capital costs for excavation, but the present worth costs for Alternative 9 would be lower. The present worth costs for Alternative 10 are estimated to be greater than Alternative 9. The treatment costs for Alternative 10 are lower than those for Alternative 8 making Alternative 8 the most costly option for remediation of petroleum-impacted sediment due to the low volume.

6.2.5 Alternatives for Metals in Soil and Sediment

Metals were encountered in surface soil, subsurface soil, and/or sediment at 7 AOCs. The metals include arsenic, cadmium, chromium, lead, mercury, and silver. The AOCs include C1, C2, C4, C7, E1 (drum dump), M2, and O1. The remedial alternatives applicable to surface soil, subsurface soil, and/or sediment impacted with metals at the 7 AOCs are indicated on Table 6.2-5 and include:

- Alternative 1 - No Action
- Alternative 2 - Institutional Controls
- Alternative 10 - Excavation and Off-Site Disposal
- Alternative 11 - Soil Washing.

Overall Protection of Human Health and the Environment

Risks through direct contact with impacted surface soil, subsurface soil, and sediment and potential ingestion of impacted groundwater are addressed with Alternatives 10 and 11 by removal of the COCs from the environment. Alternative 2 would neither prevent nor reduce the risk of direct contact with impacted surface soil or sediment. Deed restrictions can be implemented under Alternative 2 to reduce risks associated with direct contact of impacted subsurface soil and potential ingestion of impacted groundwater by prohibiting excavation below a depth of 2 feet bgs and installation of drinking water wells, respectively. Risks through direct contact with impacted surface soil, subsurface soil, and sediment and potential ingestion of impacted groundwater are not addressed with Alternative 1.

Compliance with ARARs

Alternatives 10 and 11 would achieve ARARs by removal of the COCs from the environment followed by short-term off-site disposal or on-site treatment. Alternatives 1 and 2 would not achieve ARARs.

Long-Term Effectiveness and Permanence

Alternatives 10 and 11 can be effective in the long-term in reducing the hazards posed by the COCs in the impacted surface and subsurface soil, sediment and excavation wastes. Alternatives 1 and 2 would not be effective in reducing the hazards posed by the COCs in the impacted surface and subsurface soil and sediment over the long term.

Reduction in Toxicity, Mobility, or Volume through Treatment

Alternatives 10 and 11 achieve complete reduction in toxicity, mobility, and volume of contaminants through excavation and disposal or treatment of impacted surface and subsurface soil and sediment. Alternatives 1 and 2 would not achieve reduction in toxicity, mobility, and volume of contaminants.

Short-Term Effectiveness

Alternatives 1 and 2 do not pose risks to workers, the community, and the environment during implementation. Alternative 2 poses less risk to workers, the community, and the environment because no action is taken with Alternative 1 in the short term to reduce exposure to COCs. Alternatives 10 and 11 require the use of excavation equipment and transport trucks to move impacted soil on Yakutat roads and pose the greatest risks to workers, the community, and the environment during implementation. The risks posed to workers, the community, and the environment would be greater for Alternative 10 if Alternative 11 can be implemented at the individual AOCs which eliminates the risk posed by off-site transport.

Alternatives 10 and 11 require the least time and are the most effective at achieving ARARs. Alternatives 1 and 2 do not achieve ARARs.

Implementability

Alternative 1 would be the simplest to implement as no action is required. Alternative 2 is also simple to implement although acceptance by ADEC, EPA and the local community of the necessary deed restrictions is an unknown. Mobilization of equipment, excavation, and soil transportation requirements for Alternatives 10 and 11 are fairly common tasks in Alaska and can be successfully implemented with a high degree of certainty. Implementation of Alternative 11 at the individual AOCs will reduce soil transportation requirements making Alternative 10 more complex. A nationwide permit to disturb surface soil in a wetland or drainage channel may be required, but can typically be obtained within about 30 days.

Cost

As indicated on Table 6.2-5, Alternative 1 would have no cost to implement. Alternative 2 would have low cost to implement and, with the exception of Alternative 1, would have the least O&M costs. The treatment costs for Alternative 11 are lower than those for Alternative 10 making Alternative 10 the most costly option for remediation of metals-impacted surface and subsurface soil and sediment due to the off-site disposal component.

6.2.6 Alternatives for Lead in Soil

Lead was encountered in surface soil at the Rifle Range. The remedial alternatives applicable to surface soil impacted with lead at the Rifle Range are indicated on Table 6.2-6 and include:

- Alternative 1 - No Action
- Alternative 2 - Institutional Controls
- Alternative 10 - Excavation and Off-Site Disposal
- Alternative 11 -Soil Washing.

Overall Protection of Human Health and the Environment

Risks through direct contact with impacted surface soil and potential ingestion of impacted groundwater are addressed with Alternatives 10 and 11 by removal of the COCs from the environment. Alternative 2 would not prevent the risk of direct contact with impacted surface soil. Deed restrictions can be implemented under Alternative 2 to reduce risks associated with direct contact of impacted surface soil and potential ingestion of impacted groundwater by prohibiting excavation and installation of drinking water wells, respectively. Risks through direct contact with impacted surface soil and potential ingestion of impacted groundwater are not addressed with Alternative 1.

Compliance with ARARs

Alternatives 10 and 11 would achieve ARARs by removal of the COCs from the environment followed by short-term off-site disposal or on-site treatment. Alternatives 1 and 2 would not achieve ARARs.

Long-Term Effectiveness and Permanence

Alternatives 10 and 11 can be effective in the long-term in reducing the hazards posed by the COCs in the impacted surface soil and excavation wastes. Alternatives 1 and 2 would not be effective in reducing the hazards posed by the COCs in the impacted surface soil over the long term.

Reduction in Toxicity, Mobility, or Volume through Treatment

Alternatives 10 and 11 achieve complete reduction in toxicity, mobility, and volume of contaminants through excavation and disposal or treatment of impacted surface soil. Alternatives 1 and 2 would not achieve reduction in toxicity, mobility, and volume of contaminants.

Short-Term Effectiveness

Alternatives 1 and 2 do not pose risks to workers, the community, and the environment during implementation. Alternative 2 poses less risk to workers, the community, and the environment because no action is taken with Alternative 1 in the short term to reduce exposure to COCs. Alternatives 10 and 11 require the use of excavation equipment and transport trucks to move impacted soil on Yakutat roads and pose the greatest risks to workers, the community, and the environment during implementation. The risks posed to workers, the community, and the environment would be greater for Alternative 10 if Alternative 11 can be implemented at the individual AOCs which eliminates the risk posed by off-site transport.

Alternatives 10 and 11 require the least time and are the most effective at achieving ARARs. ARARs are not achieved with Alternatives 1 and 2.

Implementability

Alternative 1 would be the simplest to implement as no action is required. Alternative 2 is also simple to implement although acceptance by ADEC, EPA and the local community of the necessary deed restrictions is an unknown. Mobilization of equipment, excavation, and soil transportation requirements for Alternatives 10 and 11 are fairly common tasks in Alaska and can be successfully implemented with a high degree of certainty. Implementation of Alternative 11 at the individual AOCs will reduce soil transportation requirements making Alternative 10 more complex.

Cost

Alternative 1 would have no cost to implement, as indicated on Table 6.2-6. Alternative 2 would have low cost to implement and, with the exception of Alternative 1, would have the least O&M costs. The treatment costs for Alternative 11 are lower than those for Alternative 10 making Alternative 10 the most costly option for remediation of metals-impacted surface and subsurface soil and sediment due to the off-site disposal component.

6.2.7 Alternatives for Multiple COC Types in Soil and Sediment

A mixture of multiple COC types including DRO, pentachlorophenol, SVOCs, and/or metals were detected in surface and subsurface soil and sediment at 4 AOCs. DRO, cadmium, and mercury were encountered in sediment at AOC C2. DRO, arsenic, and chromium were encountered in surface and subsurface soil at AOC E1 (drum dump). DRO, pentachlorophenol, arsenic, cadmium, chromium, and mercury were encountered in sediment at AOC E1 (drainage ditch). DRO, chrysene, phenanthrene, pyrene, arsenic, cadmium, chromium, and mercury were encountered in sediment at AOC G4. The remedial alternatives applicable to surface and subsurface soil and sediment impacted with multiple COC types, including DRO, pentachlorophenol, SVOCs, and/or metals, at the 4 AOCs are indicated on Table 6.2-7 and include:

- Alternative 1 - No Action
- Alternative 2 - Institutional Controls
- Alternative 10 - Excavation and Off-Site Disposal.

Overall Protection of Human Health and the Environment

Risks through direct contact with impacted sediment, surface soil and subsurface soil and potential ingestion of impacted groundwater are addressed with Alternative 10 by removal of the COCs from the environment. Alternative 2 would neither prevent nor reduce the risk of direct contact with impacted surface soil or sediment. Deed restrictions can be implemented under Alternative 2 to reduce risks associated with direct contact of impacted subsurface soil and potential ingestion of impacted groundwater by prohibiting excavation below a depth of 2 feet bgs and installation of drinking water wells, respectively. Risks through direct contact with impacted sediment, surface soil and subsurface soil and potential ingestion of impacted groundwater are not addressed with Alternative 1.

Compliance with ARARs

Alternative 10 would achieve ARARs by removal of the COCs from the environment followed by short-term off-site disposal. Although Alternatives 1 and 2 achieve ARARs for the petroleum COCs over the long term through natural biodegradation processes, for the purposes of this FS, we assume that concentrations of COCs will not change for Alternatives 1 and 2. Alternatives 1 and 2 would not achieve ARARs for pentachlorophenol and metals COCs.

Long-Term Effectiveness and Permanence

Alternative 10 can be effective in the long-term in reducing the hazards posed by the COCs in the impacted surface and subsurface soil, sediment and excavation wastes. Alternatives 1 and 2 are the less reliable in reducing the hazards posed by the petroleum COCs in the impacted surface soil over the long term. Alternatives 1 and 2 would not be effective in reducing the hazards posed by the pentachlorophenol and metals COCs in the impacted surface and subsurface soil and sediment over the long term.

Reduction in Toxicity, Mobility, or Volume through Treatment

Alternative 10 achieves complete reduction in toxicity, mobility, and volume of contaminants through excavation and disposal of impacted surface and subsurface soil and sediment. Alternatives 1 and 2 rely on natural biodegradation processes over the long term to eventually achieve reduction in toxicity, mobility, and volume of petroleum contaminants although for the purposes of this FS, it is assumed that concentrations of COCs will not change. Alternatives 1 and 2 would not achieve reduction in toxicity, mobility, and volume of pentachlorophenol and metals COCs.

Short-Term Effectiveness

Alternatives 1 and 2 do not pose risks to workers, the community, and the environment during implementation. Alternative 2 poses less risk to workers, the community, and the environment because no action is taken with Alternative 1 in the short term to reduce exposure to COCs. Alternative 10 requires the use of excavation equipment and transport trucks to move impacted soil on Yakutat roads and poses the greatest risks to workers, the community, and the environment during implementation.

Alternative 10 requires the least time and is the most effective at achieving ARARs. For the purposes of this FS, we assume ARARs are not achieved with Alternatives 1 and 2.

Implementability

Alternative 1 would be the simplest to implement as no action is required. Alternative 2 is also simple to implement although acceptance by ADEC, EPA and the local community of the necessary deed restrictions is an unknown. Mobilization of equipment, excavation, and soil transportation requirements for Alternative 10 are fairly common tasks in Alaska and can be successfully implemented with a high degree of certainty.

Cost

As indicated on Table 6.2-7, Alternative 1 would have no cost to implement. Alternative 2 would have low cost to implement and, with the exception of Alternative 1, would have the least O&M costs. Alternative 10 is the most costly option for remediation of multiple COC-impacted surface and subsurface soil and sediment.

6.2.8 Alternatives for Multiple COC Types in Landfill Cover Material

A mixture of multiple COC types including DRO, pentachlorophenol, SVOCs, and/or metals were detected in surface and subsurface soil at AOC K1. DRO, pentachlorophenol, benzo(a)pyrene, arsenic, cadmium and chromium were encountered in surface soil and near surface soil (2 to 4 feet bgs) at AOC K1. The remedial alternatives applicable to surface and subsurface landfill cover material impacted with multiple COC types, including DRO, pentachlorophenol, SVOCs, and/or metals, at the AOC K1 are indicated on Table 6.2-8 and include:

- Alternative 1 - No Action
- Alternative 2 - Institutional Controls
- Alternative 10 - Excavation and Off-Site Disposal
- Alternative 12 - Capping.

Overall Protection of Human Health and the Environment

Risks through direct contact with impacted surface soil and subsurface soil and potential ingestion of impacted groundwater are addressed with Alternative 10 by removal of the COCs from the environment. Although COCs are not removed from the environment, risks through direct contact are addressed with Alternative 12 by the construction of a physical barrier. Alternative 2 would neither prevent nor reduce the risk of direct contact with impacted surface soil. Deed restrictions can be implemented under Alternative 2 to reduce risks associated with direct contact of impacted subsurface soil and potential ingestion of impacted groundwater by prohibiting excavation below a depth of 2 feet bgs and installation of drinking water wells, respectively. Risks through direct contact with impacted surface soil and subsurface soil and potential ingestion of impacted groundwater are not addressed with Alternative 1.

Compliance with ARARs

Alternative 10 would achieve ARARs by removal of the COCs from the environment followed by short-term off-site disposal. Although Alternatives 1, 2 and 12 achieve ARARs for the petroleum COCs over the long term through natural biodegradation processes, for the purposes of this FS, we assume that concentrations of COCs will not change for Alternatives 1, 2 and 12. Alternatives 1, 2 and 12 would not achieve ARARs for pentachlorophenol and metals COCs.

Long-Term Effectiveness and Permanence

Alternative 10 can be effective in the long-term in reducing the hazards posed by the COCs in the impacted surface and subsurface soil and excavation wastes. Alternative 12 is also effective in the long-term in reducing the hazards posed by the COCs but requires long-term monitoring to maintain the integrity of the cap. Alternatives 1 and 2 are the less reliable in reducing the hazards posed by the petroleum COCs in the impacted surface soil over the long term. Alternatives 1 and 2 would not be effective in reducing the hazards posed by the pentachlorophenol and metals COCs in the impacted surface and subsurface soil over the long term.

Reduction in Toxicity, Mobility, or Volume through Treatment

Alternative 10 achieves complete reduction in toxicity, mobility, and volume of contaminants through excavation and disposal of impacted surface and subsurface soil.

Although Alternative 12 does not directly reduce the toxicity, mobility and volume of COCs, it limits the vertical migration of COCs by preventing entry of surface water to the impacted soil. Alternatives 1, 2 and 12 rely on natural biodegradation processes over the long term to eventually achieve reduction in toxicity, mobility, and volume of petroleum contaminants although for the purposes of this FS, it is assumed that concentrations of COCs will not change. Alternatives 1 and 2 would not achieve reduction in toxicity, mobility, and volume of pentachlorophenol and metals COCs.

Short-Term Effectiveness

Alternatives 1 and 2 do not pose risks to workers, the community, and the environment during implementation. Alternative 2 poses less risk to workers, the community, and the environment because no action is taken with Alternative 1 in the short term to reduce exposure to COCs. Alternative 12 requires the use of earthwork equipment to remove vegetation and construct the cap, posing an increased risk to workers, the community and the environment during construction. Alternative 10 requires the use of excavation equipment and transport trucks to move impacted soil on Yakutat roads and poses the greatest risks to workers, the community, and the environment during implementation.

Alternative 10 requires the least time and is the most effective at achieving ARARs. For the purposes of this FS, we assume ARARs are not achieved with Alternatives 1, 2 and 12.

Implementability

Alternative 1 would be the simplest to implement as no action is required. Alternative 2 is also simple to implement although acceptance by ADEC, EPA and the local community of the necessary deed restrictions is an unknown. Mobilization of equipment, excavation, and soil transportation requirements for Alternatives 10 and 12 are fairly common tasks in Alaska and can be successfully implemented with a high degree of certainty. Alternative 10 requires the excavation and transport of the contaminated soil making it more difficult to implement than Alternative 12. On the other hand, Alternative 12 requires the implementation of deed restrictions. Acceptance of these restrictions by the community is an unknown.

Cost

Alternative 1 would have no cost to implement as indicated on Table 6.2-8. Alternative 2 would have low cost to implement and, with the exception of Alternative 1, would have the least O&M costs. Alternative 12 costs would be much less than Alternative 10. Alternative 10 is the most costly option for remediation of surface and subsurface landfill cover material impacted with multiple COC types.

6.2.9 Alternatives for COCs in Surface Water

Dioxins were encountered in surface water at AOC C1. PCBs, SVOCs (bis(2-ethylhexyl)phthalate and 2-methylnaphthalene), and lead were encountered in surface water at AOC C2. Barium was encountered in surface water at AOC G4. Cadmium and lead were encountered in surface water at AOC K1. Lead was encountered in surface water at AOC O1. The USACE plans to resample surface water and sediment from AOCs C1, C2, K1, and O1. The results of the analyses, however, will not be included in this FS.

The remedial alternatives applicable to surface water impacted with dioxins, PCBs, SVOCs, and/or metals at the 5 AOCs are indicated on Table 6.2-9 and include:

- Alternative 1 - No Action
- Alternative 2 - Institutional Controls
- Alternative 3 - Monitored Natural Attenuation.

Overall Protection of Human Health and the Environment

Alternative 3 is the only remedial alternative that provides adequate protection of human health but would not likely protect other biota. Risks through direct contact and ingestion with impacted surface water are addressed with Alternative 3 through long-term monitoring. Alternative 2 would neither prevent nor reduce the risk of direct contact and ingestion with impacted surface water. Deed restrictions can be implemented under Alternative 2 to reduce risks associated with direct contact and ingestion with impacted surface water by prohibiting recreational and subsistence use of the water body. Risks through direct contact with impacted surface water are not addressed with Alternative 1.

Compliance with ARARs

Each alternative can achieve ARARs as long as the sources of the COCs in soil and/or sediment have been removed, however, for the purposes of this FS, it is assumed that Alternatives 1 and 2 do not achieve ARARs. Alternative3 achieves ARARs over the long term through natural attenuation processes such as dilution and dispersion.

Long-Term Effectiveness and Permanence

All of the alternatives can be effective in the long-term, however, for the purposes of this FS, it is assumed that Alternatives 1 and 2 do not reduce the hazards posed by the COCs. Alternative 3 reduces the hazards posed by the COCs in the impacted surface water over the long term through natural attenuation processes such as dilution and dispersion.

Reduction in Toxicity, Mobility, or Volume through Treatment

Alternative 3 relies on natural attenuation processes such as dilution and dispersion over the long term to eventually achieve reduction in toxicity, mobility, and volume of contaminants in the impacted surface water. Alternatives 1 and 2 are assumed to not reduce the toxicity, mobility, or volume of COCs.

Short-Term Effectiveness

Alternatives 1, 2, and 3 do not pose risks to workers, the community, and the environment during implementation. Alternatives 2 and 3 pose less risk to workers, the community, and the environment than Alternative 1 because no action is taken with Alternative 1 in the short term to reduce or monitor exposure to COCs.

The time required to achieve ARARs with Alternative 3 may be up to 30 years or more and depends on whether the sources of the COCs in soil and/or sediment have been removed. It is assumed that ARARs are not achieved with Alternatives 1 and 2.

Implementability

Alternative 1 would be the simplest to implement as no action is required. Alternative 2 is also simple to implement although acceptance by ADEC, EPA and the local community is an unknown. The monitoring tasks associated with Alternative 3 could easily be implemented. Evaluating treatment with Alternative 3 and the unknown length of time required for long-term monitoring make implementation more complex.

Cost

As indicated on Table 6.2-9, Alternative 1 would have no cost to implement. Alternative 2 would have low cost to implement and, with the exception of Alternative 1, is estimated to have the lowest O&M costs. Alternative 3 would have capital and O&M costs associated with the continual monitoring requirements for an estimated 10 years making Alternative 3 the most costly remedial alternative for impacted surface water.

6.2.10 Alternatives for Petroleum COCs in Groundwater

Petroleum COCs were encountered in groundwater at 3 AOCs. The COCs include DRO at AOCs C6 and D-AST7 and GRO and benzene at AOC L1-South Drum Dump. The remedial alternatives applicable to groundwater impacted with DRO, GRO, and benzene at the 3 AOCs are indicated on Table 6.2-10 and include:

- Alternative 1 - No Action

- Alternative 2 - Institutional Controls
- Alternative 3 - Monitored Natural Attenuation
- Alternative 13 - Air Sparging/Soil Vapor Extraction.

Overall Protection of Human Health and the Environment

Risk to humans through potential ingestion of impacted groundwater are addressed with Alternative 3 through long-term monitoring. Alternative 3, however, would not necessarily protect biota in the case of shallow groundwater. Risks through potential ingestion of impacted groundwater are addressed with Alternative 13 through in-situ treatment and monitoring. Risks through potential ingestion of impacted groundwater are addressed with Alternative 3 through long-term monitoring. Deed restrictions can be implemented under Alternative 2 to reduce risks associated with potential ingestion of impacted groundwater by prohibiting installation of drinking water wells. Risks through potential ingestion of impacted groundwater are not addressed with Alternative 1.

Compliance with ARARs

COCs are not removed from the environment with Alternative 13 but are reduced to ARARs by implementing medium-term in-situ treatment. Alternative3 achieves ARARs over the long term through natural attenuation processes such as dispersion, sorption, dilution, and volatilization. For the purposes of this FS, it is assumed that ARARs are not achieved with Alternatives 1 and 2.

Long-Term Effectiveness and Permanence

Alternative 13 is a reliable technology to reduce the hazards posed by the COCs in the impacted groundwater and is effective over the medium term. Alternative 3 is reliable in reducing the hazards posed by the COCs in the impacted groundwater through long-term monitoring. Alternative 2 relies on deed restrictions to reduce hazards posed by the COCs in the impacted groundwater by prohibiting installation of drinking water wells. Alternative 1 does not reduce the hazards posed by the COCs in the impacted groundwater over the long term.

Reduction in Toxicity, Mobility, or Volume through Treatment

Alternative 13 achieves reduction in toxicity, mobility, and volume of contaminants through in-situ treatment. Alternative 3 relies on natural attenuation processes over the long term to eventually achieve reduction in toxicity, mobility, and volume of contaminants. Alternatives 1 and 2 do not reduce the toxicity, mobility, or volume of COCs.

Short-Term Effectiveness

Alternatives 1 and 2 do not pose risks to workers, the community, and the environment during implementation. Alternative 2 poses less risk to workers, the community, and the environment because no action is taken with Alternative 1 in the short term to reduce exposure to COCs. Alternative 3 poses less risk than Alternative 13 to workers, the community, and the environment during the installation and decommissioning of potential monitoring wells and fencing and advancement of confirmation borings. Alternative 13 poses risks to workers, the community, and the environment during installation/decommissioning of the air injection/extraction system, potential monitoring wells, and fencing and advancement of confirmation borings.

Alternative 13 may require about 10 years to achieve ARARs. Alternative 3 may require up to 30 years or more to achieve ARARs. It is assumed ARARs are not achieved with Alternatives 1 and 2.

Implementability

Alternative 1 would be the simplest to implement as no action is required. Alternative 2 is also simple to implement although acceptance by ADEC, EPA and the local community is an unknown. The construction tasks associated with Alternative 3, including installation and decommissioning of potential monitoring wells, fencing, advancement of confirmation borings, and monitoring, could easily be implemented. Evaluating treatment with Alternative 3 and the unknown length of time required for long-term monitoring make implementation more complex. Installing and decommissioning the air injection/extraction system with Alternative 13, however, would be more complex than Alternative 3. Also, boulders and erratics at Concern D may affect the implementability of Alternative 13.

Cost

Alternative 1 would have no cost to implement as indicated on Table 6.2-10. Alternative 2 would have low cost to implement and, with the exception of Alternative 1, would have the least O&M costs. Of the active remedial alternatives, Alternative 3 is estimated to have the lowest capital costs but due to the continual monitoring requirements for an estimated 30 years, would have high O&M costs. The present worth costs of Alternative 3, however, would still be much lower than Alternative 13. Alternative 13 is the most costly remedial alternative for treating petroleum contaminated groundwater.

6.3 <u>Site-Specific Considerations</u>

This FS addresses remedial alternatives for 28 individual sites with various media, including surface soil, subsurface soil, sediment, surface water and groundwater, impacted with one or more types of COCs, including petroleum, metals, PCBs and dioxins. Site-specific considerations addressed below, and summarized in Table 6.3-1, should be taken into account when selecting the preferred remedial alternative(s).

6.3.1 AOC C1 - Ankau Bridge Garbage/Drum Dump

AOC C1 has surface soil impacted with chromium at one hotspot location. Remedial alternatives feasible for addressing the chromium-impacted surface soil include Alternative 1 - No Action, Alternative 2 - Institutional Controls, Alternative 10 - Excavation and Off-Site Disposal, and Alternative 11 - Excavation and Soil Washing.

Remedial action of the surface soil at AOC C1 may not be warranted depending on the type of chromium present in the surface soil. The chromium concentration in surface soil is assumed to be Cr6+, a known carcinogen. The surface soil at AOC C1 will be retested to determine if the chromium concentration is due to Cr6+ and/or Cr3+. The cleanup level for Cr3+ is 124,000 mg/kg. If it is determined that the chromium concentration in surface soil is actually Cr3+, then chromium is not a COC at AOC C1. If the chromium in the surface soil is found to be Cr6+, a remedial alternative will be selected to address the hotspot of chromium-impacted surface soil.

Selection of the remedial alternative should also consider access to the impacted surface soil. The groundwater at AOC C1 is near the site surface, ranging from 2.2 to 15.8 inches bgs during sampling of five monitoring wells in 2000. Vegetation in the area consists primarily of moss, alders and spruce trees which may require clearing to access the impacted soil.

AOC C1 also has surface water impacted with dioxins at one location, apparently in the creek located south of the dump area. Remedial alternatives feasible for addressing the dioxin-impacted surface water include Alternative 1 - No Action, Alternative 2 - Institutional Controls, and Alternative 3 - Monitored Natural Attenuation.

The surface water at AOC C1 should be retested to determine if dioxins remain. The calculated 2,3,7,8-TCDD equivalent for the surface water sample collected in 1996 was 0.03848 ppt exceeding the 0.03 ppt ARAR. The dioxin concentrations measured over 14 years ago may no longer be present in the creek due to natural attenuation processes such as dilution and dispersion.

6.3.2 AOC C2 - Garrison Area Drum Dump

AOC C2 has four distinct areas with different media impacted with various COCs. The largest area (est. 10,845 sf) comprises surface and subsurface soil (estimated up to 4 feet bgs) impacted with DRO. A hotspot (est. 78 sf) of silver-impacted surface soil is located within the DRO impacted area. The southern boundary of the DRO-impacted area abuts a pond. An area (est. 470 sf) of DRO-impacted sediment extends into the pond from the edge of the DRO-impacted soil area. Likewise, a hotspot (est. 314 sf) of sediment impacted with DRO, cadmium and mercury is located between the pond edge and DRO-impacted soil area.

The common remedial alternatives feasible for addressing the four areas include Alternative 1 - No Action, Alternative 2 - Institutional Controls, and Alternative 10 - Excavation and Off-Site Disposal which are the three alternatives feasible for addressing multiple COCs in sediment. Additional remedial alternatives are viable if each impacted area is addressed separately. The silver-impacted surface soil can also be addressed using Alternative 11 - Excavation and Soil Washing. The DRO-impacted sediment can be addressed using Alternative 3 - Monitored Natural Attenuation, Alternative 8 - Biopiles, and Alternative 9 - Excavation and On-site LTTD. The DRO-impacted surface and subsurface soil can be addressed with the same remedial alternatives as DRO-impacted sediment and with Alternative 4 - In-Situ Fenton's Reagent Oxidation, Alternative 5 - In-Situ Soil Heating, Alternative 6 - Bioventing, and Alternative 7 - Passive Bioventing.

Selection of the remedial alternative should consider access to the impacted surface and subsurface soil and sediment. The majority of the DRO-impacted surface and subsurface soil is located within the estimated limits of the drum dump where drums and other metal debris are apparently buried. Debris should be expected to be encountered during implementation of in-situ or ex-situ remedial alternatives. Vegetation may require clearing in order to access the impacted soil. Although surface water and wetland vegetation surround the dump area, groundwater was encountered at AOC C2 from 9 to 12 feet bgs during sampling of monitoring wells in 2000. The boggy nature of the ground surface at AOC C2 may require implementation of the selected remedial alternative during mid-winter when surface and subsurface materials are frozen. Further, wetland permits may need to be obtained prior to implementing remedial activities.

AOC C2 also has surface water impacted with PCBs, bis(2-ethylhexyl)phthalate, and lead. The exact location of the surface water sample collected in 1996 with the elevated concentrations of the COCs is unknown. Apparently the sample was collected from a trench in the landfill. Remedial alternatives feasible for addressing the impacted surface water include Alternative 1 - No Action, Alternative 2 - Institutional Controls, and Alternative 3 - Monitored Natural Attenuation. The surface water at AOC C2 should be retested to determine if COCs remain. The concentrations measured over 14 years ago may no longer be present in the surface water due to natural attenuation processes such as dilution and dispersion.

6.3.3 AOC C4 - Garrison Area Surface Debris

AOC C4 has three distinct areas with different media impacted with various COCs. The largest area (est. 1,426 sf) comprises surface and subsurface soil (estimated up to 4 feet bgs) impacted with DRO. Two hotspots (est. 78 sf each) of chromium-impacted surface soil are located outside of the DRO-impacted area. Information regarding the location of DRO-impacted sediment is not known.

The common remedial alternatives feasible for addressing the DRO-impacted surface and subsurface soil and sediment include Alternative 1 - No Action, Alternative 2 - Institutional Controls, Alternative 3 - Monitored Natural Attenuation, Alternative 7 - Passive Bioventing, Alternative 8 - Biopiles, Alternative 9 - Excavation and On-site LTTD, and Alternative 10 - Excavation and Off-Site Disposal. The DRO-impacted surface and subsurface soil may also be addressed with Alternative 4 - In-Situ Fenton's Reagent Oxidation, Alternative 5 - In-Situ Soil Heating, and Alternative 6 - Bioventing. The chromium-impacted surface soil can be addressed using Alternative 1 - No Action, Alternative 2 - Institutional Controls, Alternative 10 - Excavation and Off-Site Disposal, and Alternative 11 - Excavation and Soil Washing.

Remedial action of the chromium-impacted surface soil at AOC C4 may not be warranted depending on the type of chromium present in the surface soil. The chromium concentration in surface soil is assumed to be Cr6+, a known carcinogen. The surface soil at AOC C4 will be retested to determine if the chromium concentration is due to Cr6+ and/or Cr3+. The cleanup level for Cr3+ is 124,000 mg/kg. If it is determined that the chromium concentration in surface soil is actually Cr3+, then chromium is not a COC at AOC C4.

Selection of the remedial alternative should consider access to the impacted surface and subsurface soil and sediment. The eastern section of the DRO-impacted surface and subsurface soil area is located within the estimated limits of the surface debris at AOC C4. In addition, an approximately 5 by 12 feet concrete pad is present within the DRO-impacted area. Although surface water and wetland vegetation surround the area, groundwater was encountered at AOC C4 from 9 to 12 feet bgs during sampling of monitoring wells in 2000. The boggy nature of the ground surface at AOC C4 may require implementation of the selected remedial alternative during mid-winter when surface and subsurface materials are frozen. Further, wetland permits may need to be obtained prior to implementing remedial activities.

6.3.4 AOC C6 - 50,000-Gallon Fuel Tank

AOC C6 has an estimated 20,000 sf area of DRO-impacted surface and subsurface soil (up to 15 feet bgs). The remedial alternatives feasible for addressing the DRO-impacted surface and subsurface soil include Alternative 1 - No Action, Alternative 2 - Institutional Controls, Alternative 3 - Monitored Natural Attenuation, Alternative 4 - In-Situ Fenton's Reagent Oxidation, Alternative 5 - In-Situ Soil Heating, Alternative 6 - Bioventing, Alternative 7 - Passive Bioventing, Alternative 8 - Biopiles, Alternative 9 - Excavation and On-site LTTD, and Alternative 10 - Excavation and Off-Site Disposal.

AOC C6 also has an estimated 40,000 sf groundwater plume impacted with DRO. The remedial alternatives feasible for addressing the DRO-impacted groundwater include Alternative 1 - No Action, Alternative 2 - Institutional Controls, Alternative 3 - Monitored Natural Attenuation, and Alternative 13 - Air Sparging/Soil Vapor Extraction. Selection of the remedial alternative should consider access to the impacted surface and subsurface soil and groundwater. The circular concrete foundation of the former 50,000-gallon fuel tank remains on the site within the soil and groundwater impacted area. The site is covered with old growth forest with large diameter (>12-inch) trees with the exception of the area around the tank foundation. The existing rough terrain, heavy vegetation, and wetlands may impact implementation of the selected remedial alternative. Further, wetland permits may need to be obtained prior to implementing remedial activities. Vehicular access to the site has formerly been made along a trail off of Point Carrew Road or along the slough shoreline. In addition to the rough terrain, the site slopes steeply to the south and east towards Ankau Slough, located approximately 170 feet west of the tank foundation. Groundwater is located between 10 and 20 feet bgs across the site. The difference in the depths to groundwater is reportedly due to the site topography (USACE 2006).

6.3.5 AOC C7 - Powerhouse No. 1093

AOC C7 has one hotspot (est. 78 sf) of arsenic and chromium-impacted surface soil. The remedial alternatives feasible for addressing the impacted surface soil include Alternative 1 - No Action, Alternative 2 - Institutional Controls, Alternative 10 - Excavation and Off-Site Disposal, and Alternative 11 - Soil Washing.

Remedial action of the chromium-impacted surface soil may not be warranted depending on the type of chromium present in the surface soil. The chromium contamination at AOC C7, however, is co-located with arsenic concentrations exceeding the cleanup criterion. Regardless of the type of chromium present in the soil, the hotspot is assumed to require remedial action based on the reported arsenic concentration.

The hotspot at AOC C7 is located in a shallow ditch which parallels the access drive to the former powerhouse. Selection of the remedial alternative should consider the potential presence of surface water within the ditch and impact to surface water runoff. Further, wetland permits may need to be obtained prior to implementing remedial activities.

6.3.6 AOC D - AST1 - Former AST No. 1

AOC D - AST1 has two discrete areas of DRO-impacted subsurface soil. The first area is an estimated 15,100 sf area of DRO-impacted subsurface soil extending from an estimated 4 to 47 feet bgs. This area encompasses the location of the former AST No. 1 and extends beneath the Malaspina Investments Office/Warehouse structure. The second area is located downslope of the former AST and is an estimated 11,100 sf area of DRO-impacted soil extending from 7 to 16 feet bgs. The remedial alternatives feasible for addressing the DRO-impacted subsurface soil present up to 15 feet bgs include Alternative 1 - No Action, Alternative 2 - Institutional Controls, Alternative 3 - Monitored Natural Attenuation, Alternative 4 - In-Situ Fenton's Reagent Oxidation, Alternative 5 - In-Situ Soil Heating, Alternative 6 - Bioventing, Alternative 7 - Passive Bioventing, Alternative 8 - Biopiles, Alternative 9 - Excavation and On-site LTTD, and Alternative 10 - Excavation and Off-Site Disposal. The impacted soil present at depths greater than 15 feet bgs may be addressed using only Alternatives 1 through 7 due to difficulties excavating soil at depths greater than 15 feet bgs.

We understand that the USACE is considering conducting a groundwater use determination in accordance with 18 AAC 75.350 for AOC D - AST1. If there is no potential for groundwater use, the cleanup level for diesel in soil would be 8,250 mg/Kg.

Selection of the remedial alternative should consider access to the impacted subsurface soil. The larger DRO-impacted soil plume extends beneath the occupied Malaspina Investments Office/Warehouse structure. An estimated 4,000 cy of DRO-impacted soil may be present beneath the structure. This impacted soil cannot be removed by excavation without disturbing the structure. Other site features that need to be considered include active utilities associated with the structure.

The DRO-impacted soil at the downslope soil plume appears to extend to a depth of 16 feet (USACE 2006), only 1 foot deeper than the 15-foot depth used to define shallow versus deep contamination. It may be feasible to excavate the additional 1 foot of impacted soil extending beyond the 15-foot cutoff with the standard excavation equipment available in Yakutat. Abandoned piping should be expected to be encountered during implementation of in-situ or ex-situ remedial alternatives. Vegetation may require clearing in order to access the impacted soil.

Special drilling equipment may be necessary to advance borings/monitoring wells at AOC D - AST1 due to the presence of boulders and erratics in the subsurface. Tubex drilling tools were mobilized to the site in 2005 to successfully drill and install monitoring wells up to 72 feet bgs. Tubex drilling tools have been included in the cost estimates presented in Appendix C.

6.3.7 AOC D - AST2 - Former AST No. 2

AOC D - AST2 has one hotspot (est. 314 sf) of DRO and benzene-impacted surface soil. The remedial alternatives feasible for addressing the DRO and benzene-impacted surface soil include Alternative 1 - No Action, Alternative 2 - Institutional Controls, Alternative 3 - Monitored Natural Attenuation, Alternative 4 - In-Situ Fenton's Reagent Oxidation, Alternative

5 - In-Situ Soil Heating, Alternative 8 - Biopiles, Alternative 9 - Excavation and On-site LTTD, and Alternative 10 - Excavation and Off-Site Disposal.

Abandoned piping should be expected to be encountered during implementation of in-situ or ex-situ remedial alternatives. We understand that the USACE is considering conducting a groundwater use determination in accordance with 18 AAC 75.350 for AOC D - AST2. If there is no potential for groundwater use, the cleanup level for diesel in soil would be 8,250 mg/Kg.

6.3.8 AOC D - AST3 - Former AST No. 3

AOC D - AST3 has an estimated 3,188 sf area of DRO and benzene-impacted surface and subsurface soil extending from an estimated 0 to 12 feet bgs. The remedial alternatives feasible for addressing the DRO and benzene-impacted soil include Alternative 1 - No Action, Alternative 2 - Institutional Controls, Alternative 3 - Monitored Natural Attenuation, Alternative 4 - In-Situ Fenton's Reagent Oxidation, Alternative 5 - In-Situ Soil Heating, Alternative 6 - Bioventing, Alternative 7 - Passive Bioventing, Alternative 8 - Biopiles, Alternative 9 - Excavation and On-site LTTD, and Alternative 10 - Excavation and Off-Site Disposal.

We understand that the USACE is considering conducting a groundwater use determination in accordance with 18 AAC 75.350 for AOC D - AST3. If there is no potential for groundwater use, the cleanup level for diesel in soil would be 8,250 mg/Kg.

It is noted that the lateral extent of soil contamination may not be defined due to physical site constraints. The area north of the former AST 3 was not accessible due to dense vegetation and a steep upward slope. Clearing of vegetation and ground leveling will likely be required to provide access for drill rigs and other heavy equipment utilized to implement in situ and ex situ remedial alternatives. Other site features that should be anticipated include the presence of active utilities and abandoned piping.

Special drilling equipment may be necessary to advance borings/monitoring wells at AOC D - AST3 due to the presence of boulders and erratics in the subsurface. Tubex drilling tools were mobilized to the site in 2005 to successfully drill and install monitoring wells up to 72 feet bgs.

6.3.9 AOC D - AST4 - Former AST No. 4

AOC D - AST4 has two discrete areas of DRO-impacted soil designated D - AST4 (north) and D - AST4 (south). D - AST4 (north) is an estimated 3,775 sf area of DRO-impacted surface and subsurface soil extending from an estimated 0 to 12 feet bgs. This area encompasses the location of the former AST No. 4. D - AST4 (south) is a hotspot (est. 314 sf) of DRO-impacted subsurface soil located from 2 to 4 feet bgs. The remedial alternatives feasible for addressing the DRO-impacted surface and subsurface soil include Alternative 1 - No Action, Alternative 2 - Institutional Controls, Alternative 3 - Monitored Natural Attenuation, Alternative 4 - In-Situ Fenton's Reagent Oxidation, Alternative 5 - In-Situ Soil Heating, Alternative 6 - Bioventing, Alternative 7 - Passive Bioventing, Alternative 8 - Biopiles, Alternative 9 - Excavation and On-site LTTD, and Alternative 10 - Excavation and Off-Site Disposal.

We understand that the USACE is considering conducting a groundwater use determination in accordance with 18 AAC 75.350 for AOC D - AST4. If there is no potential for groundwater use, the cleanup level for diesel in soil would be 8,250 mg/Kg.

It is noted that the lateral extent of soil contamination may not be defined due to physical site constraints. The area east of the former AST 4 was not accessible due to trees and brush. Access to the area west of former AST 4 is also limited. Clearing of vegetation and ground leveling will likely be required to provide access for drill rigs and other heavy equipment utilized to implement in situ and ex situ remedial alternatives. Other site features that should be anticipated include the presence of active utilities and abandoned piping.

Special drilling equipment may be necessary to advance borings/monitoring wells at AOC D - AST4 due to the presence of boulders and erratics in the subsurface. Tubex drilling tools were mobilized to the site in 2005 to successfully drill and install monitoring wells up to 72 feet bgs.

6.3.10 AOC D - AST5 - Former AST No. 5

AOC D - AST5 has an estimated 4,369 sf area of DRO-impacted surface and subsurface soil extending from an estimated 0 to 24 feet bgs. The remedial alternatives feasible for addressing the DRO-impacted soil present up to 15 feet bgs include Alternative 1 - No Action, Alternative 2 - Institutional Controls, Alternative 3 - Monitored Natural Attenuation, Alternative 4 - In-Situ Fenton's Reagent Oxidation, Alternative 5 - In-Situ Soil Heating, Alternative 6 - Bioventing, Alternative 7 - Passive Bioventing, Alternative 8 - Biopiles, Alternative 9 - Excavation and On-site LTTD, and Alternative 10 - Excavation and Off-Site Disposal. The impacted soil present at depths greater than 15 feet bgs may be addressed using only Alternatives 1 through 7 due to difficulties excavating soil at depths greater than 15 feet bgs.

We understand that the USACE is considering conducting a groundwater use determination in accordance with 18 AAC 75.350 for AOC D – AST5. If there is no potential for groundwater use, the cleanup level for diesel in soil would be 8250 mg/Kg.

It is noted that the lateral extent of soil contamination may not be defined due to physical site constraints. The area north and east of the former AST 5 were not accessible due to heavy vegetation and rough terrain. North of former AST 5 the terrain rises abruptly to thick, old growth forest with large diameter (>12-inch) trees and extensive deadfall. Clearing of vegetation and ground leveling will likely be required to provide access for drill rigs and other heavy equipment utilized to implement in situ and ex situ remedial alternatives. Other site features that should be anticipated include the presence of active utilities and abandoned piping. In addition, remnants of the former AST5 concrete foundation remain on site.

Special drilling equipment may be necessary to advance borings/monitoring wells at AOC D - AST5 due to the presence of boulders and erratics in the subsurface. Tubex drilling tools were mobilized to the site in 2005 to successfully drill and install monitoring wells up to 82 feet bgs.

6.3.11 AOC D - AST6 - Former AST No. 6

AOC D - AST6 has an estimated 3,388 sf area of DRO-impacted surface and subsurface soil extending from an estimated 0 to 16.5 feet bgs. The remedial alternatives feasible for addressing the DRO-impacted soil present up to 15 feet bgs include Alternative 1 - No Action, Alternative 2 - Institutional Controls, Alternative 3 - Monitored Natural Attenuation, Alternative 4 - In-Situ Fenton's Reagent Oxidation, Alternative 5 - In-Situ Soil Heating, Alternative 6 - Bioventing, Alternative 7 - Passive Bioventing, Alternative 8 - Biopiles, Alternative 9 - Excavation and On-site LTTD, and Alternative 10 - Excavation and Off-Site Disposal. The impacted soil present at depths greater than 15 feet bgs may be addressed using only Alternatives 1 through 7 due to difficulties excavating soil at depths greater than 15 feet bgs.

We understand that the USACE is considering conducting a groundwater use determination in accordance with 18 AAC 75.350 for AOC D – AST6. If there is no potential for groundwater use, the cleanup level for diesel in soil would be 8,250 mg/Kg.

The DRO-impacted soil extends to 16.5 feet, only 1.5 feet deeper than the 15-foot depth used to define shallow versus deep contamination. It may be feasible to excavate the additional 1.5 feet of impacted soil extending beyond the 15-foot cutoff with the standard excavation equipment available in Yakutat.

Access to AOC D - AST6 is limited to the former tank foundation area and the adjacent cleared roadway. The remainder of the site is covered with dense vegetation. In addition, existing utility lines prevent access to the east while steep terrain makes access to the north and west infeasible. Clearing of vegetation and ground leveling will likely be required to provide access for drill rigs and other heavy equipment utilized to implement in situ and ex situ remedial alternatives. Abandoned piping should be expected to be encountered during implementation of in-situ or ex-situ remedial alternatives. ARCO Well #2, enclosed within a shed and chain-link fence, is located immediately south of the former tank foundation.

Special drilling equipment may be necessary to advance borings/monitoring wells at AOC D - AST6 due to the presence of boulders and erratics in the subsurface. Tubex drilling tools were mobilized to the site in 2005 to successfully drill and install monitoring wells up to 82 feet bgs.

6.3.12 AOC D - AST7 - Former AST No. 7

AOC D - AST7 has an estimated 7,867 sf area of DRO-impacted surface and subsurface soil extending from an estimated 0 to 53 feet bgs. In addition, 2-methylnaphthalene-impacted subsurface soil was encountered from 20 to 22 feet bgs in one location. The remedial alternatives feasible for addressing the DRO-impacted soil present up to 15 feet bgs include Alternative 1 - No Action, Alternative 2 - Institutional Controls, Alternative 3 - Monitored Natural Attenuation, Alternative 4 - In-Situ Fenton's Reagent Oxidation, Alternative 5 - In-Situ Soil Heating, Alternative 6 - Bioventing, Alternative 7 - Passive Bioventing, Alternative 8 - Biopiles, Alternative 9 - Excavation and On-site LTTD, and Alternative 10 - Excavation and Off-Site Disposal. The DRO and 2-methylnaphthalene-impacted soil present at depths greater than 15 feet bgs may be addressed using only Alternatives 1 through 7 due to difficulties excavating soil at depths greater than 15 feet bgs.

AOC D - AST7 also has an estimated 16,000 sf groundwater plume impacted with DRO. The remedial alternatives feasible for addressing the DRO-impacted groundwater include Alternative 1 - No Action, Alternative 2 - Institutional Controls, Alternative 3 - Monitored Natural Attenuation, and Alternative 13 - Air Sparging/Soil Vapor Extraction.

A drinking water well capture zone study should be conducted if a remedial alternative is selected that will disturb the groundwater, particularly in-situ chemical oxidation for impacted soil and air sparging/soil vapor extraction for impacted groundwater. We understand that the USACE is considering conducting a groundwater use determination in accordance with 18 AAC 75.350 for AOC D – AST7. If there is no potential for groundwater use, the cleanup level for diesel in soil would be 8,250 mg/Kg.

Select technologies evaluated require installation of wells into the unconfined aquifer. Drilling into the aquifer raises the concern of potentially creating a vertical pathway to the lower drinking water source by puncturing through the confining layer. A confining layer was not encountered in the unconfined aquifer during drilling of the borings for Monitoring Wells AST5-4, AST6-3 or AST7-4 which were positioned closest to the two City Water supply wells. Monitoring Well AST5-4 was drilled to about 15 feet below the static water level. We do not anticipate that the technologies evaluated will need to be extended beyond a depth of 15 feet below the water table.

It is noted that site access is limited to the area immediately surrounding the former AST 7 foundation and along an existing trail extending downslope toward the west. The remaining areas around the former foundation rise or drop abruptly to old growth forest with large diameter (>12-inch) trees and extensive deadfall. Clearing of vegetation and ground leveling will likely be required to provide access for drill rigs and other heavy equipment utilized to implement in situ and ex situ remedial alternatives. Abandoned piping should be expected to be encountered during implementation of in-situ or ex-situ remedial alternatives.

Special drilling equipment may be necessary to advance borings/monitoring wells at AOC D - AST7 due to the presence of boulders and erratics in the subsurface. Tubex drilling tools were mobilized to the site in 2005 to successfully drill and install monitoring wells up to 82 feet bgs.

6.3.13 AOC D - AST8 - Former AST No. 8

AOC D - AST8 has an estimated 5,381 sf area of DRO-impacted subsurface soil extending from an estimated 4 to 27 feet bgs. The remedial alternatives feasible for addressing the DRO-impacted soil present up to 15 feet bgs include Alternative 1 - No Action, Alternative 2 - Institutional Controls, Alternative 3 - Monitored Natural Attenuation, Alternative 4 - In-Situ Fenton's Reagent Oxidation, Alternative 5 - In-Situ Soil Heating, Alternative 6 - Bioventing, Alternative 7 - Passive Bioventing, Alternative 8 - Biopiles, Alternative 9 - Excavation and On-site LTTD, and Alternative 10 - Excavation and Off-Site Disposal. The DRO impacted soil present at depths greater than 15 feet bgs may be addressed using only Alternatives 1 through 7 due to difficulties excavating soil at depths greater than 15 feet bgs.

Selection of the remedial alternative should consider access to the impacted subsurface soil. The Yakutat Community Water Supply tank and ARCO Well #1 shed are located within the area of impacted soil. The water supply tank, positioned in the same location as the former AST8, covers an estimated 850 sf area. An estimated 750 cy of DRO-impacted soil may be present beneath the water tank. An additional 50 cy of DRO-impacted soil may be present beneath the ARCO Well #1 shed. This impacted soil cannot be removed by excavation without disturbing the structures.

The ground surface drops abruptly on the southeast side and rises abruptly on the southwest side of the site beyond the chain-link fence. Clearing of vegetation and ground leveling will likely be required to provide access for drill rigs and other heavy equipment utilized to implement in situ and ex situ remedial alternatives. Abandoned piping should be expected to be encountered during implementation of in-situ or ex-situ remedial alternatives.

Special drilling equipment may be necessary to advance borings/monitoring wells at AOC D - AST8 due to the presence of boulders and erratics in the subsurface. Tubex drilling tools were mobilized to the site in 2005 to successfully drill and install monitoring wells up to 82 feet bgs.

6.3.14 AOC E1 - Drum Dump

The AOC E1 – Drum Dump has three distinct areas with different media impacted with various COCs. The largest area (est. 903 sf) comprises surface and subsurface soil (estimated up to 4 feet bgs) impacted with DRO and chromium. The other two areas are a hotspot (est. 78 sf) of chromium-impacted surface soil and a hotspot (est. 78 sf) of arsenic-impacted surface soil.

The common remedial alternatives feasible for addressing the three areas include Alternative 1 - No Action, Alternative 2 - Institutional Controls, and Alternative 10 - Excavation and Off-Site Disposal which are the three alternatives feasible for addressing multiple COCs in soil and sediment. The two hotspots of arsenic and chromium-impacted surface soil can also be addressed using Alternative 11 - Excavation and Soil Washing.

Remedial action of the hotspot of chromium-impacted surface soil at AOC E1 – Drum Dump may not be warranted depending on the type of chromium present in the surface soil. In addition, the remedial alternatives feasible for addressing the estimated 903 sf area of DRO and chromium-impacted soil may change. The chromium concentration in the soil is assumed to be Cr6+, a known carcinogen. The soil at AOC E1 – Drum Dump will be retested to determine if the chromium concentration is due to Cr6+ and/or Cr3+. The cleanup level for Cr3+ is 124,000 mg/kg. If it is determined that the chromium concentration in the soil is actually Cr3+, then chromium is not a COC at AOC E1 – Drum Dump. In this case, the surface soil in the one hotspot will not need to be remediated. In addition, the remedial alternatives feasible for addressing the 903 sf area of DRO-impacted soil will expand to include Alternative 3 - Monitored Natural Attenuation, Alternative 4 - In-Situ Fenton's Reagent Oxidation, Alternative 5 - In-Situ Soil Heating, Alternative 6 - Bioventing, Alternative 7 - Passive Bioventing, Alternative 8 - Biopiles, and Alternative 9 - Excavation and On-site LTTD.

Selection of the remedial alternative should consider access to the impacted surface and subsurface soil and sediment. The groundwater at AOC E1 – Drum Dump is near or above the site surface. Former studies have documented parts of the site to be covered with several inches of water. Further, debris may be encountered during implementation of in-situ or ex-situ remedial alternatives. Vegetation may require clearing in order to access the impacted soil. The boggy nature of the ground surface at AOC E1 – Drum Dump may require implementation of the selected remedial alternative during mid-winter when surface and subsurface materials are frozen. Wetlands are also subject to permitting. Permits may need to be obtained prior to implementing remedial activities.

6.3.15 AOC E1 – Drainage Ditch

AOC E1 – Drainage Ditch has different media impacted with various COCs. The area consists of about 200 linear feet (est. 1,347 sf) of drainage ditch bordering the north side of the logging road accessing the site. The soil in the ditch sediment is impacted with DRO, pentachlorophenol, arsenic, cadmium, chromium and mercury.

The remedial alternatives feasible for addressing AOC E1 – Drainage Ditch include Alternative 1 - No Action, Alternative 2 - Institutional Controls, and Alternative 10 - Excavation and Off-Site Disposal which are the three alternatives feasible for addressing multiple COCs in soil and sediment.

Selection of the remedial alternative should consider access to the impacted surface and subsurface soil and sediment. Surface water in the drainage ditch has been documented to be 4 to 6 feet deep. Sticks, leaves and muck are also present in the drainage ditch. Further, debris may be encountered during implementation of Alternative 10. Vegetation may require clearing in order to access the impacted sediment. The presence of surface water at AOC E1 – Drainage Ditch may require implementation of Alternative 10 during mid-winter when surface and subsurface materials are frozen. The surface water in the drainage ditch is connected to navigable water and may be considered US Waters subject to permitting. Wetlands are also subject to permitting. Permits may need to be obtained prior to implementing Alternative 10.

6.3.16 AOC G4 - Seaplane Base, Seaplane Slough

AOC G4 has an estimated 625 sf area of sediment within the seaplane slough impacted with DRO, chrysene, phenanthrene, pyrene, arsenic, cadmium, chromium, and mercury. The remedial alternatives feasible for addressing the impacted sediment include Alternative 1 - No Action, Alternative 2 - Institutional Controls, and Alternative 10 - Excavation and Off-Site Disposal. The surface water in the seaplane slough at AOC G4 is impacted with barium. The remedial alternatives feasible for addressing the impacted surface water include Alternative 1 - No Action, Alternative 2 - Institutional Controls, and Alternative 3 - Monitored Natural Attenuation.

The chromium concentration in the sediment is assumed to be $Cr6+$, a known carcinogen. The sediment at AOC G4 will be retested to determine if the chromium concentration is due to $Cr6+$ and/or $Cr3+$. The cleanup level for $Cr3+$ is 124,000 mg/kg. If it is determined that the chromium concentration in sediment is actually $Cr3+$, then chromium is not a COC at AOC G4.

Selection of the remedial alternative should consider access to the impacted sediment. Implementation of the selected remedial alternative should be conducted when water in the slough is minimal. The surface water in the slough is connected to navigable water and is therefore considered US Waters subject to permitting. Wetlands adjacent to US Waters and with migrating birds are also subject to permitting. Permits may need to be obtained prior to implementing remedial activities.

6.3.17 AOC K1 - Solid Waste Disposal Dump No. 4

AOC K1 is a former dump area covering approximately 82,150 square feet. Surface soil impacted with DRO, pentachlorophenol, arsenic, cadmium, chromium, and benzo(a)pyrene is located within the dump area. The remedial alternatives feasible for addressing the impacted surface soil include Alternative 1 - No Action, Alternative 2 - Institutional Controls, Alternative 10 - Excavation and Off-Site Disposal, and Alternative 12 - Capping. The surface water at AOC K1 is impacted with arsenic, cadmium, and lead. The remedial alternatives feasible for addressing the impacted surface water include Alternative 1 - No Action, Alternative 2 - Institutional Controls, and Alternative 3 - Monitored Natural Attenuation.

The chromium concentration in the soil is assumed to be Cr6+, a known carcinogen. The soil at AOC K1 will be retested to determine if the chromium concentration is due to Cr6+ or Cr3+. The cleanup level for Cr3+ is 124,000 mg/kg. If it is determined that the chromium concentration in surface soil is actually Cr3+, then chromium is not a COC at AOC K1.

Selection of the remedial alternative should consider access to the impacted surface soil. Trash and debris may be encountered during excavation activities. The former dump area is heavily vegetated with alders, spruce and various berry bushes. The area surrounding the dump area consists of flat grassy wetlands with randomly scattered willow bushes. The area is often flooded from water overflowing from nearby Tawah Creek. Water levels have been observed to fluctuate by several feet within a day, depending on precipitation. Implementation of the selected remedial alternative may need to be conducted in the winter when the surface and subsurface materials are frozen. Wetland permits may need to be obtained prior to implementing remedial activities.

6.3.18 AOC L1 - South Dump

AOC L1 has an estimated 314 sf area of GRO, benzene, and toluene-impacted surface and subsurface soil extending from an estimated 0 to 12.5 feet bgs. The remedial alternatives feasible for addressing the petroleum-impacted soil include Alternative 1 - No Action, Alternative 2 - Institutional Controls, Alternative 3 - Monitored Natural Attenuation, Alternative 4 - In-Situ Fenton's Reagent Oxidation, Alternative 5 - In-Situ Soil Heating, Alternative 6 - Bioventing, Alternative 7 - Passive Bioventing, Alternative 8 - Biopiles, Alternative 9 - Excavation and On-site LTTD, and Alternative 10 - Excavation and Off-Site Disposal.

AOC L1 also has an estimated 630 sf groundwater plume impacted with GRO and benzene. The remedial alternatives feasible for addressing the GRO and benzene-impacted groundwater include Alternative 1 - No Action, Alternative 2 - Institutional Controls, Alternative 3 - Monitored Natural Attenuation, and Alternative 13 - Air Sparging/Soil Vapor Extraction.

A geophysical survey of AOC L1 found several anomalies interpreted as surface debris. The survey did not find evidence of buried drums or debris at the site. Vegetation may require clearing in order to access the impacted soil and groundwater.

The groundwater at AOC L1 is relatively shallow at less than 10 feet bgs and is not likely to impact in situ and ex situ remedial alternative selection. An underground lateral fuel pipeline is present in the vicinity of the impacted soil and groundwater.

6.3.19 AOC L3 - Tank 1

Surface soil impacted with benzo(a)pyrene is present at the former Tank 1 location within AOC L3. The impacted soil location is a hotspot with an estimated 314 sf of impacted soil. The remedial alternatives feasible for addressing the petroleum-impacted soil include Alternative 1 - No Action, Alternative 2 - Institutional Controls, Alternative 3 - Monitored Natural Attenuation, Alternative 4 - In-Situ Fenton's Reagent Oxidation, Alternative 5 - In-Situ Soil Heating, Alternative 8 - Biopiles, Alternative 9 - Excavation and On-site LTTD, and Alternative 10 - Excavation and Off-Site Disposal.

Selection of the remedial alternative should consider the following site conditions. The impacted surface soil is located at an end of the former AST tank foundation in the vicinity of the tank's service pipelines. Although the tank was removed, the connecting pipeline system was left in place as well as the concrete tank supports. The tank support is four concrete blocks measuring 3 feet high, 4 feet wide and 10 feet long. The underground piping and tank supports most likely will be encountered within the impacted surface soil area. Evidence gathered during former studies suggests the pipeline system has not been fully emptied.

The groundwater at AOC L3 – Tank 1 is relatively shallow at an average depth of about 7 feet bgs and is not likely to impact in situ and ex situ remedial alternative selection.

6.3.20 AOC L3 - Tank 3

Surface soil impacted with benzo(a)pyrene is present at the former Tank 3 location within AOC L3. The impacted soil location is a hotspot with an estimated 314 sf of impacted soil. The remedial alternatives feasible for addressing the petroleum-impacted soil include Alternative 1 - No Action, Alternative 2 - Institutional Controls, Alternative 3 - Monitored Natural Attenuation, Alternative 4 - In-Situ Fenton's Reagent Oxidation, Alternative 5 - In-Situ Soil Heating, Alternative 8 - Biopiles, Alternative 9 - Excavation and On-site LTTD, and Alternative 10 - Excavation and Off-Site Disposal.

Selection of the remedial alternative should consider the following site conditions. The impacted surface soil is located at an end of the former AST tank foundation in the vicinity of the tank's service pipelines. Although the tank was removed, the connecting pipeline system was left in place as well as the concrete tank supports. The tank support is four concrete blocks measuring 3 feet high, 4 feet wide and 10 feet long. The underground piping and tank supports most likely will be encountered within the impacted surface soil area. Evidence gathered during former studies suggests the pipeline system has not been fully emptied.

The groundwater at AOC L3 – Tank 3 is relatively shallow at an average depth of about 7 feet bgs and is not likely to impact in situ and ex situ remedial alternative selection.

6.3.21 AOC L3 - Tank 7

Surface soil impacted with benzo(a)pyrene is present at the former Tank 7 location within AOC L3. The impacted soil location is a hotspot with an estimated 314 sf of impacted soil. The remedial alternatives feasible for addressing the petroleum-impacted soil include Alternative 1 - No Action, Alternative 2 - Institutional Controls, Alternative 3 - Monitored Natural Attenuation, Alternative 4 - In-Situ Fenton's Reagent Oxidation, Alternative 5 - In-Situ Soil Heating, Alternative 8 - Biopiles, Alternative 9 - Excavation and On-site LTTD, and Alternative 10 - Excavation and Off-Site Disposal.

Selection of the remedial alternative should consider the following site conditions. The impacted surface soil is located at an end of the former AST tank foundation in the vicinity of the tank's service pipelines. Although the tank was removed, the connecting pipeline system was left in place as well as the concrete tank supports. The tank support is four concrete blocks measuring 3 feet high, 4 feet wide and 10 feet long. The underground piping and tank supports most likely will be encountered within the impacted surface soil area. Evidence gathered during former studies suggests the pipeline system has not been fully emptied.

The groundwater at AOC L3 – Tank 7 is relatively shallow at an average depth of about 7 feet bgs and is not likely to impact in situ and ex situ remedial alternative selection.

6.3.22 AOC L3 - Tank 8

Surface soil impacted with benzo(a)pyrene and benzo(a)anthracene is present at the former Tank 8 location within AOC L3. The impacted soil location is a hotspot with an estimated 525 sf of impacted soil. The remedial alternatives feasible for addressing the petroleum-impacted soil include Alternative 1 - No Action, Alternative 2 - Institutional Controls, Alternative 3 - Monitored Natural Attenuation, Alternative 4 - In-Situ Fenton's Reagent

Oxidation, Alternative 5 - In-Situ Soil Heating, Alternative 8 - Biopiles, Alternative 9 - Excavation and On-site LTTD, and Alternative 10 - Excavation and Off-Site Disposal.

Selection of the remedial alternative should consider the following site conditions. The impacted surface soil is located at an end of the former AST tank foundation in the vicinity of the tank's service pipelines. Although the tank was removed, the connecting pipeline system was left in place as well as the concrete tank supports. The tank support is four concrete blocks measuring 3 feet high, 4 feet wide and 10 feet long. The underground piping and tank supports most likely will be encountered within the impacted surface soil area. Evidence gathered during former studies suggests the pipeline system has not been fully emptied.

The groundwater at AOC L3 – Tank 8 is relatively shallow at an average depth of about 7 feet bgs and is not likely to impact in situ and ex situ remedial alternative selection.

6.3.23 AOC L3 - Tank 11

Surface soil impacted with benzo(a)pyrene is present at the former Tank 11 location within AOC L3. The impacted soil location is a hotspot with an estimated 314 sf of impacted soil. The remedial alternatives feasible for addressing the petroleum-impacted soil include Alternative 1 - No Action, Alternative 2 - Institutional Controls, Alternative 3 - Monitored Natural Attenuation, Alternative 4 - In-Situ Fenton's Reagent Oxidation, Alternative 5 - In-Situ Soil Heating, Alternative 8 - Biopiles, Alternative 9 - Excavation and On-site LTTD, and Alternative 10 - Excavation and Off-Site Disposal.

Selection of the remedial alternative should consider the following site conditions. The impacted surface soil is located at an end of the former AST tank foundation in the vicinity of the tank's service pipelines. Although the tank was removed, the connecting pipeline system was left in place as well as the concrete tank supports. The tank support is four concrete blocks measuring 3 feet high, 4 feet wide and 10 feet long. The underground piping and tank supports most likely will be encountered within the impacted surface soil area. Evidence gathered during former studies suggests the pipeline system has not been fully emptied.

The groundwater at AOC L3 – Tank 11 is relatively shallow at an average depth of about 7 feet bgs and is not likely to impact in situ and ex situ remedial alternative selection.

6.3.24 AOC L3 - Tank 14

Surface soil impacted with benzene is present at the former Tank 14 location within AOC L3. The impacted soil location is a hotspot with an estimated 314 sf of impacted soil. The remedial alternatives feasible for addressing the petroleum-impacted soil include Alternative 1 - No Action, Alternative 2 - Institutional Controls, Alternative 3 - Monitored Natural Attenuation, Alternative 4 - In-Situ Fenton's Reagent Oxidation, Alternative 5 - In-Situ Soil Heating, Alternative 8 - Biopiles, Alternative 9 - Excavation and On-site LTTD, and Alternative 10 - Excavation and Off-Site Disposal.

Selection of the remedial alternative should consider the following site conditions. The impacted surface soil is located at an end of the former AST tank foundation in the vicinity of the tank's service pipelines. Although the tank was removed, the connecting pipeline system was left in place as well as the concrete tank supports. The tank support is four concrete blocks measuring 3 feet high, 4 feet wide and 10 feet long. The underground piping and tank supports most likely will be encountered within the impacted surface soil area. Evidence gathered during former studies suggests the pipeline system has not been fully emptied.

The groundwater at AOC L3 – Tank 14 is relatively shallow at an average depth of about 7 feet bgs and is not likely to impact in situ and ex situ remedial alternative selection.

6.3.25 AOC L4 - Truck Fill Stand No. 4

AOC L4 has an estimated 570 sf area of DRO and benzo(a)pyrene-impacted surface soil. The remedial alternatives feasible for addressing the petroleum-impacted soil include Alternative 1 - No Action, Alternative 2 - Institutional Controls, Alternative 3 - Monitored Natural Attenuation, Alternative 4 - In-Situ Fenton's Reagent Oxidation, Alternative 5 - In-Situ Soil Heating, Alternative 8 - Biopiles, Alternative 9 - Excavation and On-site LTTD, and Alternative 10 - Excavation and Off-Site Disposal.

Selection of the remedial alternative should consider the following site conditions. The impacted surface soil is located adjacent to and beneath the northeast end of a wood cribbing tank support. The wood cribbing appears to have supported a small tank approximately 20 feet long. A capped 6-inch diameter pipe extending up from a trench is present within the impacted area at the northeast end of the tank support. The pipe in the trench runs southeast toward the tank farm and is believed to be the main delivery line from the Army Dock to the Air Corps Operations Reserve Tank Farm. The pipe should be empty and clear from former pigging activities.

Groundwater is located approximately 10 feet bgs and is not likely to impact in situ and ex situ remedial alternative selection.

6.3.26 AOC M2 - Fuel/Water Separator and Pressure Tank Pit

AOC M2 has three distinct areas with surface and subsurface soil impacted with either DRO or chromium. The area referred to as AOC M2 (Tank) has an estimated 16,921 sf of DRO-impacted subsurface soil extending from 4 to 6 feet bgs. The area referred to as AOC M2 (Quonset Hut) has an estimated 1,514 sf of DRO-impacted subsurface soil extending from 3.5 to 5 feet bgs. The third location is a hotspot (est. 78 sf) of chromium-impacted surface soil. The remedial alternatives feasible for addressing the DRO-impacted subsurface soil include Alternative 1 - No Action, Alternative 2 - Institutional Controls, Alternative 3 - Monitored Natural Attenuation, Alternative 4 - In-Situ Fenton's Reagent Oxidation, Alternative 5 - In-Situ Soil Heating, Alternative 6 - Bioventing, Alternative 7 - Passive Bioventing, Alternative 8 - Biopiles, Alternative 9 - Excavation and On-site LTTD, and Alternative 10 - Excavation and Off-Site Disposal. The chromium-impacted surface soil can be addressed using Alternative 1 - No Action, Alternative 2 - Institutional Controls, Alternative 10 - Excavation and Off-Site Disposal, and Alternative 11 - Excavation and Soil Washing.

Remedial action of the chromium-impacted surface soil at AOC M2 may not be warranted depending on the type of chromium present in the surface soil. The chromium concentration in surface soil is assumed to be Cr6+, a known carcinogen. The surface soil at AOC M2 will be retested to determine if the chromium concentration is due to Cr6+ and/or Cr3+. The cleanup level for Cr3+ is 124,000 mg/kg. If it is determined that the chromium concentration in surface soil is actually Cr3+, then chromium is not a COC at AOC M2 and remedial action is not needed at the hotspot location.

Selection of the remedial alternative should consider access to the impacted subsurface soil. The DRO-impacted soil plume at AOC M2 (Tank) extends beneath the occupied Forest Service Garage structure. An estimated 50 cy of DRO-impacted soil may be present beneath the structure. This impacted soil cannot be removed by excavation without disturbing the structure. Other site features that need to be considered include the concrete tank foundation, ruins from a Quonset hut (most of the debris has reportedly been removed), a soil berm located southwest of the Quonset hut ruins and active utilities associated with the Forest Service Garage. Vegetation may require clearing in order to access the impacted soil.

The depth to groundwater at AOC M2 is shallow at 0.5 feet bgs and may require implementation of the selected remedial alternative during mid-winter when surface and subsurface materials are frozen.

6.3.27 AOC O1 - Air Corps Warehouse Group No. 2

AOC O1 has surface soil impacted with arsenic at two hotspot locations (est. 156 sf total). Remedial alternatives feasible for addressing the arsenic-impacted surface soil include Alternative 1 - No Action, Alternative 2 - Institutional Controls, Alternative 10 - Excavation and Off-Site Disposal, and Alternative 11 - Excavation and Soil Washing.

AOC O1 also has surface water impacted with lead at two locations along a drainage ditch. Remedial alternatives feasible for addressing the lead-impacted surface water include Alternative 1 - No Action, Alternative 2 - Institutional Controls, and Alternative 3 - Monitored Natural Attenuation.

The surface water at AOC O1 should be retested to determine if lead concentrations above cleanup criteria remain. The lead concentrations measured over 9 years ago may no longer be present due to natural attenuation processes such as dilution and dispersion.

It is noted that one of the arsenic-impacted surface soil hotspots is located adjacent to the 30 by 40-foot warehouse foundation. It may not be possible to remove the impacted soil without disturbing the structure.

Groundwater at AOC O1 is shallow at approximately 2 to 3 feet bgs and is not likely to impact in situ and ex situ remedial alternative selection. Higher groundwater levels may require implementation of the selected remedial alternative during mid-winter when surface and subsurface materials are frozen.

6.3.28 Rifle Range

The surface soil present in two locations, the Target Berm and the Backstop Berm, is impacted with lead at the Rifle Range for a total estimated impacted area of 5,404 sf. Remedial alternatives feasible for addressing the lead-impacted surface soil include Alternative 1 - No Action, Alternative 2 - Institutional Controls, Alternative 10 - Excavation and Off-Site Disposal, and Alternative 11 - Excavation and Soil Washing.

Selection of the remedial alternative should consider the following site conditions. The Rifle Range is covered with thick, old growth forest with large diameter (>12-inch) trees limiting accessibility. The Target Berm consists of a concrete side which houses a small room that may require concrete demolition equipment.

TABLE 6.0-1 - DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

Alternatives	Applicable COCs	Applicable Affected Media	Description of Alternative	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-Term Effectiveness	Implementability	Cost
Alternative 1 - No Action	GRO, DRO, VOCs, SVOCs, Metals, PCBs, and PCP	Surface and Subsurface Soil, Sediment, Surface Water, and Groundwater	No active remediation or action.	No action when contaminants are present, does not provide protection to human health and the environment. However, if pathways to potential receptors are not complete, or likely to be complete, no action may be justifiable.	No Action does not achieve ARARs.	Conditions and residual risk may not change for the practical long term.	COCs are still present 60 years after introduction to environment. With no action, there is no reduction of toxicity, mobility, or volume.	No Action is ineffective but does not pose additional risks to workers, the community, or the environment.	With no action, implementation is immediate.	See Table 6.0-2
Alternative 2 - Institutional Controls	GRO, DRO, VOCs, SVOCs, Metals, PCBs and PCP	Surface and Subsurface Soil, Sediment, Surface Water, and Groundwater	ICs are administrative and/or non-engineering physical measures designed to prevent or limit exposure to COCs left in place at a site, or supplement the chosen remedy.	ICs are used to reduce human or environmental exposure to COCs that remain on site.	ICs do not achieve ARARs.	Conditions and residual risk may not change for the practical long term. Oversight, monitoring and appropriate enforcement mechanisms may be required to protect human health and the environment. Become less desirable if the Yakutat population grows and demand for real estate increases.	ICs reduce potential exposure. These is no reduction of toxicity, mobility, or volume.	ICs are effective immediately upon implementation and do not pose additional risks to workers, the community, or the environment during implementation.	ICs such as easements, restrictive covenants, and zoning ordinances may be implemented following acceptance by ADEC, EPA and local community.	See Table 6.0-2
Alternative 3 - Monitored Natural Attenuation (MNA)	GRO, DRO, VOCs, and SVOCs	Surface and Subsurface Soil, Sediment and Groundwater	MNA is the monitoring of naturally occurring processes that reduce the concentrations of contaminants through biodegradation, dilution, advection, etc.	Engineering controls may limit access to sites, and therefore, exposure during the natural attenuation process. Risk through exposure may ultimately be reduced.	MNA may achieve ARARs for petroleum COCs over time but metals and PCP concentrations may not be reduced. Time required depends on magnitude of COC concentration and soil conditions.	Without continuing or new sources of contamination, this alternative may achieve permanent and irreversible results by natural attenuation processes for petroleum COC concentrations over long-term. Metals and PCP concentrations may not be reduced.	Attenuation of contaminants by natural processes may reduce toxicity, mobility, and volume to acceptable, risk-based levels, eventually achieving degradation of petroleum COCs but not metals and PCP COCs.	MNA is long-term and poses additional risks to workers, the community, and the environment during the installation and decommissioning of potential monitoring wells and fencing and advancement of confirmation borings.	There is no remedial action to be implemented; however, additional monitoring wells may be needed, fences installed and confirmation borings drilled and sampled.	See Tables 6.0-2 and 6.0-3
	SVOCs, Metals and PCBs	Surface Water								
Alternative 4 - In-Situ Fenton's Reagent Oxidation	GRO, DRO, VOCs, and SVOCs	Surface and Subsurface Soil	Oxidation using liquid hydrogen peroxide in the presence of ferrous iron produces Fenton's Reagent oxidation. Oxidant delivery systems employ vertical and/or horizontal injection points.	Risk to human and ecological receptors may be reduced.	ARARs may be achieved with this process.	Strong oxidants rapidly degrade organic compounds achieving permanent and irreversible results. Process by-products (e.g. heat, redox residuals) may pose residual risk and/or limit further treatment using natural attenuation.	Introduction of a chemical oxidant into the subsurface transforms soil contaminants into non-hazardous or less toxic compounds. Concentrations of contaminants may be reduced to levels that reduce the potential for mobility and toxicity.	Fenton's Reagent oxidation poses additional risks to workers, the community, and the environment during implementation. Liquid hydrogen peroxide persists in soil for minutes to hours and reacts immediately upon contact with contaminants. Oxidation may be either short or long-term, depending on soil conditions and the method of delivery and distribution throughout the subsurface. Limitations include handling hazardous oxidizing chemicals. Precautions are needed, in the form of PPE, to prevent dermal contact with hydrogen peroxide.	This alternative is technically and administratively feasible, and has been used effectively at other sites. Alternative will need drill rig and injection method appropriate for soil conditions.	See Table 6.0-2
Alternative 5 - In-Situ Soil Heating	GRO, DRO, VOCs, and SVOCs	Surface and Subsurface Soil	Uses thermally enhanced SVE technology to increase the volatilization rate of semi-volatiles and facilitate extraction. Process is similar to standard SVE but requires heat resistant extraction wells.	Risk to human and ecological receptors may be reduced.	ARARs may be achieved with this process.	Contaminants are permanently removed by volatilization and extraction.	Contaminants are reduced which also reduces the toxicity, mobility and volume of contaminants. There is less certainty of removing residual contaminants compared to ex-situ alternatives.	Volatile constituents, mobilized during operation of thermally enhanced SVE system, pose additional risks to workers, the community, and the environment during implementation. Capture and treatment (if necessary) of volatile emissions at the surface may reduce risks. This alternative may take 6 months to 1 year to achieve goals, depending on soil conditions, method of delivery and distribution throughout the subsurface. Precautions, in the form of PPE, may be needed to prevent ingestion or inhalation during placement of SVE wells and manifold piping.	This alternative is technically and administratively feasible, and has been used effectively at other sites. A power source is required for implementation.	See Table 6.0-2

TABLE 6.0-1 - DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

Alternatives	Applicable COCs	Applicable Affected Media	Description of Alternative	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-Term Effectiveness	Implementability	Cost
Alternative 6 - Bioventing	GRO, DRO, VOCs, and SVOCs	Subsurface Soil	Air is forced into sub-surface contaminated zone using air injection wells. Forced air provides oxygen for metabolizing bacteria. May be used in conjunction with SVE wells to optimize air flow. Nutrient amendments may also be introduced through injection wells.	Risk to human and ecological receptors may be reduced.	ARARs may be achieved with this process.	Contaminants are permanently altered to harmless constituents through bacterial metabolic processes.	Concentration of contaminants is reduced to levels that reduce the potential for mobility and toxicity. There is less certainty of removing residual contaminants compared to ex-situ alternatives.	Volatile constituents, mobilized during operation of Bioventing system, pose additional risks to workers, the community, and the environment during implementation. Capture and treatment (if necessary) of volatile emissions at the surface may reduce risks. After application of this process, subsurface conditions are excellent for biodegradation of residual contaminants. This alternative may take 10 or more years to achieve goals, depending on soil conditions and degradation rates. Precautions may be needed to prevent ingestion or inhalation during placement of air ducts, probably in the form of PPE.	This alternative is technically and administratively feasible, and has been used effectively at other sites. A power source is required for implementation.	See Table 6.0-2
Alternative 7 - Passive Bioventing	GRO, DRO, VOCs, and SVOCs	Subsurface Soil	Airway passage is provided to sub-surface contaminated zone using aeration wells/points. Air provides oxygen for metabolizing bacteria. Nutrient amendments may also be introduced through injection wells.	Risk to human and ecological receptors may be reduced.	ARARs may be achieved with this process.	Contaminants are permanently altered to harmless constituents through bacterial metabolic processes.	Concentration of contaminants is reduced to levels that reduce the potential for mobility and toxicity. There is less certainty of removing residual contaminants compared to active in-site and ex-situ alternatives.	This alternative may take 20 or more years to achieve goals, depending on soil conditions and degradation rates. Precautions may be needed to prevent ingestion or inhalation during placement of air ducts, probably in the form of PPE.	This alternative is technically and administratively feasible, and has been used effectively at other sites.	See Table 6.0-2
Alternative 8 - Biopiles	GRO, DRO, VOCs, and SVOCs	Surface Soil, Subsurface Soil < 15 feet bgs, and sediment	Contaminated soil is excavated and mounded in a treatment cell. Perforated ducts are placed within biopiles, through which air and water are injected to promote biodegradation. Amendments to soil may likely be added.	Risk to human and ecological receptors may be reduced.	ARARs may be achieved with this process.	Contaminants are permanently altered to harmless constituents through bacterial metabolic processes.	Concentration of contaminants is reduced to levels that reduce the potential for mobility and toxicity.	This alternative requires the use of excavation equipment and transport trucks to move impacted soil on Yakutat roads and poses risks to workers, the community, and the environment during implementation. Volatile constituents may also be mobilized during operation of biopiles and escape into the atmosphere posing additional risks to workers, the community, and the environment during implementation. Precautions may be needed to prevent ingestion or inhalation during excavation, transport, and placement of contaminated soil into biopiles. This is a short duration alternative that may take several months; however, it may take 2 - 5 years due to climatic conditions.	This alternative is technically and administratively feasible, and has been used effectively at other sites. A power source and land to accommodate biopile is needed for implementation.	See Table 6.0-2
Alternative 9 - Excavation and On-Site Low-Temperature Thermal Desorption	GRO, DRO, VOCs, and SVOCs	Surface Soil, Subsurface Soil < 15 feet bgs, and sediment	Contaminated soil is excavated, placed in a long-term stockpile, and remediated when an LTTD unit is available. Treated soil may be re-used as backfill material.	Risk to human and ecological receptors may be reduced.	ARARs may be achieved with this process.	The removal of contaminated soil is a permanent solution at the site.	Concentration of contaminants is reduced to levels that reduce the potential for mobility and toxicity.	On-site workers may be exposed to contaminated soil through direct contact and/or ingestion. PPE may be used to prevent exposure. An exclusion zone may be established to prevent exposure to local residents who may pass by project site. Dry, dusty conditions may create an inhalation hazard (unlikely in Yakutat); however, watering exposed surfaces may mitigate potential risk. This alternative requires the use of excavation equipment and transport trucks to move impacted soil on Yakutat roads and poses risks to workers, the community, and the environment during implementation. This alternative may be completed in several weeks to months, depending on volume of soil to be excavated.	This alternative is technically and administratively feasible, and has been used effectively at other sites. Mobilization of equipment, excavation, and soil transportation requirements for this alternative are fairly common tasks in Alaska and may be successfully implemented with a high degree of certainty. A power and/or energy source is needed for implementation.	See Table 6.0-2
Alternative 10 - Excavation and Off-Site Disposal	GRO, DRO, VOCs, SVOCs, Metals, and PCP	Surface Soil, Subsurface Soil < 15 feet bgs, and sediment	Contaminated soil is excavated and transported off site for disposal.	Contaminated soil is removed from the site, thereby reducing the source of potential risk to human health and the environment.	Contaminants are removed from the site, leaving clean native soil and/or backfill material; therefore, ARARs compliance may be achieved.	The removal of contaminated soil is a permanent solution at the site.	Physical removal of contaminants reduces the toxicity, mobility and volume of contaminants.	On-site workers may be exposed to contaminated soil through direct contact and/or ingestion. PPE may be used to prevent ingestion. An exclusion zone may be established to prevent exposure to local residents who may pass by project site. Dry, dusty conditions may create an inhalation hazard (unlikely in Yakutat); however, watering exposed surfaces may mitigate potential risk. This alternative may be completed in several weeks to months, depending on volume of soil to be excavated.	This alternative is technically and administratively feasible, and has been used effectively at other sites. Mobilization of equipment, excavation, and soil transportation requirements for this alternative are fairly common tasks in Alaska and may be successfully implemented with a high degree of certainty.	See Table 6.0-2

TABLE 6.0-1 - DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

Alternatives	Applicable COCs	Applicable Affected Media	Description of Alternative	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-Term Effectiveness	Implementability	Cost
Alternative 11 - Soil Washing	Metals	Surface Soil, Subsurface Soil < 15 feet bgs, and sediment	(a) Excavation of contaminated soil and particle size separation, gravity separation, attrition scrubbing and mineral jigging to remove lead particles at the Rifle Range. (b) Washing soil with water or chemical solution for sorbed metals removal. Use of decontaminated soil as backfill. Rinsate requires treatment and/or disposal.	Metals may be removed from soil either to acceptable levels or to background concentrations. Risk to receptors may be reduced.	ARARs may be achieved with this process.	The removal of contaminants from soil and sediment is a permanent solution.	With the removal of metals from the soil, the volume, toxicity, and mobility of contaminants is effectively reduced.	On-site workers may be exposed to contaminated soil through direct contact and/or ingestion. PPE may be used to prevent ingestion. An exclusion zone may be established to prevent exposure to local residents who may pass by project site. Dry, dusty conditions may create an inhalation hazard (unlikely in Yakutat); however, watering exposed surfaces may mitigate potential risk. This alternative requires the use of excavation equipment and transport trucks to move impacted soil on Yakutat roads and poses risks to workers, the community, and the environment during implementation. This alternative may be completed within 6 months, depending on the volume of soil.	This alternative is technically and administratively feasible, and has been used effectively at other sites. Mobilization of equipment, excavation, and soil transportation requirements for this alternative are fairly common tasks in Alaska and may be successfully implemented with a high degree of certainty.	See Table 6.0-2
Alternative 12 - Capping	GRO, DRO, VOCs, SVOCs, Metals, PCBs, and PCP	Surface and Subsurface Soil	Capping is an in-situ technology in which an impervious cover is engineered and placed over the contaminated area to prevent direct contact by potential receptors and to act as a barrier that prevents percolation of precipitation into contaminated soil.	Engineering controls limit access to COCs, and therefore, exposure. Risk through exposure is reduced.	ARARs are not achieved with this process.	Risk through exposure or ingestion of impacted soil is reduced.	COCs remain. With capping, reduction of toxicity or volume is limited. Mobility of COC is reduced.	This alternative poses a temporary increase of risk to workers, the community and the environment due to exposure to COCs during the construction of the cap. These risks may be mitigated using dust control measures and PPE. Capping does not reduce the concentrations of COCs. This alternative may be completed in several weeks to months.	This alternative has been used effectively at many sites. Equipment and personnel needed to implement this alternative are readily available.	See Table 6.0-2
Alternative 13 - Air Sparging/Soil Vapor Extraction	GRO, DRO, VOCs, and SVOCs	Groundwater	Air sparging is an in-situ technology in which air is injected into the water-bearing formation. Injected air induces volatilization of contaminants and also provides oxygen that promotes biodegradation. Nutrients and oil-degrading bacteria may also be introduced. An SVE system used in conjunction with air sparging extracts vapor and enhances air flow.	Physical removal of volatile constituents and biodegradation of heavy petroleum hydrocarbons. Used effectively, this alternative may reduce risk to acceptable levels.	ARARs may be achieved with this process.	Risk through exposure or ingestion of groundwater is permanently reduced, provided there is not a new or continuing source of contamination.	The effected bioremediation processes may reduce toxicity, mobility, and volume to acceptable, risk-based levels, eventually achieving degradation of contaminants.	This alternative poses additional risks to workers, the community, and the environment during the installation and decommissioning of air injection and SVE wells, monitoring wells and fencing and advancement of confirmation borings.	This alternative has been used effectively at many sites. Equipment and personnel needed to implement this alternative are readily available. A power source is needed for implementation.	See Table 6.0-3

KEY	DESCRIPTION
ADEC	Alaska Department of Environmental Conservation
AOC	Area of Concern
ARARs	Applicable or Relevant and Appropriate Requirement
AST	Above ground storage tank
COC	Chemicals of potential concern
IC	Institutional Controls
LTTD	Low-Temperature Thermal Desorption
MNA	Monitored Natural Attenuation
PCP	Pentachlorophenol
PPE	Personal Protective Equipment
PRG	Preliminary remediation goal
RCRA	Resource Conservation and Recovery Act criteria listed in 40 CFR 261.24, Table 1
SVE	Soil Vapor Extraction

TABLE 6.0-2 - ROUGH ORDER OF MAGNITUDE REMEDIAL ALTERNATIVE COST SUMMARY FOR SOIL AND SEDIMENT

Area Of Concern	Impacted Media	Chemicals Of Concern	Volume of Impacted Soil or Sediment (Cubic Yards)	Alternative 1 - No Action	Alternative 2 - Institutional Controls	Alternative 3 - Monitored Natural Attenuation (Soil)	Alternative 4 - In-Situ Fenton's Reagent Oxidation	Alternative 5 - In-Situ Soil Heating	Alternative 6 - Bioventing	Alternative 7 - Passive Bioventing	Alternative 8 - Biopiles	Alternative 9 - Excavation and On-Site Low-Temp Thermal Desorption	Alternative 10 - Excavation and Off-Site Disposal	Alternative 11 - Excavation and Soil Washing	Alternative 12 - Capping
Net Present Value of Total Mobilization/Demobilization Costs				$0	$0	$99,259.57	$128,367	$206,176	$144,651	$173,710	$18,189	$278,078	$161,466	$360,436	$5,520
		Cost per cubic yard to implement remedial alternative for:	20	$0	NA	$1,132	$2,472	$2,753	$13,605	$2,620	$3,815	$1,846	$2,220	$962	$70
			2000	$0	NA	$23	$214	$440	$229	$107	$428	$397	$1,002	$962	$70
			20000	$0	NA	$6	$104	$299	$36	$42	$279	$319	$947	$962	$70
C1	surface soil*	chromium	7	$0	$12,766								$16,238	$6,393	
C2	surface soil, subsurface soil (<15 ft)	diesel range organics	1,386	$0	$12,766	$53,442	$465,804	$879,719	$480,184	$250,542	$926,337	$798,195	$1,691,433		
C2	sediment	diesel range organics	80	$0	$12,766	$28,542					$162,731	$96,793	$141,588		
C2	surface soil*	silver	7	$0	$12,766								$16,238	$6,393	
C2	sediment**	diesel range organics, cadmium, mercury	27	$0	$12,766								$54,542		
C4	surface soil, subsurface soil (<15 ft)	diesel range organics	243	$0	$12,766	$36,435	$181,916	$273,974	$376,308	$127,050	$320,261	$220,060	$371,865		
C4	sediment**	diesel range organics	27	$0	$12,766	$22,424					$83,366	$42,999	$54,542		
C4	surface soil* (two hotspots)	chromium	13	$0	$12,766								$29,677	$12,787	
C6	surface soil, subsurface soil (<15 ft)	diesel range organics	12,709	$0	$12,766	$87,019	$1,541,420	$3,883,107	$654,861	$594,610	$3,579,791	$4,114,480	$11,629,961		
C7	surface soil*	arsenic, chromium	7	$0	$12,766								$16,238	$6,393	
D - AST1	subsurface soil (<15 ft)	diesel range organics	7,075	$0	$12,766	$76,497	$1,123,397	$2,622,507	$603,295	$473,160	$2,504,150	$2,667,121	$6,986,042		
	subsurface soil (>15 ft)	diesel range organics	20,581	$0	$12,766	$96,754	$1,999,688	$5,363,324	$700,577	$717,584					
D - AST1 (downslope)	subsurface soil (<15 ft)	diesel range organics	3,782	$0	$12,766	$66,652	$801,081	$1,723,875	$552,657	$370,633	$1,709,097	$1,678,011	$4,051,622		
	subsurface soil (>15 ft)	diesel range organics	473	$0	$12,766	$42,183	$260,620	$427,992	$413,070	$164,717					
D - AST2	surface soil	diesel range organics, benzene	27	$0	$12,766	$22,424	$55,263	$62,474	$276,307	$53,736	$83,366	$42,999	$54,542		
D - AST3	surface soil, subsurface soil (<15 ft)	diesel range organics, benzene	1,629	$0	$12,766	$55,380	$508,383	$980,568	$491,197	$266,880	$1,022,543	$899,843	$1,947,414		
D - AST4 (north)	subsurface soil (<15 ft), surface soil**	diesel range organics	1,929	$0	$12,766	$57,478	$556,963	$1,098,133	$502,958	$285,064	$1,133,587	$1,019,722	$2,255,875		
D - AST4 (south)	subsurface soil (<15 ft)**	diesel range organics	27	$0	$12,766	$22,424	$55,263	$62,474	$276,307	$53,736	$83,366	$42,999	$54,542		
D - AST5	surface soil, subsurface soil (<15 ft)	diesel range organics	2,791	$0	$12,766	$62,343	$679,875	$1,406,391	$529,644	$329,221	$1,419,984	$1,340,169	$3,110,580		
	subsurface soil (>15 ft)	diesel range organics	1,675	$0	$12,766	$55,716	$515,978	$998,775	$493,089	$269,754					
D - AST6	surface soil, subsurface soil (<15 ft)	diesel range organics	2,165	$0	$12,766	$58,951	$592,642	$1,186,075	$511,120	$298,138	$1,215,951	$1,110,286	$2,493,215		
	subsurface soil (>15 ft)	diesel range organics	216	$0	$12,766	$35,521	$170,920	$253,578	$370,274	$121,455					
D - AST7 (D2)	surface soil, subsurface soil (<15 ft)	diesel range organics	5,026	$0	$12,766	$70,955	$934,028	$2,085,654	$575,101	$414,100					
	subsurface soil (>15 ft)	diesel range organics, 2-methylnaphthalene	12,733	$0	$12,766	$87,055	$1,542,957	$3,887,910	$655,030	$595,038					
D - AST8	subsurface soil (<15 ft)	diesel range organics	2,521	$0	$12,766	$60,962	$643,505	$1,313,652	$522,148	$316,405	$1,334,476	$1,242,906	$2,846,899		
	subsurface soil (>15 ft)	diesel range organics	2,750	$0	$12,766	$62,140	$674,462	$1,392,511	$528,548	$327,326					
E1 - Drum Dump	surface soil, subsurface soil (<15 ft)	diesel range organics, chromium, arsenic	154	$0	$12,766								$249,891		
E1 - Drum Dump	surface soil* (two hotspots)	arsenic, chromium	13	$0	$12,766								$29,677	$12,787	
E1 - Drainage Ditch	sediment	diesel range organics, pentachlorophenol, arsenic, cadmium, chromium, and mercury	172	$0	$12,766								$275,521		
G4	sediment	diesel range organics, chrysene, phenanthrene, pyrene, arsenic, cadmium, chromium, and mercury	80	$0	$12,766								$141,260		
K1	surface soil	diesel range organics, pentachlorophenal, arsenic, cadmium, chromium, benzo(a)pyrene	6,998	$0	$12,766								$6,920,131		$489,744
K1	subsurface soil (two locations)	arsenic	13	$0	$12,766								$29,677	$12,787	
L1 - South Dump	surface soil, subsurface soil (<15 ft)**	gasoline range organics, benzene, toluene,	167	$0	$12,766	$33,559	$148,664	$213,276	$357,121	$109,815	$254,963	$166,882	$268,627		
L3 - Tank 1	surface soil**	benzo(a)pyrene	27	$0	$12,766	$22,424	$55,263	$62,474			$83,366	$42,999	$54,542		
L3 - Tank 3	surface soil**	benzo(a)pyrene	27	$0	$12,766	$22,424	$55,263	$62,474			$83,366	$42,999	$54,542		
L3 - Tank 7	surface soil**	benzo(a)pyrene	27	$0	$12,766	$22,424	$55,263	$62,474			$83,366	$42,999	$54,542		
L3 - Tank 8	surface soil	benzo(a)pyrene, benzo(a)anthracene	45	$0	$12,766	$25,109	$72,942	$88,159			$114,067	$62,900	$85,299		
L3 - Tank 11	surface soil**	benzo(a)pyrene	27	$0	$12,766	$22,424	$55,263	$62,474			$83,366	$42,999	$54,542		
L3 - Tank 14	surface soil**	benzene	27	$0	$12,766	$22,424	$55,263	$62,474			$83,366	$42,999	$54,542		
L4	surface soil	diesel range organics, benzo(a)pyrene	49	$0	$12,766	$25,567	$76,254	$93,153			$119,935	$66,847	$91,626		
M2	surface soil*	chromium	7	$0	$12,766	$16,506							$16,238	$6,393	
M2 (Tank)	subsurface soil (<15 ft)	diesel range organics	1,441	$0	$12,766	$53,907	$475,817	$903,243	$482,839	$254,420	$948,862	$821,801	$1,750,396		
M2 (Quonset Hut)	subsurface soil (<15 ft)	diesel range organics	97	$0	$12,766	$29,753	$110,635	$147,820	$330,787	$88,713	$182,611	$111,319	$166,885		
O1	surface soil*	arsenic	13	$0	$12,766								$29,677	$12,787	
Rifle Range	surface soil	lead	460	$0	$12,766								$648,437	$442,942	
		Total Cost of Alternative Including Mob/Demob	-	**$0**	**$574,470**	**$1,557,077**	**$14,593,157**	**$31,866,892**	**$10,828,075**	**$6,655,808**	**$17,634,467**	**$17,039,405**	**$48,960,577**	**$880,098**	**$495,264**
		Total Cubic Yards Treated by Alternative	**89,748**	**89,748**	**89,748**	**81,784**	**81,671**	**81,671**	**81,444**	**81,444**	**38,323**	**38,323**	**46,294**	**540**	**6,998**
		Cost per Cubic Yard Including Mob/Demob		**$0**	**$6**	**$19**	**$179**	**$391**	**$133**	**$82**	**$460**	**$445**	**$1,058**	**$1,630**	**$71**

KEY	DESCRIPTION
AST	Above Ground Storage Tank
NA	Not Applicable
*	Treated as "hotspot" with assumed diameter of 10 feet
**	Treated as "hotspot" with assumed diameter of 20 feet

NOTES:
1. Costs shown on this table are present value costs. (See Appendix C)
2. The cost per cubic yard to implement the remedial alternative assumes that the equipment and personnel are already at the site
3. Assumes that 1 mobilization/demobilization cost will be incurred to implement each remedial alternative and that subsequent mobilization/demobilization costs t perform O&M and Confirmation Sampling will be shared with other AOCs.
4. No costs are provided when remedial alternative is not applicable.
5. The estimates shown on this table should not be interpreted as exact areas or volumes. Table is linked to Table 3.1-2 and the numbers are not rounded for ease of use
6. The cost per cubic yard is estimated by dividing the Total Cost of Alternative Including Mob/Demob by the Total Cubic Yards Treated by Alternative

TABLE 6.0-3 - ROUGH ORDER OF MAGNITUDE REMEDIAL ALTERNATIVE COST SUMMARY FOR WATER

Area Of Concern	Impacted Media	Chemicals Of Concern	Area of Impacted Water (Square Feet)	Alternative 1 - No Action	Alternative 2 - Institutional Controls	Alternative 3 - Monitored Natural Attenuation (Groundwater)	Alternative 3 - Monitored Natural Attenuation (Surface Water)	Alternative 13 - Air Sparging - Soil Vapor Extraction
		Mobilization/Demobilization Costs		$0	$0	$49,034	$0	$0
C2	Surface Water	Polychlorinated Biphenyls, bis(2-ethylhexyl)phthalate, Lead	Uncertain	$0	$12,766		$32,655	
C6	Groundwater	Diesel Range Organics	40,000	$0	$12,766	$408,955		$1,395,317
D-AST7	Groundwater	Diesel Range Organics	16,000	$0	$12,766	$397,594		$1,352,104
G4	Surface Water	Barium	Uncertain	$0	$12,766		$32,655	
K1	Surface Water	Cadmium, Lead	Uncertain	$0	$12,766		$32,655	
L1	Groundwater	Gasoline Range Organics, benzene	630	$0	$12,766	$183,075		$266,639
O1	Surface Water	Lead	Uncertain	$0	$12,766		$32,655	
		Total	**56,630**	**$0**	**$89,362**	**$989,624**	**$130,619**	**$3,014,060**

KEY	DESCRIPTION
AST	Above Ground Storage Tank
NA	Not Applicable

NOTES:

1. Costs shown on this table are present value costs. (See Appendix C)
2. Assumes that 1 mobilization/demobilization cost will be incurred to implement Alternative 3 and that mobilization/demobilization costs to implement the other remedial alternatives and to perform O&M and Confirmation Sampling will be shared with other AOCs shown on Table 6.0-2.
3. No costs are provided when remedial alternative is not applicable.
4. The estimates of the aerial extent of the groundwater plumes shown on this table should not be interpreted as exact areas or volumes. Table is linked to Table 3.1-3 and the numbers are not rounded for ease of use.
5. Areal extent of impacted surface water is uncertain and cannot be estimated with available data.

TABLE 6.2-1 - COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR PETROLEUM COCS IN SURFACE SOIL (< 2 FEET BGS)

Alternatives	Applicable AOCs	Volume Impacted Soil (Cubic Yards)	Overall Protection of Human Health and the Environment	Compliance with ARARs~	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-Term Effectiveness*			Implementability	Cost**		Overall Score^
							(A)	(B)	(avg)				
Alternative 1 - No Action	D-AST2, L3-Tank 1, L3-Tank 3, L3-Tank 7, L3-Tank 8, L3-Tank 11, L3-Tank 14, and L4	254	8	8	8	8	2	8	5	1	1	$0	39
Alternative 2 - Institutional Controls			6	8	8	8	1	8	5	2	2	$102,128	39
Alternative 3 - Monitored Natural Attenuation			5	5	5	5	3	6	5	3	3	$185,220	31
Alternative 4 - In-Situ Fenton's Reagent Oxidation			3	3	3	2	6	3	5	8	5	$480,772	29
Alternative 5 - In-Situ Soil Heating			3	3	3	2	5	2	4	7	7	$556,158	29
Alternative 8 - Biopiles			2	2	2	3	7	4	6	6	8	$734,200	29
Alternative 9 - Excavation and On-Site Low Temperature Thermal Desorption			2	1	1	1	7	1	4	4	4	$387,741	17
Alternative 10 - Excavation and Off-Site Disposal			1	1	1	1	8	1	5	4	6	$504,179	19

Scoring criteria: The alternative (s) that best addresses the specific criterion is given the lowest score of 1 on a scale of 1 to 8. Alternatives are then incrementally scored higher in the order in which they address the criterion.

* Separate scores are given to each alternative based on (A) risk to workers, the community, and the environment during implementation and (B) time required to achieve ARARs. The average (avg) of the two scores for each alternative is added to the Overall Score.

** The rough order magnitude remedial alternative cost to treat the applicable AOCs listed is shown in gray for comparison purposes. The total cost for the alternative does not include mobilization and demobilization as these costs can be shared while implementing remedial alternatives at other AOCs.

~ For this FS, we assume that Alternatives 1 and 2 will not comply with ARARs.

^ Alternatives 1 and 2 do not comply with the ARARs, do not adequately protect human health and the environment, and are not considered a viable alternative by ADEC.

TABLE 6.2-2 - COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR PETROLEUM COCS IN SUBSURFACE SOIL (< 15 FEET BGS)

Alternatives	Applicable AOCs	Volume Impacted Soil (Cubic Yards)	Overall Protection of Human Health and the Environment	Compliance with ARARs~	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-Term Effectiveness*			Implementability	Cost**		Overall Score^
							(A)	(B)	(ave)				
Alternative 1 - No Action	C2, C4, C6, D-AST1, D-AST1 (downslope), D-AST3, D-AST4 (north), D-AST4 (south), D-AST5, D-AST6, D-AST7, D-AST8, L1-South Dump, M2 (tank) and M2 (quonset hut)	42,989	10	10	10	10	2	10	6	1	1	$0	48
Alternative 2 - Institutional Controls			9	10	10	10	1	10	6	2	2	$191,490	49
Alternative 3 - Monitored Natural Attenuation			8	8	8	8	3	8	6	3	3	$825,756	44
Alternative 4 - In-Situ Fenton's Reagent Oxidation			2	3	3	2	8	2	5	10	6	$8,819,394	31
Alternative 5 - In-Situ Soil Heating			2	3	3	2	7	2	5	9	9	$18,780,469	33
Alternative 6 - Bioventing			2	3	3	4	6	4	5	8	5	$7,246,529	30
Alternative 7 - Passive Bioventing			2	3	3	4	4	7	6	8	4	$4,232,487	30
Alternative 8 - Biopiles			1	2	2	3	10	3	7	7	8	$16,635,980	30
Alternative 9 - Excavation and On-Site Low Temperature Thermal Desorption			1	1	1	1	10	1	6	5	7	$16,233,794	22
Alternative 10 - Excavation and Off-Site Disposal			1	1	1	1	10	1	6	5	10	$39,625,358	25

Scoring criteria: The alternative (s) that best addresses the specific criterion is given the lowest score of 1 on a scale of 1 to 10. Alternatives are then incrementally scored higher in the order in which they address the criterion.

* Separate scores are given to each alternative based on (A) risk to workers, the community, and the environment during implementation and (B) time required to achieve ARARs. The average (ave) of the two scores for each alternative is added to the Overall Score.

** The rough order magnitude remedial alternative cost to treat the applicable AOCs listed is shown in gray for comparison purposes. The total cost for the alternative does not include mobilization and demobilization as these costs can be shared while implementing remedial alternatives at other AOCs.

~ For this FS, we assume that Alternatives 1 and 2 will not comply with ARARs.

^ Alternatives 1 and 2 do not comply with the ARARs, do not adequately protect human health and the environment, and are not considered a viable alternative by ADEC.

TABLE 6.2-3 - COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR PETROLEUM COCS IN SUBSURFACE SOIL (> 15 FEET BGS)

Alternatives	Applicable AOCs	Volume Impacted Soil (Cubic Yards)	Overall Protection of Human Health and the Environment	Compliance with ARARs~	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-Term Effectiveness*			Implementability	Cost**		Overall Score^
							(A)	(B)	(ave)				
Alternative 1 - No Action	D-AST1, D-AST1 (downslope), D-AST5, D-AST6, D-AST7 and D-AST8	38,428	7	7	7	7	2	7	5	1	1	$0	35
Alternative 2 - Institutional Controls			5	7	7	7	1	7	4	2	2	$76,596	34
Alternative 3 - Monitored Natural Attenuation			4	5	5	5	3	5	4	3	3	$379,369	29
Alternative 4 - In-Situ Fenton's Reagent Oxidation			1	1	1	1	7	1	4	7	6	$5,164,624	21
Alternative 5 - In-Situ Soil Heating			1	1	1	1	6	1	4	6	7	$12,324,090	21
Alternative 6 - Bioventing			1	2	2	2	5	2	4	5	5	$3,160,588	21
Alternative 7 - Passive Bioventing			3	4	4	4	4	4	4	4	4	$2,195,875	27

Scoring criteria: The alternative (s) that best addresses the specific criterion is given the lowest score of 1 on a scale of 1 to 7. Alternatives are then incrementally scored higher in the order in which they address the criterion.

* Separate scores are given to each alternative based on (A) risk to workers, the community, and the environment during implementation and (B) time required to achieve ARARs. The average (ave) of the two scores for each alternative is added to the Overall Score.

** The rough order magnitude remedial alternative cost to treat the applicable AOCs listed is shown in gray for comparison purposes. The total cost for the alternative does not include mobilization and demobilization as these costs can be shared while implementing remedial alternatives at other AOCs.

~ For this FS, we assume that Alternatives 1 and 2 will not comply with ARARs.

^ Alternatives 1 and 2 do not comply with the ARARs, do not adequately protect human health and the environment, and are not considered a viable alternative by ADEC.

TABLE 6.2-4 - COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR PETROLEUM COCS IN SEDIMENT

Alternatives	Applicable AOCs	Volume Impacted Soil (Cubic Yards)	Overall Protection of Human Health and the Environment	Compliance with ARARs~	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-Term Effectiveness*			Implementability	Cost**		Overall Score^
							(A)	(B)	(ave)				
Alternative 1 - No Action	C2 and C4	107	6	6	6	6	2	6	4	1	1	0	30
Alternative 2 - Institutional Controls			4	5	5	6	1	6	4	2	2	$25,532	28
Alternative 3 - Monitored Natural Attenuation			3	4	4	4	3	4	4	3	3	$50,966	25
Alternative 8 - Biopiles			1	2	2	2	6	2	4	5	6	$246,098	22
Alternative 9 - Excavation and On-Site Low Temperature Thermal Desorption			1	1	1	1	6	1	4	4	4	$139,793	16
Alternative 10 - Excavation and Off-Site Disposal			1	1	1	1	6	1	4	4	5	$183,660	17

Scoring criteria: The alternative (s) that best addresses the specific criterion is given the lowest score of 1 on a scale of 1 to 6. Alternatives are then incrementally scored higher in the order in which they address the criterion.

* Separate scores are given to each alternative based on (A) risk to workers, the community, and the environment during implementation and (B) time required to achieve ARARs. The average (ave) of the two scores for each alternative is added to the Overall Score.

** The rough order magnitude remedial alternative cost to treat the applicable AOCs listed is shown in gray for comparison purposes. The total cost for the alternative does not include mobilization and demobilization as these costs can be shared while implementing remedial alternatives at other AOCs.

~ For this FS, we assume that Alternatives 1 and 2 will not comply with ARARs.

^ Alternatives 1 and 2 do not comply with the ARARs, do not adequately protect human health and the environment, and are not considered a viable alternative by ADEC.

TABLE 6.2-5 - COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR METALS IN SOIL AND SEDIMENT

Alternatives	Applicable AOCs	Volume Impacted Soil (Cubic Yards)	Overall Protection of Human Health and the Environment	Compliance with ARARs~	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-Term Effectiveness*			Implementability	Cost**		Overall Score^
							(A)	(B)	(ave)				
Alternative 1 - No Action	C1, C2, C4, C7, E1 (drum dump), M2, and O1	80	4	4	4	4	2	4	3	1	1	$0	21
Alternative 2 - Institutional Controls			2	4	4	4	1	4	3	2	2	$102,128	21
Alternative 10 - Excavation and Off-Site Disposal			1	1	1	1	4	1	3	4	4	$183,660	15
Alternative 11 - Excavation and Soil Washing			1	1	1	1	3	1	2	3	3	$76,720	12

Scoring criteria: The alternative (s) that best addresses the specific criterion is given the lowest score of 1 on a scale of 1 to 4. Alternatives are then incrementally scored higher in the order in which they address the criterion.

* Separate scores are given to each alternative based on (A) risk to workers, the community, and the environment during implementation and (B) time required to achieve ARARs. The average (ave) of the two scores for each alternative is added to the Overall Score.

** The rough order magnitude remedial alternative cost to treat the applicable AOCs listed is shown in gray for comparison purposes. The total cost for the alternative does not include mobilization and demobilization as these costs can be shared while implementing remedial alternatives at other AOCs.

~ For this FS, we assume that Alternatives 1 and 2 will not comply with ARARs.

^ Alternatives 1 and 2 do not comply with the ARARs, do not adequately protect human health and the environment, and are not considered a viable alternative by ADEC.

TABLE 6.2-6 - COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR LEAD IN SOIL

Alternatives	Applicable AOCs	Volume Impacted Soil (Cubic Yards)	Overall Protection of Human Health and the Environment	Compliance with ARARs~	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-Term Effectiveness*			Implementability	Cost**		Overall Score^
							(A)	(B)	(ave)				
Alternative 1 - No Action	Rifle Range	460	4	4	4	4	2	4	3	1	1	$0	21
Alternative 2 - Institutional Controls			3	4	4	4	1	4	3	2	2	$12,766	22
Alternative 10 - Excavation and Off-Site Disposal			1	1	1	1	4	1	3	4	4	$648,437	15
Alternative 11 - Soil Washing			1	1	1	1	3	1	2	3	3	$442,942	12

Scoring criteria: The alternative (s) that best addresses the specific criterion is given the lowest score of 1 on a scale of 1 to 5. Alternatives are then incrementally scored higher in the order in which they address the criterion.

* Separate scores are given to each alternative based on (A) risk to workers, the community, and the environment during implementation and (B) time required to achieve ARARs. The average (ave) of the two scores for each alternative is added to the Overall Score.

** The rough order magnitude remedial alternative cost to treat the applicable AOC listed is shown in gray for comparison purposes. The total cost for the alternative does not include mobilization and demobilization as these costs can be shared while implementing remedial alternatives at other AOCs.

~ For this FS, we assume that Alternatives 1 and 2 will not comply with ARARs.

^ Alternatives 1 and 2 do not comply with the ARARs, do not adequately protect human health and the environment, and are not considered a viable alternative by ADEC.

TABLE 6.2-7 - COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR MULTIPLE COC TYPES IN SOIL AND SEDIMENT

Alternatives	Applicable AOCs	Volume Impacted Soil (Cubic Yards)	Overall Protection of Human Health and the Environment	Compliance with ARARs~	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-Term Effectiveness*			Implementability	Cost**		Overall Score^
							(A)	(B)	(ave)				
Alternative 1 - No Action	C2, E1 (drum dump), E1 (drainage ditch), and G4	433	3	3	3	3	2	3	3	1	1	$0	17
Alternative 2 - Institutional Controls			2	3	3	3	1	3	2	2	2	$51,064	17
Alternative 10 - Excavation and Off-Site Disposal			1	1	1	1	4	1	3	3	3	$721,215	13

Scoring criteria: The alternative (s) that best addresses the specific criterion is given the lowest score of 1 on a scale of 1 to 4. Alternatives are then incrementally scored higher in the order in which they address the criterion.

* Separate scores are given to each alternative based on (A) risk to workers, the community, and the environment during implementation and (B) time required to achieve ARARs. The average (ave) of the two scores for each alternative is added to the Overall Score.

** The rough order magnitude remedial alternative cost to treat the applicable AOCs listed is shown in gray for comparison purposes. The total cost for the alternative does not include mobilization and demobilization as these costs can be shared while implementing remedial alternatives at other AOCs.

~ For this FS, we assume that Alternatives 1 and 2 will not comply with ARARs.

^ Alternatives 1 and 2 do not comply with the ARARs, do not adequately protect human health and the environment, and are not considered a viable alternative by ADEC.

TABLE 6.2-8 - COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR MULTIPLE COC TYPES IN LANDFILL COVER MATERIAL

Alternatives	Applicable AOCs	Volume Impacted Soil (Cubic Yards)	Overall Protection of Human Health and the Environment	Compliance with ARARs~	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-Term Effectiveness*			Implementability	Cost**		Overall Score^
							(A)	(B)	(ave)				
Alternative 1 - No Action	K1	6,998	4	4	4	4	2	4	3	1	1	$0	21
Alternative 2 - Institutional Controls			3	4	4	4	1	4	3	2	2	$12,766	22
Alternative 10 - Excavation and Off-Site Disposal			1	1	1	1	4	1	3	4	4	$6,920,131	15
Alternative 12 - Capping			2	4	2	2	3	4	4	3	3	$489,744	20

Scoring criteria: The alternative (s) that best addresses the specific criterion is given the lowest score of 1 on a scale of 1 to 4. Alternatives are then incrementally scored higher in the order in which they address the criterion.

* Separate scores are given to each alternative based on (A) risk to workers, the community, and the environment during implementation and (B) time required to achieve ARARs. The average (ave) of the two scores for each alternative is added to the Overall Score.

** The rough order magnitude remedial alternative cost to treat the applicable AOC listed is shown in gray for comparison purposes. The total cost for the alternative does not include mobilization and demobilization as these costs can be shared while implementing remedial alternatives at other AOCs.

~ For this FS, we assume that Alternatives 1 and 2 will not comply with ARARs.

^ Alternatives 1 and 2 do not comply with the ARARs, do not adequately protect human health and the environment, and are not considered a viable alternative by ADEC.

TABLE 6.2-9 - COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR COCS IN SURFACE WATER

Alternatives	Applicable AOCs	Area of Impacted Surface Water (Square Feet)	Overall Protection of Human Health and the Environment	Compliance with ARARs~	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-Term Effectiveness*			Implementability	Cost**		Overall Score^
							(A)	(B)	(ave)				
Alternative 1 - No Action	C1, C2, G4, K1, and O1	Uncertain	3	3	3	3	2	3	3	1	1	$0	17
Alternative 2 - Institutional Controls			2	3	3	3	1	3	2	2	2	$51,064	17
Alternative 3 - Monitored Natural Attenuation			1	1	1	1	1	1	1	3	3	$130,619	11

Scoring criteria: The alternative (s) that best addresses the specific criterion is given the lowest score of 1 on a scale of 1 to 3. Alternatives are then incrementally scored higher in the order in which they address the criterion.

* Separate scores are given to each alternative based on (A) risk to workers, the community, and the environment during implementation and (B) time required to achieve ARARs. The average (ave) of the two scores for each alternative is added to the Overall Score.

** The rough order magnitude remedial alternative cost to treat the applicable AOCs listed is shown in gray for comparison purposes. The total cost for the alternative does not include mobilization and demobilization as these costs can be shared while implementing remedial alternatives at other AOCs. The cost for Alternative 3 was based on monitoring an impacted surface water sample location.

~ For this FS, we assume that Alternatives 1 and 2 will not comply with ARARs.

^ Alternatives 1 and 2 do not comply with the ARARs, do not adequately protect human health and the environment, and are not considered a viable alternative by ADEC.

TABLE 6.2-10 - COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR PETROLEUM COCS IN GROUNDWATER

Alternatives	Applicable AOCs	Area of Impacted Ground Water (Square Feet)	Overall Protection of Human Health and the Environment	Compliance with ARARs~	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-Term Effectiveness*			Implementability	Cost**		Overall Score^
							(A)	(B)	(ave)				
Alternative 1 - No Action	C6, D-AST7, and L1-South Drum Dump	56,630	4	4	4	4	2	4	3	1	1	$0	21
Alternative 2 - Institutional Controls			3	4	3	4	1	4	3	2	2	$38,298	21
Alternative 3 - Monitored Natural Attenuation			2	2	2	2	3	3	3	3	3	$842,523	17
Alternative 13 - Air Sparging/Soil Vapor Extraction			1	1	1	1	4	1	3	4	4	$3,014,060	15

Scoring criteria: The alternative (s) that best addresses the specific criterion is given the lowest score of 1 on a scale of 1 to 4. Alternatives are then incrementally scored higher in the order in which they address the criterion.

* Separate scores are given to each alternative based on (A) risk to workers, the community, and the environment during implementation and (B) time required to achieve ARARs. The average (ave) of the two scores for each alternative is added to the Overall Score.

** The rough order magnitude remedial alternative cost to treat the applicable AOCs listed is shown in gray for comparison purposes. The total cost for the alternative does not include mobilization and demobilization as these costs can be shared while implementing remedial alternatives at other AOCs.

~ For this FS, we assume that Alternatives 1 and 2 will not comply with ARARs.

^ Alternatives 1 and 2 do not comply with the ARARs, do not adequately protect human health and the environment, and are not considered a viable alternative by ADEC.

TABLE 6.3-1 - SITE-SPECIFIC CONSIDERATIONS

Area of Concern	Description of AOC	Chemical of Concern	Affected Media	Areal Extent of Impact (Square Feet)	Feasible Remedial Alternatives	Site Specific Consideration												
						Retest soil for Hexavalent Chromium	Retest for COCs	Surface and/or Buried Debris	Wetlands	US Waters	Rough Terrain	Heavy Vegetation	Existing Structures Over Contamination	Difficult Drilling	Underground Utilities	Groundwater Use Determination	Drinking Water Capture Zone Study	Potential Confining Layer
C1	Point Carrew - Ankau Bridge Garbage/Drum Dump	chromium	SS	78	1, 2, 10, 11	X						X						
C1	Point Carrew - Ankau Bridge Garbage/Drum Dump	dioxins	SW	Uncertain	1, 2, 3		X					X						
C2	Point Carrew - Garrison Area Drum Dump	diesel range organics	SS, S (<15 ft)	10,845	1 through 10			X	X	X								
C2	Point Carrew - Garrison Area Drum Dump	diesel range organics	Sd	470	1, 2, 3, 8, 9, 10			X	X	X								
C2	Point Carrew - Garrison Area Drum Dump	silver	SS	78	1, 2, 10, 11			X	X	X								
C2	Point Carrew - Garrison Area Drum Dump	diesel range organics, cadmium, mercury	Sd	314	1, 2, 10			X	X	X								
C2	Point Carrew - Garrison Area Drum Dump	PCBs, bis(2-ethylhexyl)phthalate, lead	SW	Uncertain	1, 2, 3		X											
C4	Point Carrew - Garrison Area Surface Debris	diesel range organics	SS, S (<15 ft)	1,426	1 through 10			X	X									
C4	Point Carrew - Garrison Area Surface Debris	diesel range organics	Sd	314	1, 2, 3, 8, 9, 10			X	X									
C4	Point Carrew - Garrison Area Surface Debris	chromium	SS	156	1, 2, 10, 11	X			X									
C6	Point Carrew - 50,000-Gallon Fuel Tank	diesel range organics	SS, S (<15 ft)	19,893	1 through 10				X		X	X						
C6	Point Carrew - 50,000-Gallon Fuel Tank	diesel range organics	GW	40,000	1, 2, 3, 13				X		X	X						
C7	Point Carrew - Powerhouse No. 1093	arsenic, chromium	SS	78	1, 2, 10, 11	X			X									
D-AST1	Army Dock Area - Former AST No. 1	diesel range organics	S (< 15 ft)	15,100	1 through 10								X	X	X	X		
D-AST1	Army Dock Area - Former AST No. 1	diesel range organics	S (> 15 ft)	15,100	1 through 7								X	X	X	X		
D-AST1 (downslope)	Army Dock Area - Former AST No. 1	diesel range organics	S (< 15 ft)	11,100	1 through 10			X						X	X	X		
D-AST1 (downslope)	Army Dock Area - Former AST No. 1	diesel range organics	S (> 15 ft)	11,100	1 through 7			X						X	X	X		
D-AST2	Army Dock Area - Former AST No. 2	diesel range organics, benzene	SS	314	1, 2, 3, 4, 5, 8, 9, 10			X							X	X		
D-AST3	Army Dock Area - Former AST No. 3	diesel range organics, benzene	SS, S (<15 ft)	3,188	1 through 10			X			X	X		X	X	X		
D-AST4 (north)	Army Dock Area - Former AST No. 4	diesel range organics	SS, S (<15 ft)	3,775	1 through 10			X			X	X		X	X	X		
D-AST4 (south)	Army Dock Area - Former AST No. 4	diesel range organics	S (< 15 ft)	314	1 through 10			X			X	X		X	X	X		
D-AST5	Army Dock Area - Former AST No. 5	diesel range organics	SS, S (<15 ft)	4,369	1 through 10			X			X	X		X	X	X		
D-AST5	Army Dock Area - Former AST No. 5	diesel range organics	S (>15 ft)	4,369	1 through 7			X			X	X		X	X	X		
D-AST6	Army Dock Area - Former AST No. 6	diesel range organics	SS, S (<15 ft)	3,388	1 through 10			X			X	X		X	X	X		
D-AST6	Army Dock Area - Former AST No. 6	diesel range organics	S (>15 ft)	3,388	1 through 7			X			X	X		X	X	X		
D-AST7	Army Dock Area - Former AST No. 7	diesel range organics	SS, S (< 15 ft)	7,867	1 through 10			X			X	X		X	X	X		
D-AST7	Army Dock Area - Former AST No. 7	diesel range organics, 2- methylnaphthalene	S (> 15 ft)	7,867	1 through 7			X			X	X		X	X	X		
D-AST7	Army Dock Area - Former AST No. 7	diesel range organics	GW	16,000	1, 2, 3, 13			X			X	X		X	X	X	X	X
D-AST8	Army Dock Area - Former AST No. 8	diesel range organics	S (<15 ft)	5,381	1 through 10			X			X		X	X	X			
D-AST8	Army Dock Area - Former AST No. 8	diesel range organics	S (>15 ft)	5,381	1 through 7			X			X		X	X	X			
E1	Northwest Drum Dump/Quartermaster Loop Area	diesel range organics, arsenic, chromium	SS, S (<15 ft)	903	1, 2, 10	X		X	X	X	X	X						
E1	Northwest Drum Dump/Quartermaster Loop Area	arsenic, chromium	SS	156	1, 2, 10, 11	X		X	X	X	X	X						
E1	Drainage Ditch/Quartermaster Loop Area	diesel range organics, pentachlorophenol, arsenic, cadmium, chromium, mercury	Sd	1,347	1, 2, 10	X		X	X	X	X	X						
G4	Seaplane Base - Seaplane Slough	diesel range organics, chrysene, phenanthrene, pyrene, arsenic, cadmium, chromium, mercury	Sd	625	1, 2, 10	X			X	X								
G4	Seaplane Base - Seaplane Slough	barium	SW	Uncertain	1, 2, 3				X	X								

TABLE 6.3-1 - SITE-SPECIFIC CONSIDERATIONS

Area of Concern	Description of AOC	Chemical of Concern	Affected Media	Areal Extent of Impact (Square Feet)	Feasible Remedial Alternatives	Site Specific Consideration												
						Retest soil for Hexavalent Chromium	Retest for COCs	Surface and/or Buried Debris	Wetlands	US Waters	Rough Terrain	Heavy Vegetation	Existing Structures Over Contamination	Difficult Drilling	Underground Utilities	Groundwater Use Determination	Drinking Water Capture Zone Study	Potential Confining Layer
K1	Solid Waste Disposal Dump No. 4 Area	arsenic	S (2-4 ft)	156	1, 2, 10, 12			X	X			X						
K1	Solid Waste Disposal Dump No. 4 Area	diesel range organics, pentachlorophenol, arsenic, cadmium, chromium, benzo(a)pyrene	SS	82,150	1, 2, 10, 12	X		X	X			X						
K1	Solid Waste Disposal Dump No. 4 Area	arsenic, cadmium, lead	SW	Uncertain	1, 2, 3				X			X						
L1	Air Corps Operations Reserve Tank Farm - South Drum Dump	gasoline range organics, benzene, toluene	SS, S (<15 ft)	314	1 through 10			X				X						
L1	Air Corps Operations Reserve Tank Farm - South Drum Dump	gasoline range organics, benzene	GW	630	1, 2, 3, 13			X				X						
L3	Air Corps Operations Reserve Tank Farm - Tank Foundations (Tank 1)	benzo(a)pyrene	SS	314	1, 2, 3, 4, 5, 8, 9, 10			X										
L3	Air Corps Operations Reserve Tank Farm - Tank Foundations (Tank 3)	benzo(a)pyrene	SS	314	1, 2, 3, 4, 5, 8, 9, 10			X										
L3	Air Corps Operations Reserve Tank Farm - Tank Foundations (Tank 7)	benzo(a)pyrene	SS	314	1, 2, 3, 4, 5, 8, 9, 10			X										
L3	Air Corps Operations Reserve Tank Farm - Tank Foundations (Tank 8)	benzo(a)pyrene, benzo(a)anthracene	SS	525	1, 2, 3, 4, 5, 8, 9, 10			X										
L3	Air Corps Operations Reserve Tank Farm - Tank Foundations (Tank 11)	benzo(a)pyrene	SS	314	1, 2, 3, 4, 5, 8, 9, 10			X										
L3	Air Corps Operations Reserve Tank Farm - Tank Foundations (Tank 14)	benzene	SS	314	1, 2, 3, 4, 5, 8, 9, 10			X										
L4	Air Corps Operations Reserve Tank Farm - Truck Fill Stand No. 4	diesel range organics, benzo(a)pyrene	SS	570	1, 2, 3, 4, 5, 8, 9, 10			X										
M2	Post Powerhouse - Fuel/water Separator	chromium	SS	78	1, 2, 10, 11	X		X										
M2 (Tank)	Post Powerhouse - Fuel/water Separator	diesel range organics	S (<15 ft)	16,921	1 through 10			X				X	X		X			
M2 (Quonset Hut)	Post Powerhouse - Fuel/water Separator	diesel range organics	S (<15 ft)	1,514	1 through 10			X				X	X		X			
O1	Air Corps Warehouse Group No. 2 - Suspected Drum Dump	arsenic	SS	156	1, 2, 10, 11													
O1	Air Corps Warehouse Group No. 2 - Suspected Drum Dump	lead	SW	Uncertain	1, 2, 3		X											
RR	Rifle Range - Target Pits	lead	SS	5,404	1, 2, 10, 11			X				X	X					

KEY	DESCRIPTION
AOC	Area of Concern
AST	Above ground storage tank
COC	Contaminants of Concern
DRO	Diesel range organics
GRO	Gasoline range organics
GW	Groundwater
PCBs	Polychlorinated Biphenyls
S	Subsurface Soil
Sd	Sediment
SS	Surface Soil
SVOCs	Semi-volatile organic compounds
SW	Surface Water
VOCs	Volatile organic compounds

KEY	DESCRIPTION
1	Alternative 1 - No Action
2	Alternative 2 - Institutional Controls
3	Alternative 3 - Monitored Natural Attenuation
4	Alternative 4 - In-Situ Fenton's Reagent Oxidation
5	Alternative 5 - In-Situ Soil Heating
6	Alternative 6 - Bioventing
7	Alternative 7 - Passive Bioventing
8	Alternative 8 - Biopiles
9	Alternative 9 - Excavation and On-Site Low Temperature Thermal Desorption
10	Alternative 10 - Excavation and Off-Site Disposal
11	Alternative 11 - Soil Washing
12	Alternative 12 - Capping
13	Alternative 13 - Air Sparging/Soil Vapor Extraction

7.0 CLOSURE/LIMITATIONS

This report was prepared for the exclusive use of our client and their representatives in the study of this site. The findings we have presented within this Feasibility Study are based on results of previous investigations presented in reports provided by the USACE, as well as results of investigations conducted by Shannon & Wilson in 2004 and 2005. There were numerous AOCs where further investigation was recommended by investigators and was not, subsequently done; therefore, assumptions made for this FS are, in some cases, based on incomplete information. In addition, changes in government codes, regulations, or laws may occur. Because of such changes beyond our control, our observations and interpretations may need to be revised.

Copies of documents that may be relied upon by our client are limited to the printed copies (also known as hard copies) that are signed or sealed by Shannon & Wilson with a wet, blue ink signature. Files provided in electronic media format are furnished solely for the convenience of the client. Any conclusion or information obtained or derived from such electronic files shall be at the user's sole risk. If there is a discrepancy between the electronic files and hard copies, or you question the authenticity of the report, please contact the undersigned.

You are advised that various state and federal agencies (ADEC, EPA, etc.) may require the reporting of this information. Shannon & Wilson does not assume the responsibility for reporting these findings and therefore has not, and would not, disclose the results of this study, unless specifically requested and authorized to do so or as required by law.

Please call the undersigned or Matt Hemry at (907) 562-2120 with questions or comments concerning this report.

Sincerely,

SHANNON & WILSON, INC.

Prepared by:

Timothy M. Terry, CPG
Associate

Reviewed by:

Matthew S. Hemry, PE
Vice President

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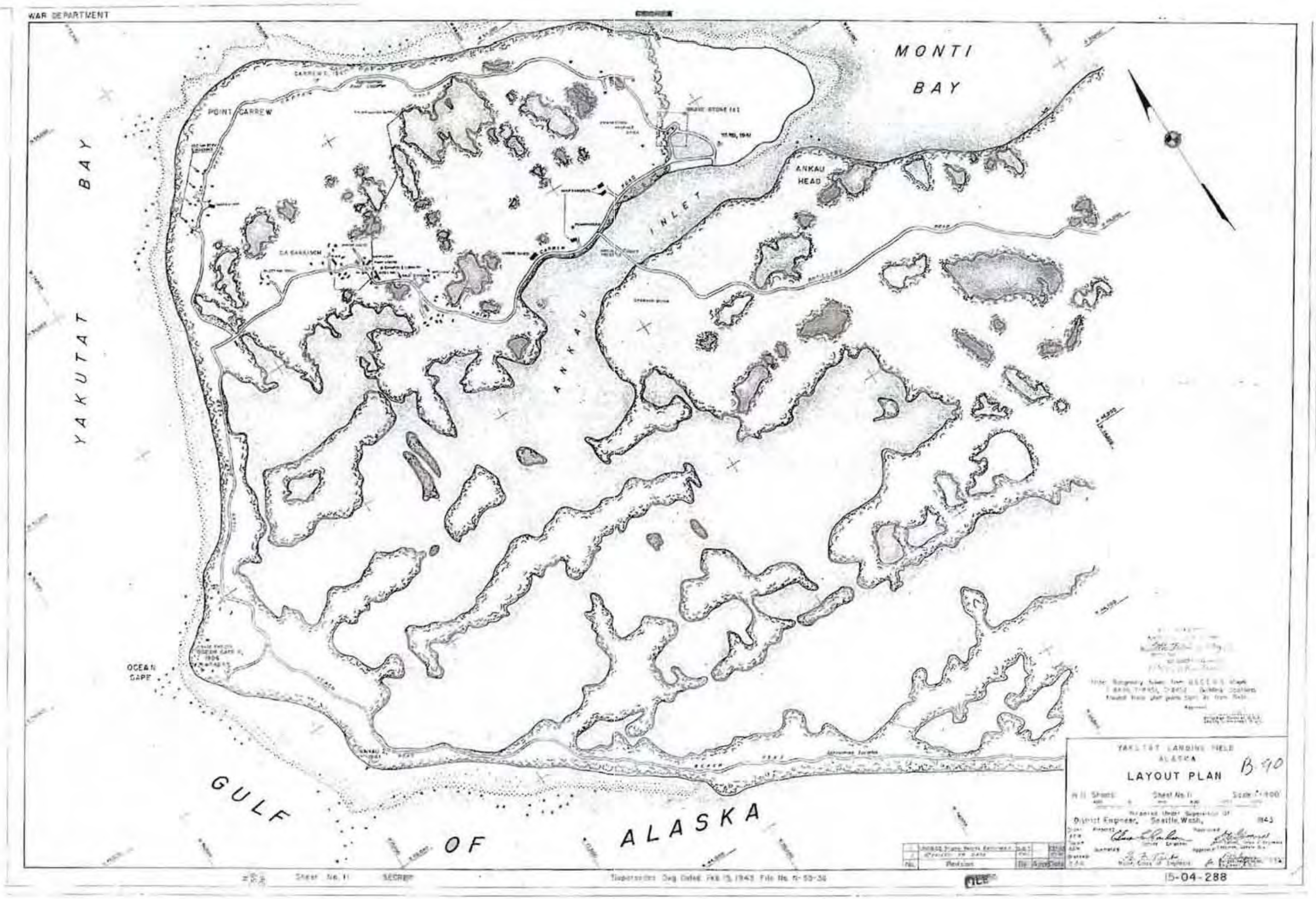
APPENDIX A

HISTORICAL MAPS

Appendix A – Table of Contents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1943
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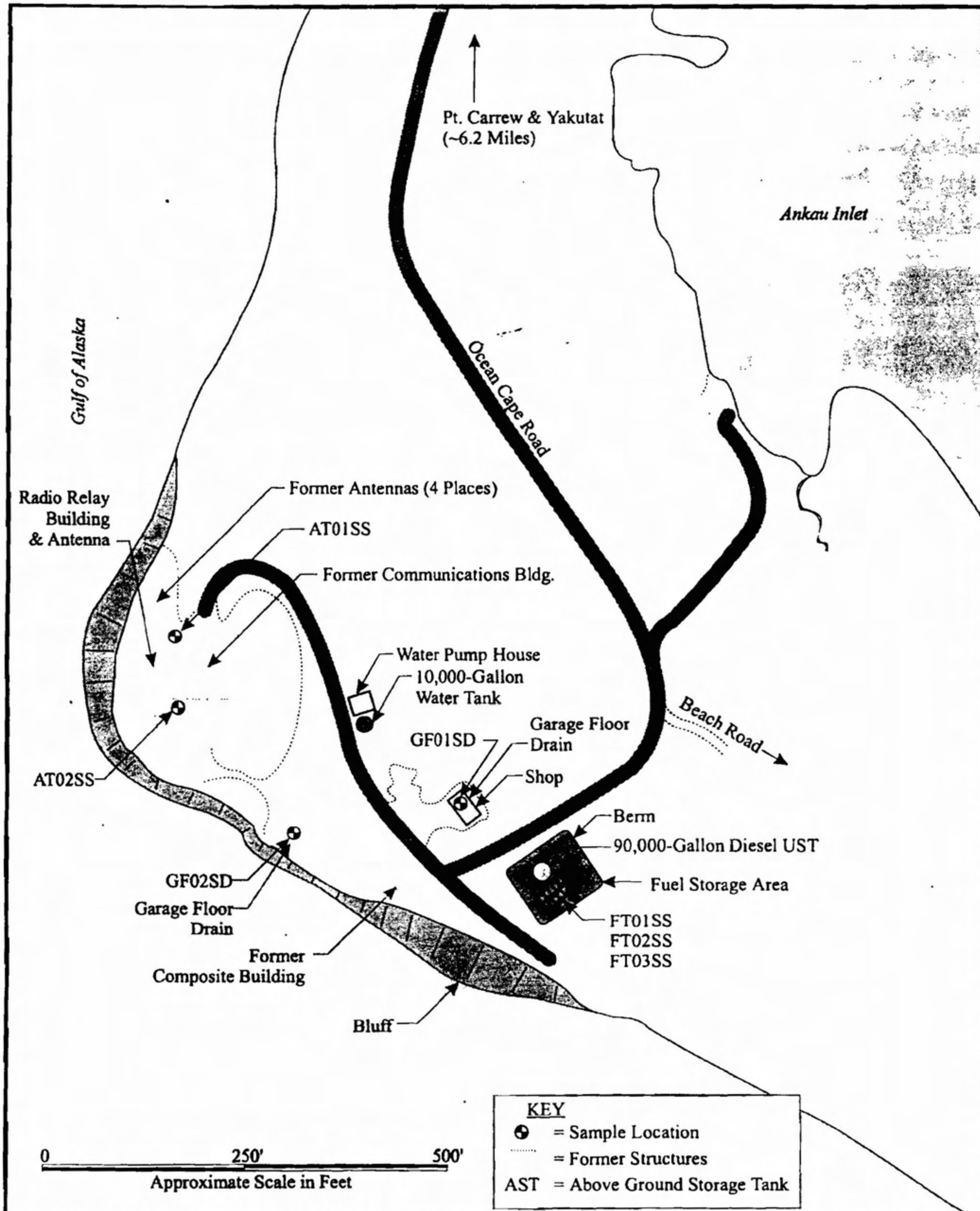

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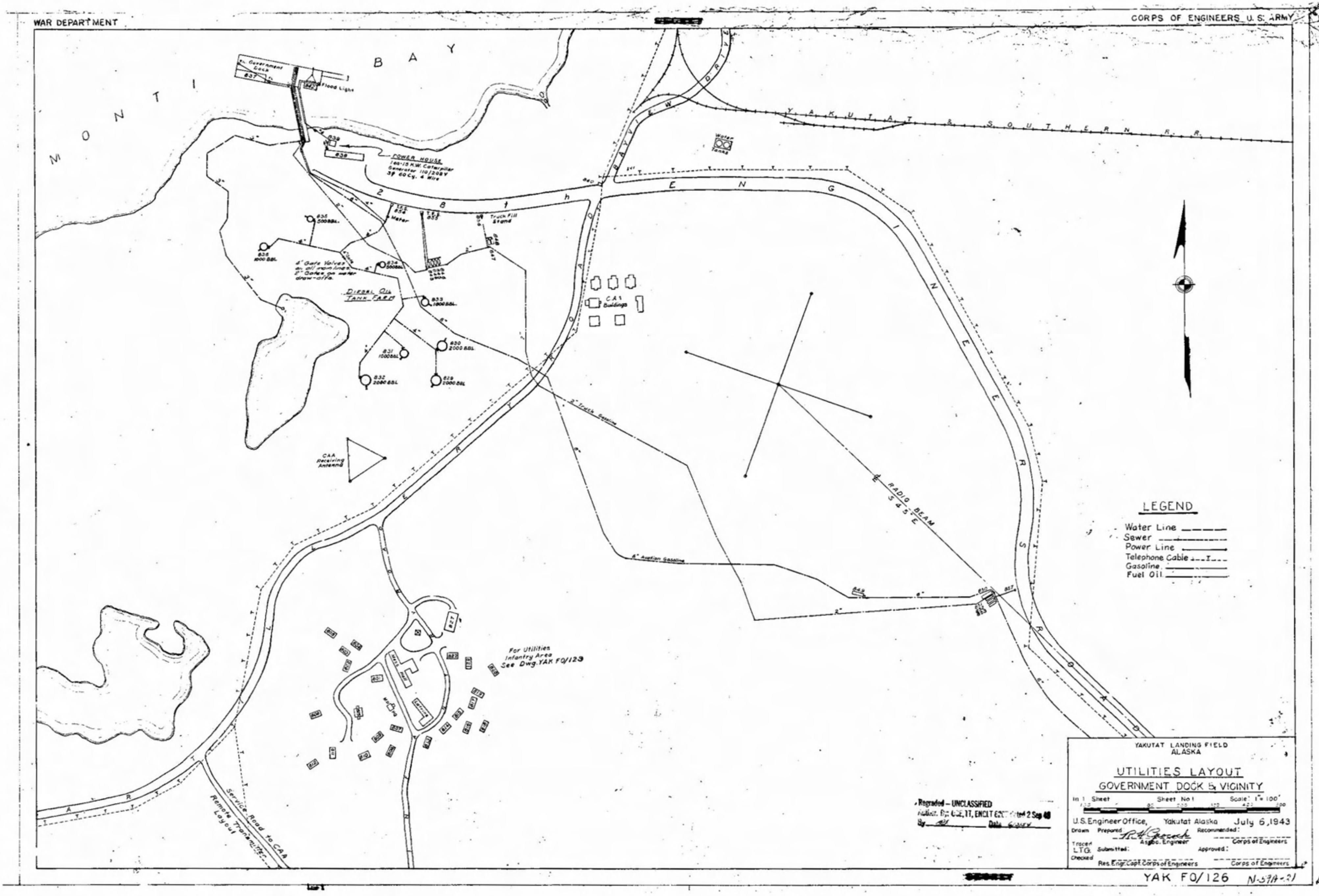
Yakutat, Alaska

Figure 5-6
OCEAN CAPE RADIO RELAY SITE
SAMPLE LOCATION MAP

Drawn:	DATE:	JOB NO.	Dwg.No.
MRE	12/4/97	BB1501SITO	BB1501F4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CORPS OF ENGINEERS U.S. ARMY
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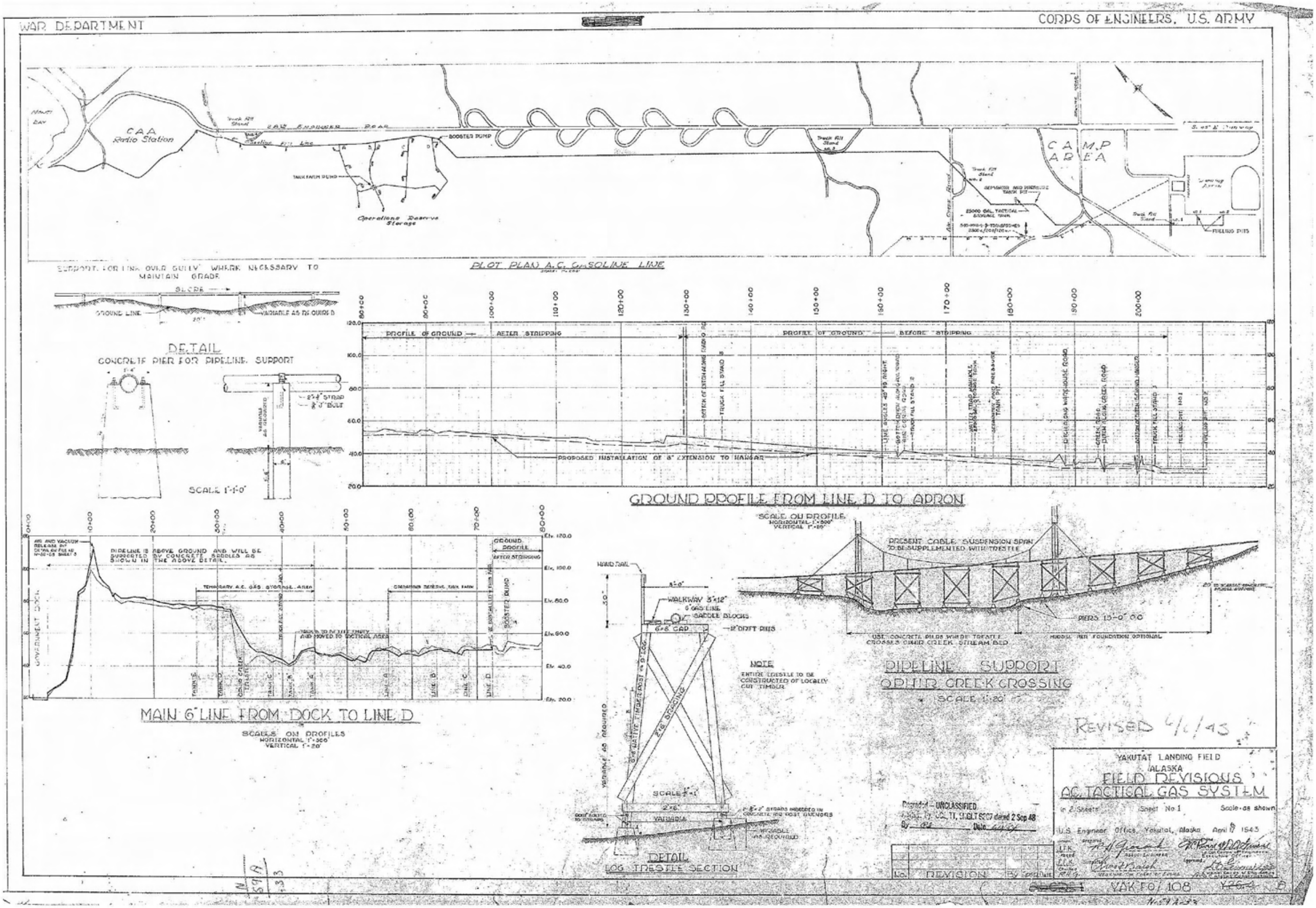
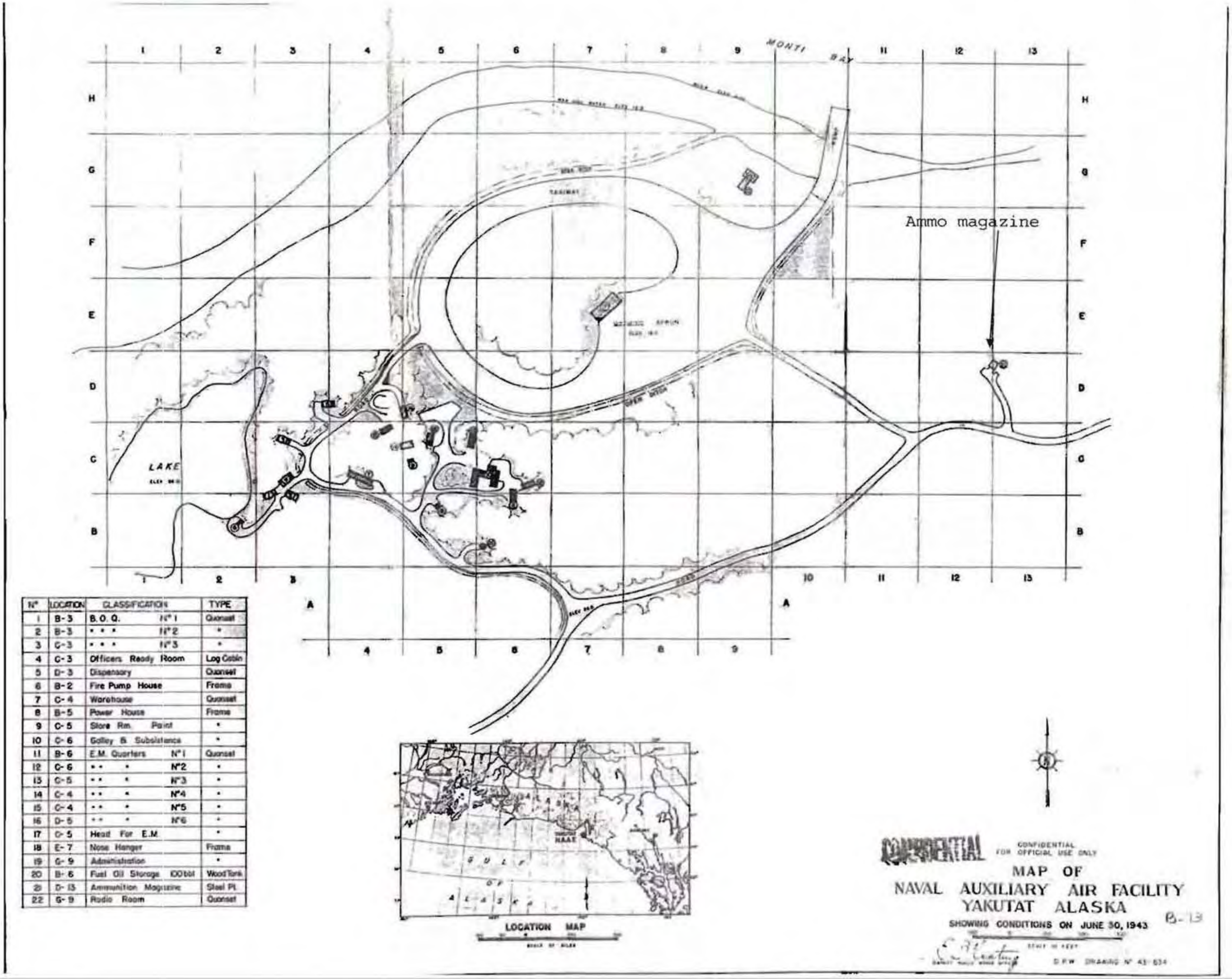
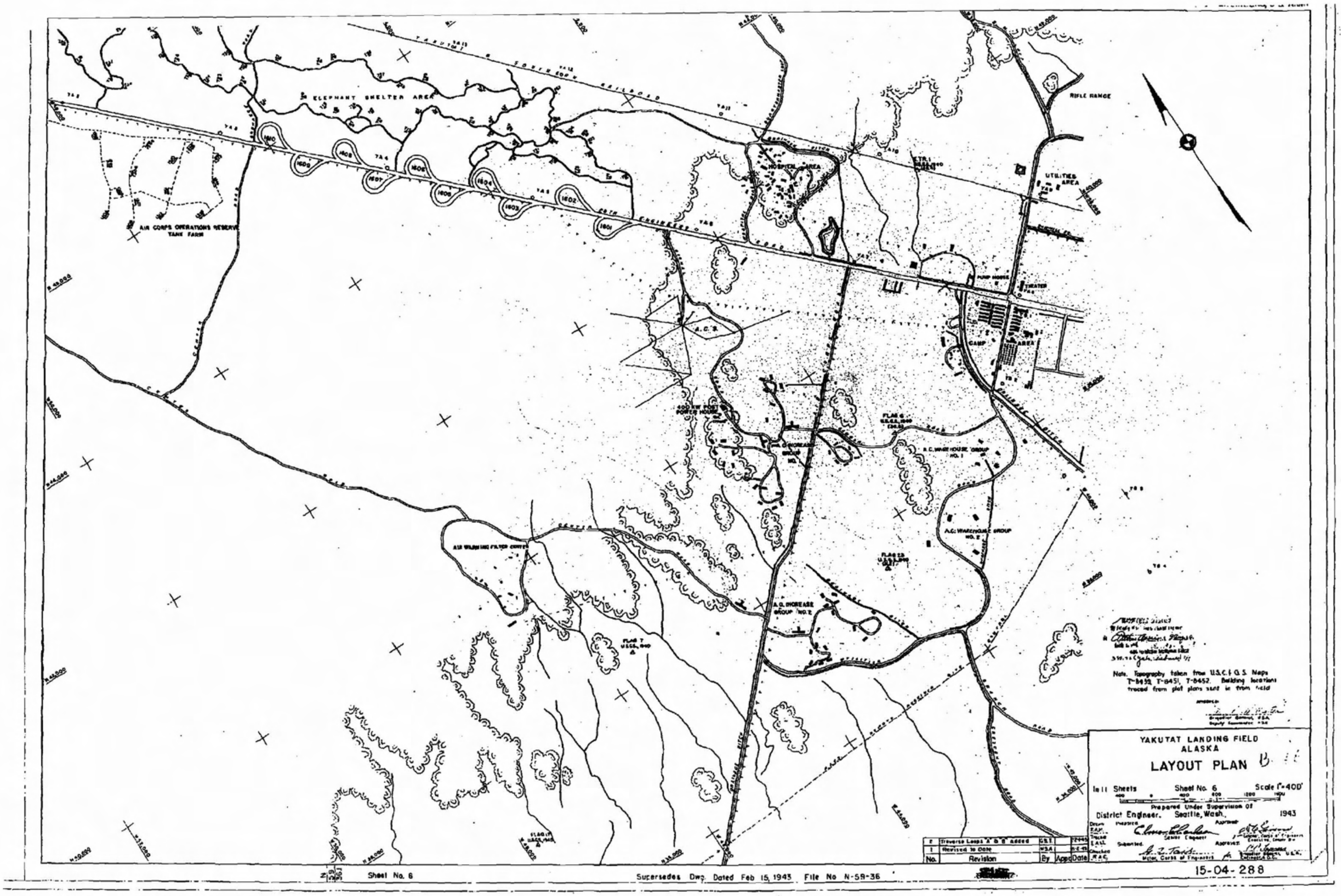
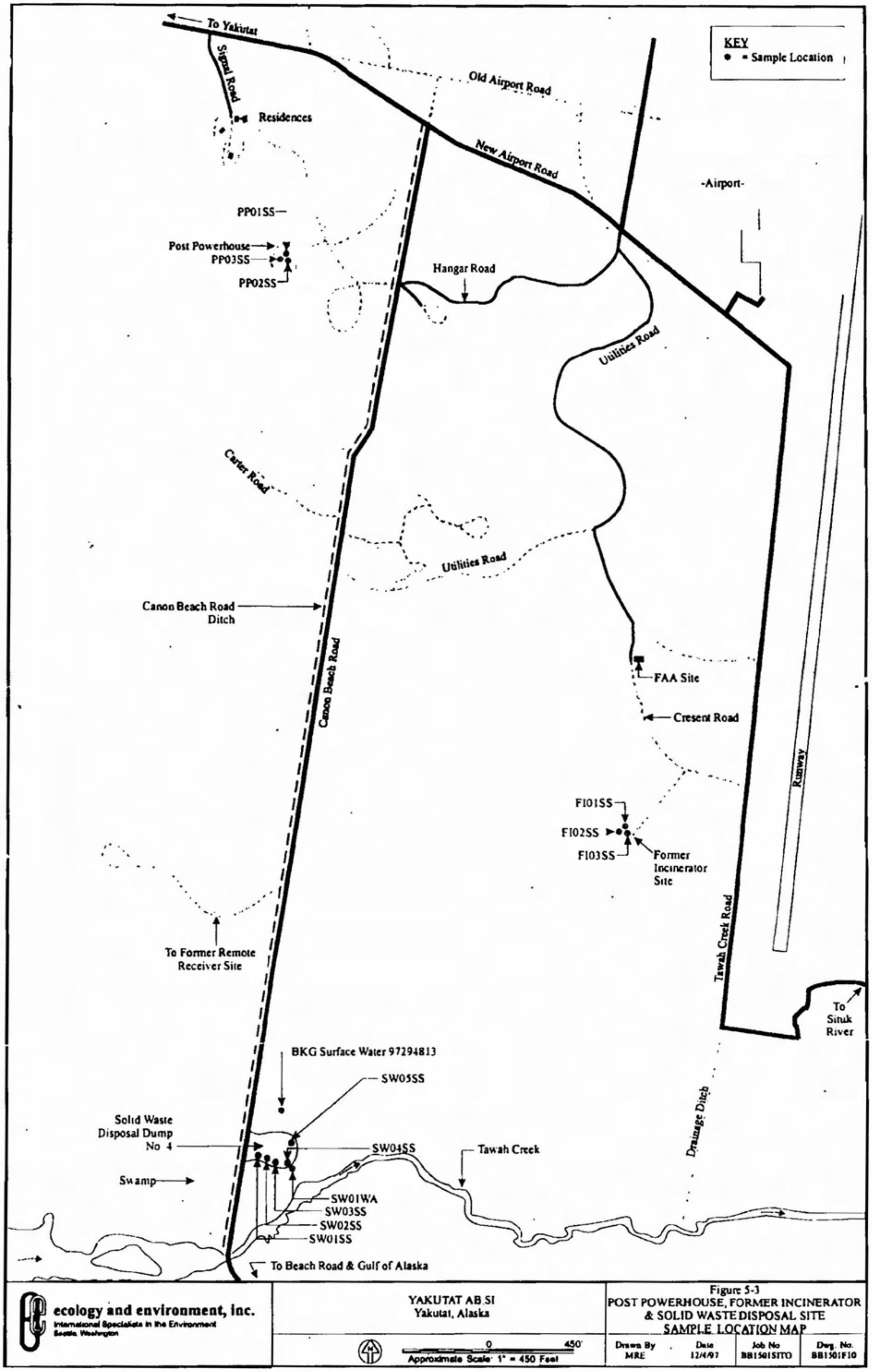
Government Dock
Flood Light
POWER HOUSE
Diesel Oil Tank Farm
C.A.A. Buildings
Water Tanks
Y A K U T A T & S O U T H E R N R. R.
E N G I N E E R S R O A D
BAYVIEW DRIVE
2 8 t h
CAA Receiving Antenna
RADIO BEAM S 45 E
For Utilities Infantry Area See Dwg. YAK FO/123
Service Road to CAA Remote Transmitter Layout
LEGEND
Water Line
Sewer
Power Line
Telephone Cable
Gasoline
Fuel Oil
Regraded – UNCLASSIFIED
YAKUTAT LANDING FIELD
ALASKA
UTILITIES LAYOUT
GOVERNMENT DOCK & VICINITY
In 1 Sheet
Sheet No 1
Scale: 1" = 100'
U.S. Engineer Office, Yakutat Alaska July 6, 1943
Drawn
Prepared
Assoc. Engineer
Recommended:
Corps of Engineers
Traced L.T.G.
Submitted:
Approved:
Checked
Res. Engr. Capt. Corps of Engineers
Corps of Engineers
YAK FO/126


WAR DEPARTMENT
CORPS OF ENGINEERS, U.S. ARMY
CAA Radio Station
BOOSTER PUMP
CAMP AREA
FILLING PITS
Operations Reserve Storage
PLOT PLAN A.C. GASOLINE LINE
SUPPORT FOR LINE OVER GULLY WHERE NECESSARY TO MAINTAIN GRADE
SLOPE
GROUND LINE
VARIABLE AS REQUIRED
DETAIL
CONCRETE PIER FOR PIPELINE SUPPORT
SCALE 1"-1'-0"
PROFILE OF GROUND — AFTER STRIPPING
PROFILE OF GROUND — BEFORE STRIPPING
PROPOSED INSTALLATION OF 8" EXTENSION TO HANGAR
GROUND PROFILE FROM LINE D TO APRON
SCALE ON PROFILE
HORIZONTAL 1"-300'
VERTICAL 1"-20'
PIPELINE IS ABOVE GROUND AND WILL BE SUPPORTED BY CONCRETE SADDLES AS SHOWN IN THE ABOVE DETAIL.
TEMPORARY A.C. GAS STORAGE AREA
OPERATIONS RESERVE TANK FARM
GROUND PROFILE
AFTER STRIPPING
BOOSTER PUMP
GOVERNMENT DOCK
MAIN 6" LINE FROM DOCK TO LINE D
SCALES ON PROFILES
HORIZONTAL 1"-300'
VERTICAL 1"-20'
HAND RAIL
WALKWAY 3"x12"
6" GAS LINE
SADDLE BLOCKS
6x8 CAP
12" DRIFT PINS
NOTE
ENTIRE TRESTLE TO BE CONSTRUCTED OF LOCALLY CUT TIMBER.
VARIABLE AS REQUIRED
SCALE 1"-1'
DETAIL
LOG TRESTLE SECTION
PRESENT CABLE SUSPENSION SPAN TO BE SUPPLEMENTED WITH TRESTLE
PIERS 15'-0" O.C.
USE CONCRETE PILES WHERE TRESTLE CROSSES OPHIR CREEK STREAM BED
PIPELINE SUPPORT
OPHIR CREEK CROSSING
SCALE 1"-20'
Revised 4/6/43
YAKUTAT LANDING FIELD
ALASKA
FIELD REVISIONS
A.C. TACTICAL GAS SYSTEM
In 2 Sheets
Sheet No 1
Scale-as shown
U.S. Engineer Office, Yakutat, Alaska April 17 1943
Regraded — UNCLASSIFIED
REVISION
YAK F0/108



N°	LOCATION	CLASSIFICATION	TYPE
1	B-3	B. O. Q. N° 1	Quonset
2	B-3	" " " N° 2	"
3	C-3	" " " N° 3	"
4	C-3	Officers Ready Room	Log Cabin
5	D-3	Dispensary	Quonset
6	B-2	Fire Pump House	Frame
7	C-4	Warehouse	Quonset
8	B-5	Power House	Frame
9	C-5	Store Rm. Paint	"
10	C-6	Galley & Subsistence	"
11	B-6	E.M. Quarters N° 1	Quonset
12	C-6	" " " N° 2	"
13	C-5	" " " N° 3	"
14	C-4	" " " N° 4	"
15	C-4	" " " N° 5	"
16	D-5	" " " N° 6	"
17	C-5	Head For E.M.	"
18	E-7	Nose Hanger	Frame
19	G-9	Administration	"
20	B-6	Fuel Oil Storage 100 bbl	Wood Tank
21	D-13	Ammunition Magazine	Steel Pl.
22	G-9	Radio Room	Quonset


ELEPHANT SHELTER AREA
RIFLE RANGE
HOSPITAL AREA
UTILITIES AREA
AIR CORPS OPERATIONS RESERVE TANK FARM
PUMP HOUSE
THEATER
CAMP AREA
A.C. WAREHOUSE GROUP NO. 1
A.C. WAREHOUSE GROUP NO. 2
A.C. INCREASE GROUP NO. 2
AIR WARNING FILTER CENTER
Note. Topography taken from U.S.C.&G.S. Maps T-8453, T-8451, T-8452. Building locations traced from plot plans sent in from field
YAKUTAT LANDING FIELD
ALASKA
LAYOUT PLAN
In 11 Sheets
Sheet No. 6
Scale 1"=400'
Prepared Under Supervision of
District Engineer. Seattle, Wash.
1943
Traverse Loops A & B added
Revised to Date
No.
Revision
By
Appd
Date
15-04-288
Sheet No. 6
Supersedes Dwg. Dated Feb 15, 1943
File No. N-59-36


To Yakutat
Signal Road
Residences
Old Airport Road
New Airport Road
KEY
● = Sample Location
-Airport-
PP01SS
Post Powerhouse
PP03SS
PP02SS
Hangar Road
Utilities Road
Carter Road
Utilities Road
Canon Beach Road Ditch
Canon Beach Road
FAA Site
Cresent Road
Runway
FI01SS
FI02SS
FI03SS
Former Incinerator Site
Tawah Creek Road
To Former Remote Receiver Site
To Situk River
BKG Surface Water 97294813
SW05SS
Solid Waste Disposal Dump No 4
SW04SS
Tawah Creek
Drainage Ditch
Swamp
SW01WA
SW03SS
SW02SS
SW01SS
To Beach Road & Gulf of Alaska
ecology and environment, inc.
International Specialists in the Environment
Seattle, Washington
YAKUTAT AB SI
Yakutat, Alaska
Figure 5-3
POST POWERHOUSE, FORMER INCINERATOR & SOLID WASTE DISPOSAL SITE
SAMPLE LOCATION MAP
0
450'
Approximate Scale: 1" = 450 Feet
Drawn By MRE
Date 12/4/97
Job No BB1501SITO
Dwg. No. BB1501FI0

5-15

APPENDIX B

REMEDIAL ALTERNATIVES DESCRIPTIONS

APPENDIX B – REMEDIAL ALTERNATIVES DESCRIPTIONS

The descriptions printed in this appendix have been obtained directly from the Federal Remediation Technologies Roundtable Screening Matrix with some items cut for brevity, and with the exception of the Institutional Controls description, which was downloaded from the US EPA's Federal Facilities Restoration and Reuse site, and the Monitored Natural Attenuation for soil, which was downloaded from the EPA website.

Alternative **Begins on Page No.**

Technology>> Soil, Sediment, Bedrock and Sludge

>>3.1 In Situ Biological Treatment

>>4.2 Enhanced Bioremediation

Introduction>> The activity of naturally occurring microbes is stimulated by circulating water-based solutions through contaminated soils to enhance *in situ* biological degradation of organic contaminants or immobilization of inorganic contaminants. Nutrients, oxygen, or other amendments may be used to enhance bioremediation and contaminant desorption from subsurface materials.

Description:

4-2 Typical Enhanced Bioremediation System Enhanced bioremediation is a process in which indigenous or inoculated micro-organisms (e.g., fungi, bacteria, and other microbes) degrade (metabolize) organic contaminants found in soil and/or ground water, converting them to innocuous end products. Nutrients, oxygen, or other amendments may be used to enhance bioremediation and contaminant desorption from subsurface materials.

Aerobic

In the presence of sufficient oxygen (aerobic conditions), and other nutrient elements, microorganisms will ultimately convert many organic contaminants to carbon dioxide, water, and microbial cell mass.

Enhanced bioremediation of soil typically involves the percolation or injection of ground water or uncontaminated water mixed with nutrients and saturated with dissolved oxygen. Sometimes acclimated microorganisms (bioaugmentation) and/or another oxygen source such as hydrogen peroxide are also added. An infiltration gallery or spray irrigation is typically used for shallow contaminated soils, and injection wells are used for deeper contaminated soils.

Although successful in situ bioremediation has been demonstrated in cold weather climate, low temperature slows the remediation process. For contaminated sites with low soil temperature, heat blankets may be used to cover the soil surface to increase the soil temperature and the degradation rate.

Enhanced bioremediation may be classified as a long-term technology which may take several years for cleanup of a plume.

Anaerobic

In the absence of oxygen (anaerobic conditions), the organic contaminants will be ultimately metabolized to methane, limited amounts of carbon dioxide, and trace amounts of hydrogen gas. Under sulfate-reduction conditions, sulfate is converted to sulfide or elemental sulfur, and under nitrate-reduction conditions, dinitrogen gas is ultimately produced.

Sometimes contaminants may be degraded to intermediate or final products that may be less, equally, or more hazardous than the original contaminant. For example, TCE anaerobically biodegrades to the persistent and more toxic vinyl chloride. To avoid such problems, most bioremediation projects are conducted *in situ*. Vinyl chloride can easily be broken down further if aerobic conditions are created.

White Rot Fungus

White rot fungus has been reported to degrade a wide variety of organopollutants because of its lignin-degrading or wood-rotting enzymes. Two different treatment configurations have been tested for white rot fungus, in situ and bioreactor. An aerobic system using moisturized air on wood chips is used in a reactor for biodegradation. A reactor was used in the bench-scale trial of the process. In the pilot-scale project, an adjustable shredder was used for making chips for the open system. The open system is similar to composting, with wood chips on a liner or hard contained surface that is covered. Temperature is not controlled in this type of system. The optimum temperature for biodegradation with lignin-degrading fungus ranges from 30 to 38° C (86 to 100° F). The heat of the biodegradation reaction will help to maintain the temperature of the process near the optimum.

TOP

Although white rot fungus degradation of TNT has been reported in laboratory-scale settings using pure cultures, several factors increase the difficulty of using this technology for full-scale remediation, and it has not yet been proven successful at this level. These factors include competition from native bacterial populations, toxicity inhibition, chemical sorption, and the inability to meet risk-based cleanup levels. White rot works best in nitrogen-limited environments.

In bench-scale studies of mixed fungal and bacterial systems, most of the reported degradation of TNT is attributable to native bacterial populations. High TNT or PCP concentrations in soil also can inhibit growth of white rot fungus. A study suggested that one particular species of white rot fungus was incapable of growing in soils contaminated with 20 ppm or more of TNT. In addition, some reports indicate that TNT losses reported in white rot fungus studies can be attributed to adsorption onto the fungus and soil amendments, such as corn cobs and straw, rather than actual destruction of TNT. Another study tested a variety of white rot fungus for PCP sensitivity. Eighteen species tested for PCP sensitivity were inhibited by 10 mg per liter of PCP when grown on agar plates. Within 2 weeks, 17 of the 18 species grew in the inhibition zones. In liquid-phase toxicity experiments, all 18 species were killed by 5 mg per liter of PCP.

Synonyms:

Biostimulation, bioaugmentation, enhanced biodegradation.

DSERTS Codes:

H1 (Bioremediation)
H12 (Bioremediation-In situ)

TOP

Applicability:

TOP

Bioremediation techniques have been successfully used to remediate soils, sludges, and ground water contaminated with petroleum hydrocarbons, solvents, pesticides, wood preservatives, and other organic chemicals. Bench- and pilot-scale studies have demonstrated the effectiveness of anaerobic microbial degradation of nitrotoluenes in soils contaminated with munitions wastes. Bioremediation is especially effective for remediating low level residual contamination in conjunction with source removal.

The contaminant groups treated most often are PAHs, non-halogenated SVOCs (not including PAHs), and BTEX. The types of Superfund sites most commonly treated by bioremediation have been contaminated through processes or wastes associated with wood preserving and petroleum refining and reuse. Wood preserving commonly employs creosote, which has a high concentration of PAHs and other non-halogenated SVOCs. Similarly, petroleum refining and reuse processes frequently involve BTEX.

Because the two contaminant groups most commonly treated using bioremediation are SVOCs (PAHs and other non-halogenated SVOCs), it may be difficult to treat them using technologies that rely on volatility, such as SVE. In addition, bioremediation treatment often does not require heating, requires relatively inexpensive inputs, such as nutrients, and usually does not generate residuals requiring additional treatment or disposal. Also, when conducted in situ, it does not require excavation of contaminated media. Compared with other technologies, such as thermal desorption and incineration (which require excavation and heating), thermally enhanced recovery (which requires heating), chemical treatment (which may require relatively expensive chemical reagents), and in situ soil flushing (which may require further management of the flushing water), bioremediation may enjoy a cost advantage in the treatment of nonhalogenated SVOCs

While bioremediation (nor any other remediation technology) cannot degrade inorganic contaminants, bioremediation can be used to change the valence state of inorganics and cause adsorption, immobilization onto soil particulates, precipitation, uptake, accumulation, and concentration of inorganics in micro or macroorganisms. These techniques, while still largely experimental, show considerable promise of stabilizing or removing inorganics from soil.

Limitations:

Factors that may limit the applicability and effectiveness of the process include:

- Cleanup goals may not be attained if the soil matrix prohibits contaminant-microorganism contact.

TOP

- The circulation of water-based solutions through the soil may increase contaminant mobility and necessitate treatment of underlying ground water.
- Preferential colonization by microbes may occur causing clogging of nutrient and water injection wells.
- Preferential flow paths may severely decrease contact between injected fluids and contaminants throughout the contaminated zones. The system should not be used for clay, highly layered, or heterogeneous subsurface environments because of oxygen (or other electron acceptor) transfer limitations.
- High concentrations of heavy metals, highly chlorinated organics, long chain hydrocarbons, or inorganic salts are likely to be toxic to microorganisms.
- Bioremediation slows at low temperatures.
- Concentrations of hydrogen peroxide greater than 100 to 200 ppm in groundwater inhibit the activity of microorganisms.
- A surface treatment system, such as air stripping or carbon adsorption, may be required to treat extracted groundwater prior to re-injection or disposal.

Many of the above factors can be controlled with proper attention to good engineering practice. The length of time required for treatment can range from 6 months to 5 years and is dependent on many site-specific factors.

TOP Data Needs:

A detailed discussion of these data elements is provided in Subsection 2.2.1 (Data Requirements for Soil, Sediment, and Sludge). Important contaminant characteristics that need to be identified in an enhanced bioremediation feasibility investigation are their potential to leach (e.g., water solubility and soil sorption coefficient); their chemical reactivity (e.g., tendency toward nonbiological reactions, such as hydrolysis, oxidation, and polymerization); and, most importantly, their biodegradability.

Soil characteristics that need to be determined include the depth and areal extent of contamination; the concentration of the contaminants; soil type and properties (e.g., organic content, texture, pH, permeability, water-holding capacity, moisture content, and nutrient level); the competition for oxygen (e.g., redox potential); the presence or absence of substances that are toxic to microorganisms; concentration of other electron acceptors, nutrients; and the ability of microorganisms in the soil to degrade contaminants.

Treatability or feasibility tests are performed to determine whether enhanced bioremediation is feasible in a given situation, and to define the remediation time frame and parameters. Field testing can be performed to determine the radius of influence and well spacing and to obtain preliminary cost estimates.

Performance Data:

The main advantage of the in situ process is that it allows soil to be treated without being excavated and transported, resulting in less disturbance of site activities. If enhanced bioremediation can reach the cleanup goal in a compatible time frame, it can save significant costs over methods involving excavation and transportation. Also, both

TOP contaminated ground water and soil can be treated simultaneously, providing additional cost advantages. In situ processes generally require longer time periods, however, and there is less certainty about the uniformity of treatment because of the inherent variability in soil and aquifer characteristics and difficulty in monitoring progress.

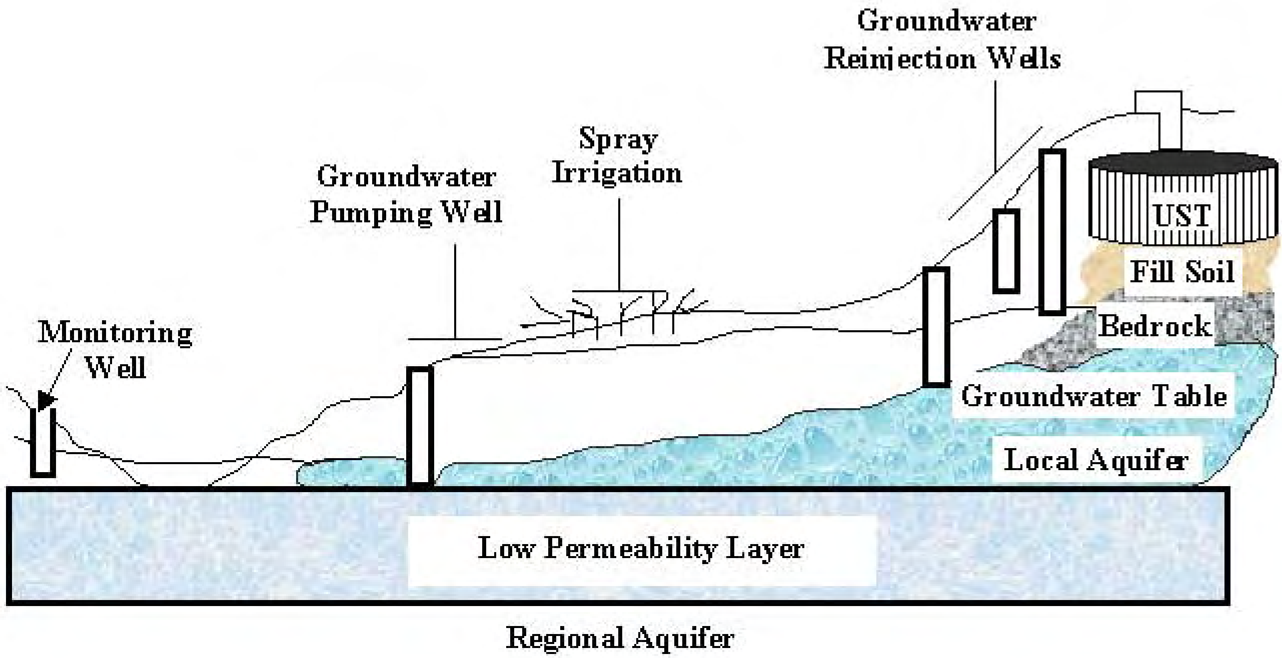
Remediation times are often years, depending mainly on the degradation rates of specific contaminants, site characteristics, and climate. Less than one year may be required to clean up some contaminants, but higher molecular weight compounds take longer to degrade.

There is a risk of increasing contaminant mobility and leaching of contaminants into ground water. Regulators often do not accept the addition of nitrates or non-native microorganisms to contaminated soils. Enhanced bioremediation has been selected for remedial and emergency response actions at an increasing number of Superfund sites. Generally, petroleum hydrocarbons can be readily bioremediated, at relatively low cost, by stimulating indigenous microorganisms with nutrients.

TOP Cost:

Typical costs for enhanced bioremediation range from $30 to $100 per cubic meter ($20 to $80 per cubic yard) of soil. Factors that affect cost include the soil type and chemistry, type and quantity of amendments used, and type and extent of contamination.

Additional cost information can be found in the Hazardous, Toxic, and Radioactive Wastes (HTRW) Historical Cost Analysis System (HCAS) developed by Environmental Historical Cost Committee of Interagency Cost Estimation Group, as well as the FRTR Cost and Performance Reports.


Groundwater
Reinjection Wells
Spray
Irrigation
Groundwater
Pumping Well
UST
Fill Soil
Bedrock
Monitoring
Well
Groundwater Table
Local Aquifer
Low Permeability Layer
Regional Aquifer

Technology>> Soil, Sediment, Bedrock and Sludge

>>**3.1 In Situ Biological Treatment**

>>4.1 Bioventing

Introduction>> Oxygen is delivered to contaminated unsaturated soils by forced air movement (either extraction or injection of air) to increase oxygen concentrations and stimulate biodegradation.

TOP Description:

Figure 4-1 Typical Bioventing System Bioventing is a promising new technology that stimulates the natural in situ biodegradation of any aerobically degradable compounds in soil by providing oxygen to existing soil microorganisms. In contrast to soil vapor vacuum extraction, bioventing uses low air flow rates to provide only enough oxygen to sustain microbial activity. Oxygen is most commonly supplied through direct air injection into residual contamination in soil. In addition to degradation of adsorbed fuel residuals, volatile compounds are biodegraded as vapors move slowly through biologically active soil.

The U.S. Air Force has produced a technical memorandum which summarizes the results of bioventing treatability studies of fuels conducted at 145 US Air Force sites. The memorandum discusses overall study results and presents cost and performance data and lessons learned.

Regulatory acceptance of this technology has been obtained in 30 states and in all 10 EPA regions, and the use of this technology in the private sector is growing rapidly following USAF leadership.

Bioventing is a medium to long-term technology. Cleanup ranges from a few months to several years.

Synonyms:

DSERTS Code: H11 (Bioventing)

Applicability:

Bioventing techniques have been successfully used to remediate soils contaminated by petroleum hydrocarbons, nonchlorinated solvents, some pesticides, wood preservatives, and other organic chemicals.

While bioremediation cannot degrade inorganic contaminants, bioremediation can be used to change the valence state of inorganics and cause adsorption, uptake, accumulation, and concentration of inorganics in micro or macroorganisms. These techniques, while still largely experimental, show considerable promise of stabilizing or removing inorganics from soil.

Limitations:

Factors that may limit the applicability and effectiveness of the process include:

- The water table within several feet of the surface, saturated soil lenses, or low permeability soils reduce bioventing performance.
- Vapors can build up in basements within the radius of influence of air injection wells. This problem can be alleviated by extracting air near the structure of concern.
- Extremely low soil moisture content may limit biodegradation and the effectiveness of bioventing.
- Monitoring of off-gases at the soil surface may be required.
- Aerobic biodegradation of many chlorinated compounds may not be effective unless there is a co-metabolite present, or an anaerobic cycle.
- Low temperatures may slow remediation, although successful remediation has been demonstrated in extremely cold weather climates.

Data Needs:

A detailed discussion of these data elements is provided in Subsection 2.2.1 (Data Requirements for Soil, Sediment, and Sludge). Two basic criteria must be satisfied for successful bioventing. First, air must be able to pass through the soil in sufficient quantities to maintain aerobic conditions; second, natural hydrocarbon-degrading microorganisms must be present in concentrations large enough to obtain reasonable biodegradation rates. Initial testing is designed to determine both air permeability of soil and in situ respiration rates.

Soil grain size and soil moisture significantly influence soil gas permeability. Perhaps the greatest limitation to air permeability is excessive soil moisture. A combination of high water tables, high moisture, and fine-grained soils has made bioventing infeasible at some Air Force test locations.

Several soil characteristics that are known to impact microbial activity are pH, moisture, TOP and basic nutrients, (e.g., nitrogen and phosphorus), and temperature. Soil pH measurements show the optional pH range to be 6 to 8 for microbial activity; however, microbial respiration has been observed at all sites, even in soils that fall outside this optimal range. Optimum soil moisture is very soil-specific. Too much moisture can reduce the air permeability of the soil and decrease its oxygen transfer capability. Too little moisture will inhibit microbial activity. Several Air Force bioventing test sites have sustained biodegradation rates with moisture levels as low as 2 to 5% by weight. However, in extremely arid climates, it may be possible to increase the rate of biodegradation through irrigation, or humidifying the injected air.

Biological activity has been measured at Eielson AFB, Alaska, in soil temperatures as low as 0° C. Bioventing will more rapidly degrade contaminants during summer months, but some remediation occurs in soil temperatures down to 0° C.

Hydrocarbon degradation rates are almost always estimated from oxygen utilization rates using a simple stoichiometric relationship with the implicit assumption that all oxygen loss is due to the mineralization of hydrocarbons by microbes. However, simple stoichiometric relationships do not account for biomass production and inorganic oxidation reactions. Oxygen serves a terminal electron acceptor not only in the degradation of organic matter but also in oxidation of reduced inorganic compounds by microorganisms which obtain energy through chemical oxidation. In situ respiration tests can also be taken. Measurement of oxygen utilization in a nearby uncontaminated area is used to account for inorganic oxidation reactions. When used with other indicators of increased microbial activity or biodegradation, respiration tests can provide one of several convergent lines of independent evidence to at least qualitatively document biodegradation.

TOP Performance Data:

Bioventing is becoming more common, and most of the hardware components are readily available. Bioventing is receiving increased exposure to the remediation consulting community, particularly its use in conjunction with soil vapor extraction (SVE). The Air Force is sponsoring bioventing demonstrations at 135 sites. As with all biological technologies, the time required to remediate a site using bioventing is highly dependent upon the specific soil and chemical properties of the contaminated media. An overview of this technology, including installation protocols, provided by the Air Force Center for Environmental Excellence (AFCEE) is located at http://www.afcee.brooks.af.mil/er/ert/bioventing.htm.

Cost:

The key cost driver information and cost analysis was developed using the Remedial Action Cost Engineering and Requirements (RACER) software.

Key Cost Drivers

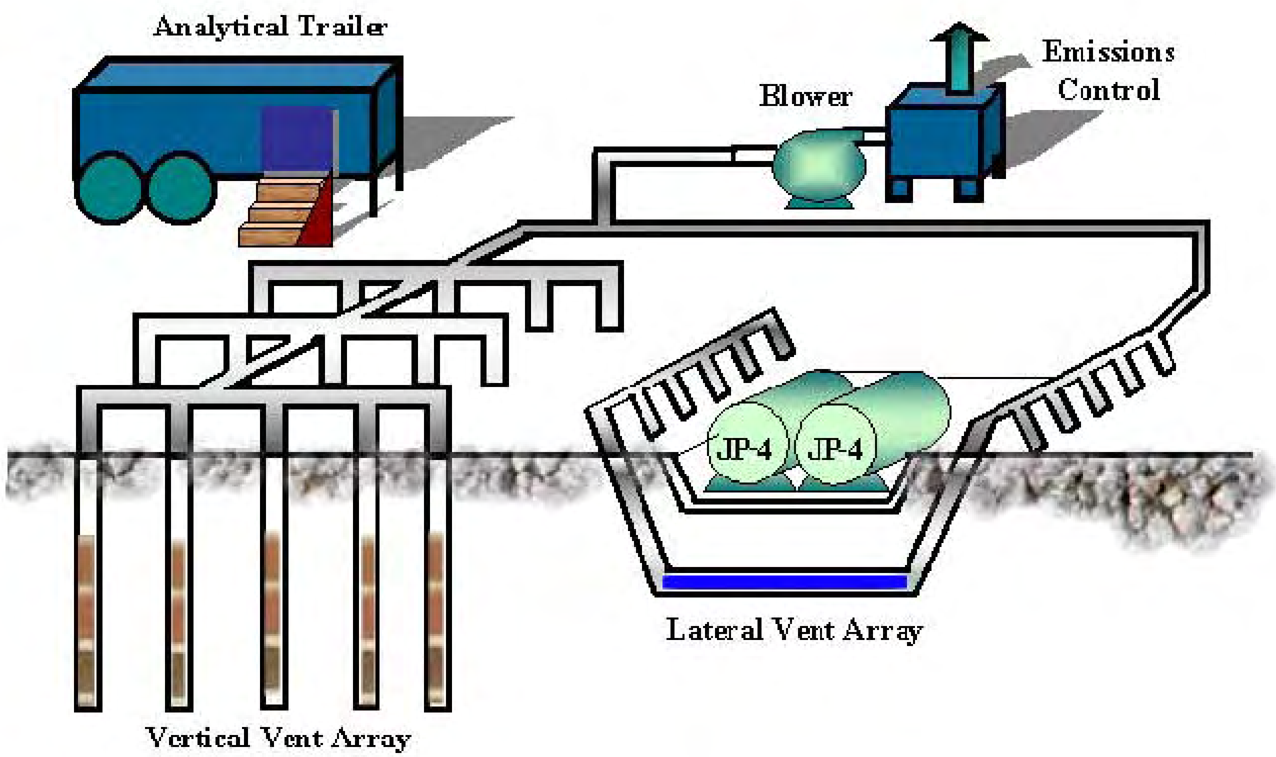
- Surface area is the primary cost driver
    - Impacts the number of injection/extraction wells that are installed. The number of wells installed (and cost) increases with surface area.
- Soil Type
    - Soil types containing sand and gravel produced significantly lower costs by reducing the number of injection/extraction wells that needed to be installed.

Cost Analysis

The following table represents estimated costs (by common unit of measure) to apply bioventing technology at sites of varying size and complexity. A more detailed cost estimate table which includes specific site characteristics and significant cost elements that contributed to the final costs can be viewed by clicking on the link below.

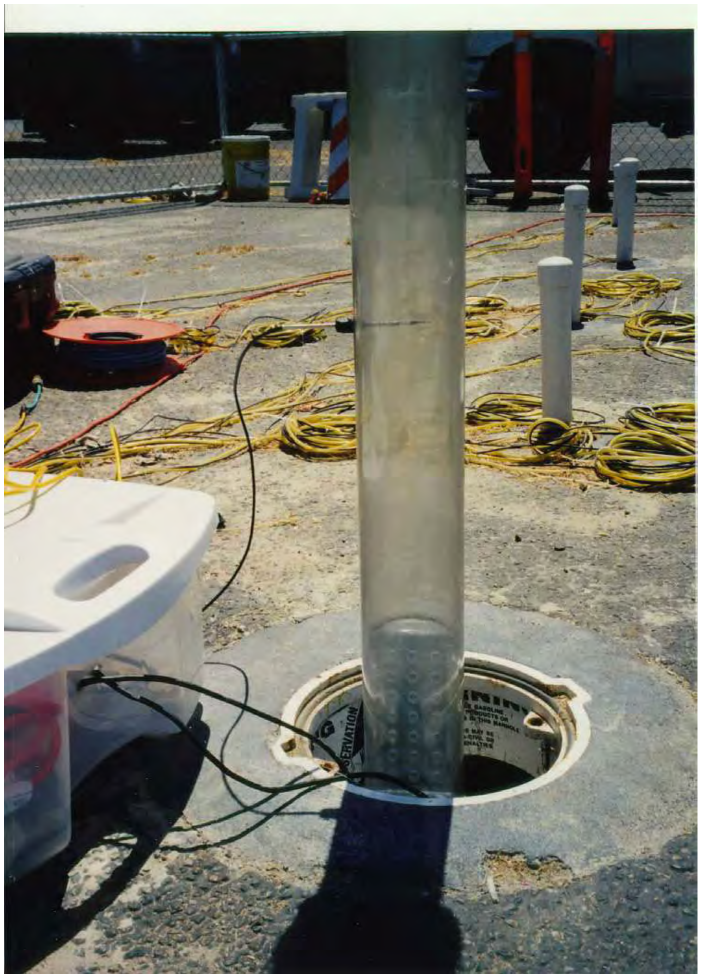
SOIL TECHNOLOGY:	Bioventing			
RACER PARAMETERS	Scenario A	Scenario B	Scenario C	Scenario D
	Small Site		Large Site	
	Easy	Difficult	Easy	Difficult
COST PER CUBIC FOOT	$26	$27	$2	$3
COST PER CUBIC METER	$928	$970	$79	$109
COST PER CUBIC YARD	$709	$742	$60	$84

Detailed Cost Estimate



Analytical Trailer
Blower
Emissions
Control
JP-4
JP-4
Lateral Vent Array
Vertical Vent Array

Design Document
For
Passive Bioventing



March 2006

2.0 INTRODUCTION

Petroleum hydrocarbons can be removed from soil using a variety of remediation technologies, including excavation of contaminated soil with off-site disposal (i.e., dig and haul) and vacuum extraction to recover volatile hydrocarbons (i.e., soil vapor extraction). Bioventing is an alternative remediation method that involves pumping air into water-unsaturated soils to stimulate in-situ aerobic biologic activity. Microbes then transform petroleum hydrocarbons into biomass and carbon dioxide, thereby transforming the unwanted contaminants into benign products.

Passive bioventing, the subject of this document, uses the difference between subsurface and atmospheric gas pressure to deliver air into contaminated soils and thus eliminates the need for the electrically powered blower normally used in conventional bioventing. However, removing the electrical blower and relying on the relatively small pressure difference that arises between the subsurface and atmosphere does reduce airflow rates and the total volume of air delivered into the contaminated subsurface region. Also, passive bioventing will work only at sites with suitable subsurface conditions that lead to sustained differences between atmospheric and subsurface gas pressure. Despite these limitations, passive bioventing may hold a cost advantage over conventional bioventing while achieving the same rate of hydrocarbon remediation. For example, electrical power is either unavailable or would be expensive to obtain at many Department of Defense (DoD) facilities such as ranges, and training and proving grounds. Even at facilities where electrical power is available, contaminated sites are often not conveniently located near power distribution points, resulting in an increase in installation costs. At these locations, passive bioventing may be a cost-effective approach. Another situation where passive bioventing may be applicable is at sites with active conventional bioventing systems where contaminant concentrations have stabilized and are no longer decreasing. The cost of operating an electrical blower at these sites may no longer be justified as the rate of biotransformation is limited by the low hydrocarbon concentration rather than the rate of oxygen delivery. Thus, the lower airflow rate provided by passive bioventing may be appropriate to treat the petroleum contamination that remains after the bulk has been remediated using conventional bioventing or soil vapor extraction.

The overall goal of this document is to provide guidelines on selecting locations where a difference between subsurface and atmospheric gas pressure is expected to occur and cause air to flow into the subsurface making passive bioventing feasible. This section provides background information on conventional and passive bioventing, including advantages and limitations, and limited results from passive bioventing demonstration projects. Section 3 describes the criteria that should be considered to determine if passive bioventing is applicable for given site conditions; Section 4 specifies testing procedures and equipment required to demonstrate the feasibility of passive bioventing; and Section 5 details considerations for the full-scale design of a passive bioventing system.

2.1 CONVENTIONAL BIOVENTING

Bioventing is a process of injecting ambient air into water-unsaturated soils to promote the in situ bioremediation of petroleum hydrocarbon contaminants. Minimum requirements for the successful application of bioventing include adequate soil gas permeability, adequate soil water content, suitable microbial population, and adequate control of the contaminant vapor plume (USEPA, 1994; Leeson and Hinchee, 1997). Delivery of ambient air into soils has been shown in controlled laboratory studies to accelerate the microbial metabolism of hydrocarbons into nontoxic byproducts, including carbon dioxide (CO_2), water, and microbial mass (NRC, 1993). Bioventing is applicable at sites where the subsurface is contaminated with aerobically biodegradable compounds, including most of the constituents found in gasoline, jet fuel, diesel fuel, and many other petroleum-based products (USEPA ORD, 1995). Bioventing is not applicable for most chlorinated solvents (e.g., tetrachloroethylene) or other halogenated compounds (e.g., polychlorinated biphenyls).

A subsurface gas-phase oxygen (O_2) concentration of less than 5% (volume or pressure basis) indicates that supplying oxygen through the injection of ambient air will stimulate resident aerobic microorganisms (Leeson and Hinchee, 1997); however, injecting air may lead to the spread of hydrocarbons from the contaminated region. Thus, the rate of air injection should be sufficient to meet microbial metabolic requirements but minimize the spread of volatile hydrocarbon contaminants (e.g., benzene) to areas outside the treatment zone. Bioventing does not rely significantly on volatilization of soil contaminants to achieve cleanup goals since contaminants are degraded in situ within water-unsaturated soil.

Conventional bioventing requires at least one electrically powered blower either to inject ambient air into or to extract soil gas from the subsurface. Extracting soil gas can potentially draw ambient air into the subsurface. A regenerative electric blower is normally used to inject air into contaminated soil via vent wells that are screened above the water table in water-unsaturated soils. Electric blowers inject air at rates between 15 and 30 cubic feet per minute (cfm), or 20,000 and 40,000 cubic feet per day (cfd), using low injection pressures of 10 to 30 in of water (2,500 to 7,500 Pa) to minimize the spread of volatile hydrocarbons while maximizing the rate of biodegradation. Conventional bioventing has been successfully demonstrated at DoD and other facilities (Miller et al., 1993; Leeson and Hinchee, 1997) and is included in the list of treatment technologies profiled in the *Remediation Technologies Screening Matrix and Reference Guide* (FRTR, 2002). The construction of bioventing systems is covered in the U.S. Air Force (AFCEE, 1996) and U.S. Army (USACE, 2002) design documents.

2.2 PASSIVE BIOVENTING

Passive bioventing uses the difference in gas pressure that develops between the atmosphere and the subsurface to drive air through vent wells and into the contaminated subsurface. Previous field tests have shown that changes in atmospheric or barometric pressure cause vent wells screened in water-unsaturated soil to inhale and exhale air, a process sometimes termed "barometric pumping" or "breathing" (Pirkle *et al*., 1992; Rossabi *et al*., 1993). During times of increasing barometric pressure, there is a positive pressure difference between the atmosphere and the subsurface, and air flows through the vent well into the subsurface (Figure 1). Air will flow from the subsurface and into the atmosphere during times of decreasing barometric pressure. The magnitude of the ensuing airflow rate is primarily a function of the rate of barometric pressure change, well screen depth and length, and the air permeability of the soil near the vent well screen (Zimmerman *et al*., 1997; Rossabi and Falta, 2002).

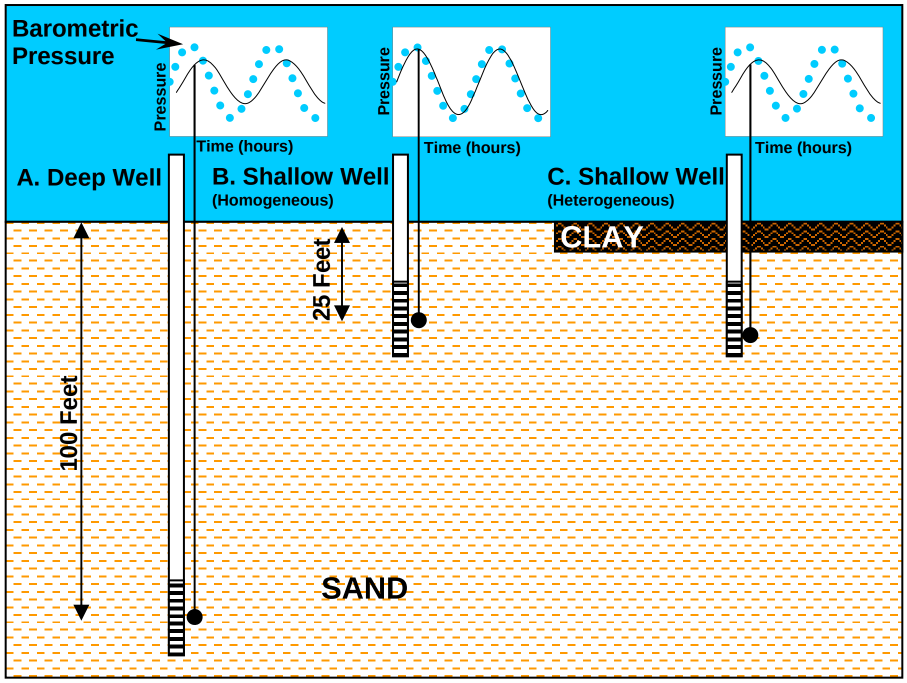


Figure 1. Air inhalation during times of increasing barometric pressure. Part A shows the vent well installed into unsaturated soil that is greater than 100 ft below ground surface (bgs). Part B shows a vent well installed at less than 25 ft bgs while Part C shows the vent well screened beneath a continuous layer of low permeability clay.

The difference in barometric pressure from day to night (diurnal) is on the order of 3 in of water (750 Pa). The passage of periodic weather fronts often causes an even greater change in barometric pressure with time. However, a significant change in barometric pressure alone is not sufficient to guarantee that air will flow between the atmosphere and subsurface. Specific subsurface lithologic and stratigraphic conditions must also exist for any change in barometric pressure to induce significant airflow through vent wells. Barometric pressure-induced airflow has been measured at sites with vent wells screened in air-permeable, contaminated soils that are isolated from the atmosphere by more than 100 ft of water-unsaturated soil, shown as the deep well configuration in Part A of Figure 1 (Rossabi et al., 1993; Hoeppel et al., 1995). Airflow through vent wells screened in shallow, air-permeable contaminated soils isolated from the atmosphere by a layer of low air permeability (Part C of Figure 1) has also been measured (Costanza and Rossabi, 2001). A thick (e.g., >100 ft) soil layer of high air permeability or a thin soil layer of low air permeability can retard the flow of air between the atmosphere and subsurface, leading to a gas pressure difference. While the magnitude of this naturally occurring pressure difference is low, between about 0.06 to 0.5 in of water (15 to 125 Pa), the rate of barometric pressure-driven airflow through vent wells can range from 0.5 to more than 50 cfm (Riha, 2001).

2.4 ADVANTAGES AND DISADVANTAGES OF BIOVENTING.

Passive bioventing shares many of the same advantages and disadvantages as conventional bioventing summarized in the following list. Those features specifically pertinent to passive bioventing are highlighted in bold print.

Advantages of passive (and conventional) bioventing include:

- **Eliminates the need for electrical lines and outlets**
- **Avoids the use of an electric blower and associated operation and maintenance costs**
- **Eliminates the need for a vacuum manifold system and associated trenching costs**
- **Low pressure air injection minimizes volatile contaminant transport to receptors**
- Applicable to both the volatile and semivolatile fractions of hydrocarbon fuel mixtures
- Uses ambient air without pretreatment
- No above-ground off-gas treatment
- Uses resident aerobic microbes for treatment
- Utilizes conventional, readily available supplies and construction techniques
- Minimal operation and maintenance requirements

Disadvantages of passive (and conventional) bioventing include:

- **Passive bioventing requires more vent wells than conventional systems**
- **Permeable soils with high moisture levels may have limited airflow**
- Presence of low air permeability soils greatly limits or prevents oxygen transport
- Extremely low water content soils (e.g., <2% by weight) may limit microbial degradation
- Significant separate phase hydrocarbon fluid may inhibit microbial degradation
- Preferential pathways (sand layers/fractures) can impede airflow to contaminant zones
- Chlorinated hydrocarbons, not biodegraded aerobically, may be mobilized
- Requires thorough subsurface characterization, including soil air permeability testing
- Multiple years may be required to achieve cleanup goals

4.11 Biopiles
(Ex Situ Soil Remediation Technology)

Technology>> Soil, Sediment, Bedrock, and Sludge

>>3.4 Ex Situ Biological Treatment (assuming excavation)

>>4.11 Biopiles

Introduction>> Excavated soils are mixed with soil amendments and placed in aboveground enclosures. It is an aerated static pile composting process in which compost is formed into piles and aerated with blowers or vacuum pumps.

Description:

Figure 4-11: Typical Biopile for Solid Phase Bioremediation Biopile treatment is a full-scale technology in which excavated soils are mixed with soil amendments and placed on a treatment area that includes leachate collection systems and some form of aeration. It is used to reduce concentrations of petroleum constituents in excavated soils through the use of biodegradation. Moisture, heat, nutrients, oxygen, and pH can be controlled to enhance biodegradation.

The treatment area will generally be covered or contained with an impermeable liner to minimize the risk of contaminants leaching into uncontaminated soil. The drainage itself may be treated in a bioreactor before recycling. Vendors have developed proprietary nutrient and additive formulations and methods for incorporating the formulation into the soil to stimulate biodegradation. The formulations are usually modified for site-specific conditions.

Soil piles and cells commonly have an air distribution system buried under the soil to pass air through the soil either by vacuum or by positive pressure. The soil piles in this case can be up to 20 feet high (generally not recommended, 2-3 meters maximum). Soil piles may be covered with plastic to control runoff, evaporation, and volatilization and to promote solar heating. If there are VOCs in the soil that will volatilize into the air stream, the air leaving the soil may be treated to remove or destroy the VOCs before they are discharged to the atmosphere.

TOP Biopile is a short-term technology. Duration of operation and maintenance may last a few weeks to several months. Treatment alternatives include static processes such as: prepared treatment beds, biotreatment cells, soil piles, and composting.

Synonyms:

TOP Heap pile bioremediation; Bioheaps; Biomounds; Static-pile composting.
DSERTS Code: H14 (Controlled Solid-Phase Bioremediation).

TOP Applicability:

Biopile treatment has been applied to treatment of nonhalogenated VOCs and fuel hydrocarbons. Halogenated VOCs, SVOCs, and pesticides also can be treated, but the process effectiveness will vary and may be applicable only to some compounds within these contaminant groups.

TOP Limitations:

Factors that may limit the applicability and effectiveness of the process include:

- Excavation of contaminated soils is required.
- Treatability testing should be conducted to determine the biodegradability of contaminants and appropriate oxygenation and nutrient loading rates.
- Solid phase processes have questionable effectiveness for halogenated compounds and may not be very effective in degrading transformation products of explosives.
- Similar batch sizes require more time to complete cleanup than slurry phase processes.
- Static treatment processes may result in less uniform treatment than processes that involve periodic mixing.

Data Needs:

A detailed discussion of these data elements is provided in Subsection 2.2.1 (Data Requirements for Soil, Sediment, and Sludge). The first steps in preparing a sound design for biotreatment of contaminated soil include:

- Site characterization.
- Soil sampling and characterization.
- Contaminant characterization.
- Laboratory and/or field treatability studies.
- Pilot testing and/or field demonstrations.

Site, soil, and contaminant characterizations will be used to:

- Identify and quantify contaminants.
- Determine requirements for organic and inorganic amendments.
- Identify potential safety issues.
- Determine requirements for excavation, staging, and movement of contaminated soil.
- Determine availability and location of utilities (electricity and water).

Laboratory or field treatability studies are needed to identify:

TOP

- Amendment mixtures that best promote microbial activity.
- Potential toxic degradation byproducts.

- Percent reduction and lower concentration limit of contaminant achievable.
- The potential degradation rate.

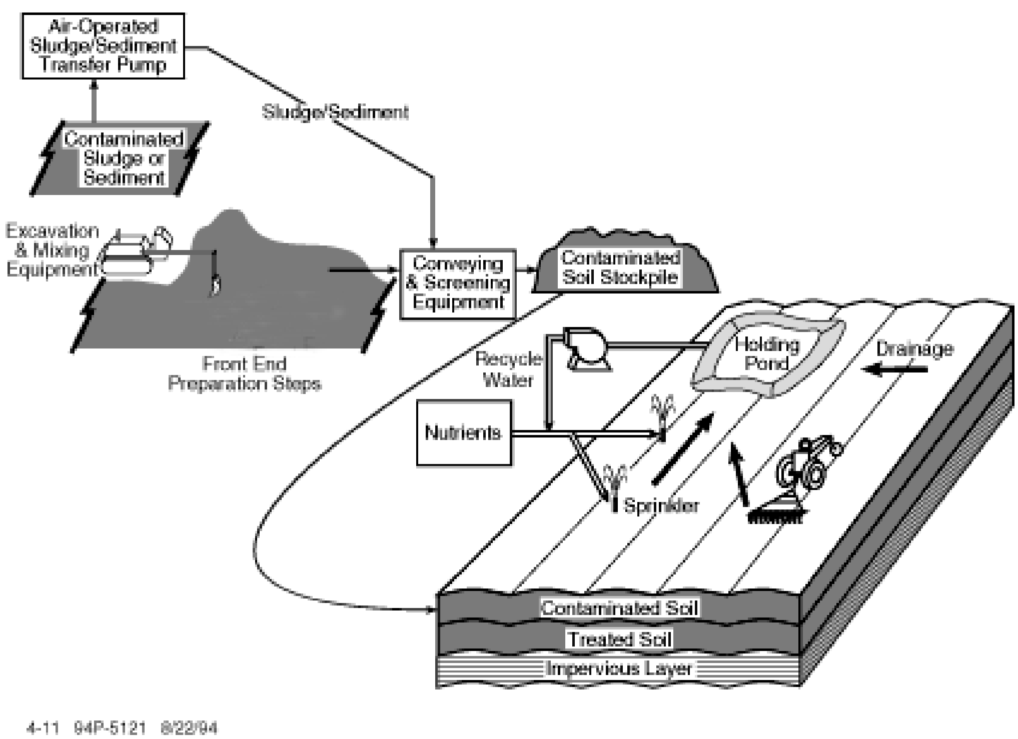
TOP Performance Data:

Biopile treatment has been demonstrated for fuel-contaminated sites. Specific site information is contained in the following site information Section.

TOP Cost:

Costs are dependent on the contaminant, procedure to be used, need for additional pre- and post-treatment, and need for air emission control equipment. Biopiles are relatively simple and require few personnel for operation and maintenance. Typical costs with a prepared bed and liner are $130 to $260 per cubic meter ($30 to $60 per cubic yard).

Typical Biopile for Solid Phase Bioremediation



Technology>> Soil, Sediment, Bedrock and Sludge

>>3.4 Ex Situ Biological Treatment (assuming excavation)

>>4.13 Landfarming

Introduction>> Contaminated soil, sediment, or sludge is excavated, applied into lined beds, and periodically turned over or tilled to aerate the waste.

Description:

Landfarming is a full-scale bioremediation technology, which usually incorporates liners and other methods to control leaching of contaminants, which requires excavation and placement of contaminated soils, sediments, or sludges. Contaminated media is applied into lined beds and periodically turned over or tilled to aerate the waste.

Soil conditions are often controlled to optimize the rate of contaminant degradation. Conditions normally controlled include:

- Moisture content (usually by irrigation or spraying).
- Aeration (by tilling the soil with a predetermined frequency, the soil is mixed and aerated).
- pH (buffered near neutral pH by adding crushed limestone or agricultural lime).
- Other amendments (e.g., Soil bulking agents, nutrients, etc.).

Contaminated media is usually treated in lifts that are up to 18 inches thick. When the desired level of treatment is achieved, the lift is removed and a new lift is constructed. It may be desirable to only remove the top of the remediated lift, then construct the new lift by adding more contaminated media to the remaining material and mixing. This serves to inoculate the freshly added material with an actively degrading microbial culture, and can reduce treatment times.

Figure 4-13b:
Typical Land Treatment Unit

Land Treatment is a full-scale bioremediation technology in which contaminated soils, sediments, or sludges are turned over (i.e., tilled) and allowed to interact with the soil and climate at the site. The waste, soil, climate, and biological activity interact dynamically as a system to degrade, transform, and immobilize waste constitutes. Wastes are periodically

TOP tilled to aerate the waste.

Soil conditions are often controlled to optimize the rate of contaminant degradation. Conditions normally controlled include:

- Moisture content (usually by irrigation or spraying).
- Aeration (by tilling the soil with a predetermined frequency, the soil is mixed and aerated).
- pH (buffered near neutral pH by adding crushed limestone or agricultural lime).
- Other amendments (e.g., Soil bulking agents, nutrients, etc.).

A Land Treatment site must be managed properly to prevent both on-site and off-site problems with ground water, surface water, air, or food chain contamination. Adequate monitoring and environmental safeguards are required.

Landfarming and Land Treatment are both medium- to long-term technologies.

TOP Synonyms:

Solid phase biodegradation.
DSERTS Code: H15 (Landfarming).

TOP Applicability:

Ex situ landfarming has been proven most successful in treating petroleum hydrocarbons. Because lighter, more volatile hydrocarbons such as gasoline are treated very successfully by processes that use their volatility (i.e., soil vapor extraction), the use of aboveground bioremediation is usually limited to heavier hydrocarbons. As a rule of thumb, the higher the molecular weight (and the more rings with a PAH), the slower the degradation rate. Also, the more chlorinated or nitrated the compound, the more difficult it is to degrade. (Note: Many mixed products and wastes include some volatile components that transfer to the atmosphere before they can be degraded.)

Contaminants that have been successfully treated using landfarming include diesel fuel, No. 2 and No. 6 fuel oils, JP-5, oily sludge, wood-preserving wastes (PCP and creosote), coke wastes, and certain pesticides.

Limitations:

Factors that may limit the applicability and effectiveness of the process include:

- A large amount of space is required.
- Conditions affecting biological degradation of contaminants (e.g., temperature, rain fall) are largely uncontrolled, which increases the length of time to complete remediation.

TOP

- Inorganic contaminants will not be biodegraded.
- Volatile contaminants, such as solvents, must be pretreated because they would volatilize into the atmosphere, causing air pollution.
- Dust control is an important consideration, especially during tilling and other material handling operations.
- Runoff collection facilities must be constructed and monitored.
- Topography, erosion, climate, soil stratigraphy, and permeability of the soil at the site must be evaluated to determine the optimum design of facility.
- Waste constitutes may be subject to "Land-ban" regulation and thus may not be applied to soil for treatment by landfarming (e.g., some petroleum sludges).

TOP Data Needs:

A detailed discussion of these data elements is provided in Subsection 2.2.1 (Data Requirements for Soil, Sediment, and Sludge). The following contaminant considerations should be addressed prior to implementation: types and concentrations of contaminants, depth profile and distribution of contaminants, presence of toxic contaminants, presence of VOCs, and presence of inorganic contaminants (e.g., metals).

The following site and soil considerations should be addressed prior to implementation: surface geological features (e.g., topography and vegetative cover), subsurface geological and hydrogeological features, temperature, precipitation, wind velocity and direction, water availability, soil type and texture, soil moisture content, soil organic matter content, cation exchange capacity, water-holding capacity, nutrient content, pH, atmospheric temperature, permeability, and microorganisms (degradative populations present at site).

TOP Performance Data:

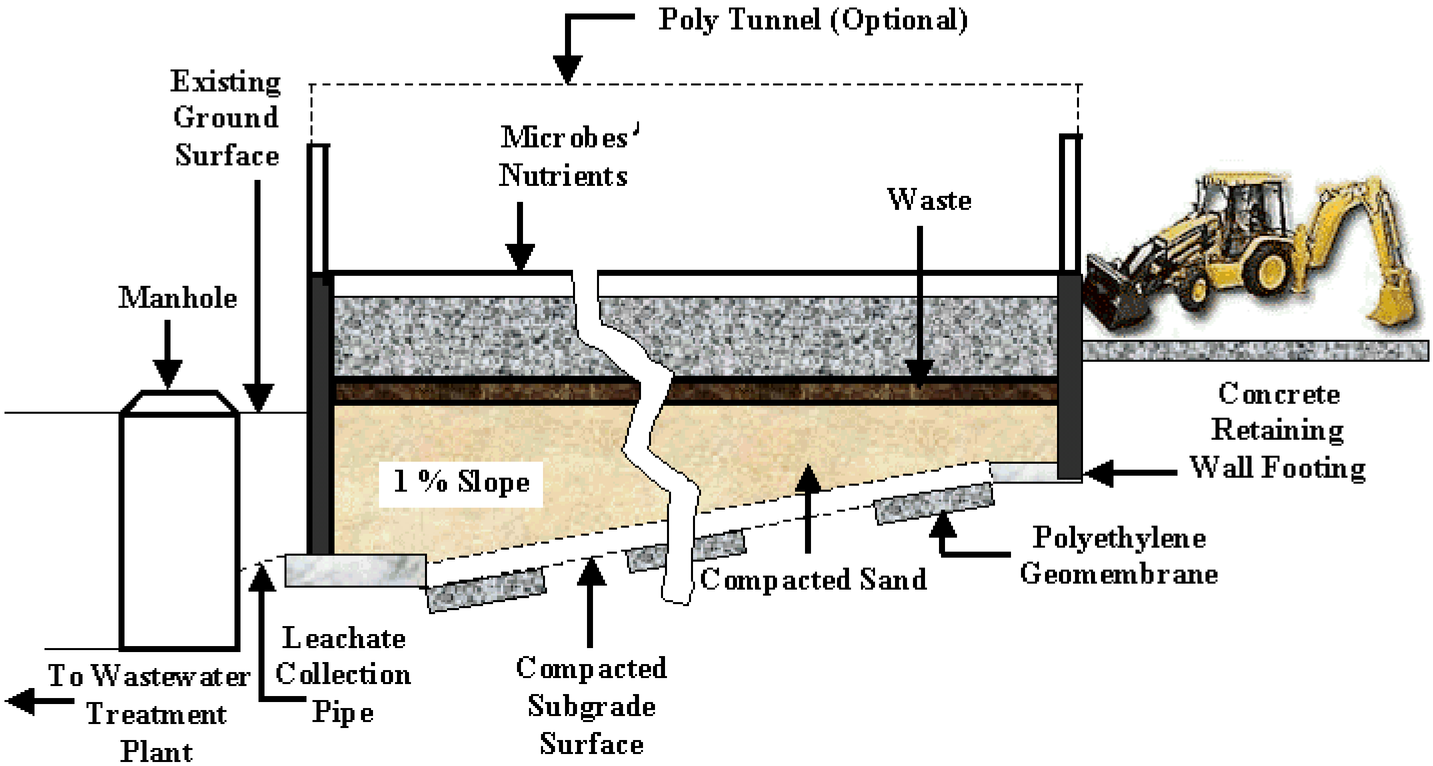
Numerous full-scale operations have been used, particularly for sludges produced by the petroleum industry. As with other biological treatments, under proper conditions, landfarming can transform contaminants into nonhazardous substances. Removal efficiencies, however, are a function of contaminant type and concentrations, soil type, temperature, moisture, waste loading rates, application frequency, aeration, volatilization, and other factors.

Cost:

Ranges of costs likely to be encountered are:

- Costs prior to treatment (assumed to be independent of volume to be treated): $25,000 to $50,000 for laboratory studies; and less than $100,000 for pilot tests or field demonstrations.
- Cost of prepared bed (ex situ treatment and placement of soil on a prepared liner): Under $100 per cubic meter (under $75 per cubic yard).

[Typical Landfarming Treatment Unit]



Technology>> Soil, Sediment, Bedrock and Sludge

>>3.1 In Situ Biological Treatment

>>4.3 Phytoremediation

Introduction>> Phytoremediation is a process that uses plants to remove, transfer, stabilize, and destroy contaminants in soil and sediment. Contaminants may be either organic or inorganic.

Description:

Phytoremediation is a process that uses plants to remove, transfer, stabilize, and destroy contaminants in soil and sediment. The mechanisms of phytoremediation include enhanced rhizosphere biodegradation, phyto-extraction (also called phyto-accumulation), phyto-degradation, and phyto-stabilization.

Enhanced Rhizosphere Biodegradation

Enhanced rhizosphere biodegradation takes place in the soil immediately surrounding plant roots. Natural substances released by plant roots supply nutrients to microorganisms, which enhances their biological activities. Plant roots also loosen the soil and then die, leaving paths for transport of water and aeration. This process tends to pull water to the surface zone and dry the lower saturated zones.

The most commonly used flora in phytoremediation projects are poplar trees, primarily because the trees are fastgrowing and can survive in a broad range of climates. In addition, poplar trees can draw large amounts of water (relative to other plant species) as it passes through soil or directly from an aquifer. This may draw greater amounts of dissolved pollutants from contaminated media and reduce the amount of water that may pass through soil or an aquifer, thereby reducing the amount of contaminant flushed though or out of the soil or aquifer.

Phyto-accumulation

Phyto-accumulation is the uptake of contaminants by plant roots and the translocation/accumulation (phytoextraction) of contaminants into plant shoots and leaves.

TOP *Phyto-degradation*

Phyto-degradation is the metabolism of contaminants within plant tissues. Plants produce enzymes, such as dehalogenase and oxygenase, that help catalyze degradation. Investigations are proceeding to determine if both aromatic and chlorinated aliphatic compounds are amenable to phyto-degradation.

Phyto-stabilization

Phyto-stabilization is the phenomenon of production of chemical compounds by plant to immobilize contaminants at the interface of roots and soil.

TOP Synonyms:

Vegetation-enhanced bioremediation.

TOP Applicability:

Phytoremediation may be applicable for the remediation of metals, pesticides, solvents, explosives, crude oil, PAHs, and landfill leachates.

Some plant species have the ability to store metals in their roots. They can be transplanted to sites to filter metals from wastewater. As the roots become saturated with metal contaminants, they can be harvested.

Hyper-accumulator plants may be able to remove and store significant amount of metallic contaminants.

Currently, trees are under investigation to determine their ability to remove organic contaminants from ground water, translocate and transpiration, and possibly metabolize them either to CO_2 or plant tissue.

Limitations:

Limitations to phytoremediation in soil include:

- The depth of the treatment zone is determined by plants used in phytoremediation. In most cases, it is limited to shallow soils.
- High concentrations of hazardous materials can be toxic to plants.
- It involves the same mass transfer limitations as other biotreatments.
- It may be seasonal, depending on location.
- It can transfer contamination across media, e.g., from soil to air.
- It is not effective for strongly sorbed (e.g., PCBs) and weakly sorbed contaminants.
- The toxicity and bioavailability of biodegradation products is not always known.

- Products may be mobilized into ground water or bioaccumulated in animals.
- It is still in the demonstration stage.
- It is unfamiliar to regulators.

Data Needs:

A detailed discussion of these data elements is provided in Subsection 2.2.1 (Data Requirements for Soil, Sediment, and Sludge). In addition, detailed information is needed to determine the kinds of soil used for phytoremediation projects. Water movement, reductive oxygen concentrations, root growth, and root structure all affect the growth of plants and should be considered when implementing phytoremediation.

Performance Data:

Currently, the Superfund Innovative Technology Evaluation (SITE) Program is attempting to demonstrate and evaluate the efficacy and cost of phytoremediation in the field at sites in Oregon, Utah, Texas, and Ohio.

USAEC is also leading the team of experts from EPA, Tennessee Valley Authority (TVA) and the Waterways Experimental Station (WES) to successfully demonstrate phytoremediation of explosive contaminated sites in Milan Army Ammunition Plant in Milan, TN.

AFCEE is currently conducting several phytoremediation demonstrations, including the following:

A "mature tree" study has been completed at Cape Canaveral Air Station. Live Oak, Saw-tooth Palmetto and Scrub Oak species in the midst of a TCE plume were evaluated for TCE transpiration and TCE transformation rates. Evapotranspiration rates were also measured. Mature trees were used in this study to obviate the waiting period for whips to grow into mature trees.

An initial planting of 110 trees in 1998 was followed by 200 (early 2000) and 150 (spring 2000) additional trees at Travis AFB, CA. The plantings are being used as hydraulic control for a TCE plume. This is a long-term test of the ability of trees to control the movement of groundwater.

A similar study is taking place at Altus AFB, OK. One hundred ten non seed-bearing hybrid cottonwood trees were planted in the fall of 1998. The plantings are being used as hydraulic control for a TCE plume. Soil moisture, groundwater levels, climatic conditions and sap flow rates are monitored remotely in this demonstration. A report on the results of the study will be released in the summer 2001.

A new effort was launched in the summer 2000, with five large-scale plantings planned for Fairchild, Offutt, Hill and Whiteman AFBs. Plantings should be complete by early 2001. More information can also be located at

TOP http://www.afcee.brooks.af.mil/er/ert/phytorem.htm.

Cost:

The key cost driver information and cost analysis was developed in 2006 using the Remedial Action Cost Engineering and Requirements (RACER) software.

Key Cost Drivers

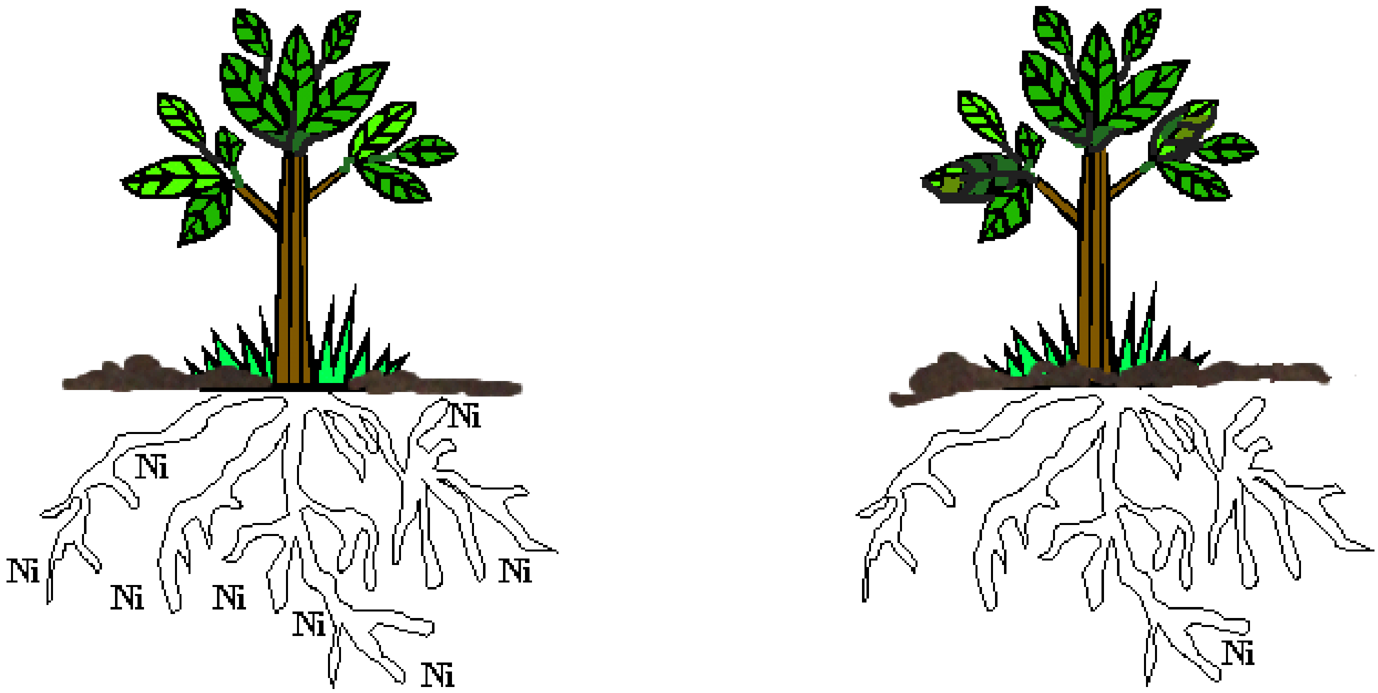
- Scale of effort
  - Area of contamination is the primary cost driver
- Density of sampling
  - Primary cost driver of sampling cost; may be directed by regulatory requirements.

Cost Analysis

The following table represents estimated costs (by common unit of measure) to apply phytoremediation technology at sites of varying size and complexity. A more detailed cost estimate table which includes specific site characteristics and significant cost elements that contributed to the final costs can be viewed by clicking on the link below.

SOIL TECHNOLOGY:	Phytoremediation			
RACER PARAMETERS	Scenario A	Scenario B	Scenario C	Scenario D
	Small Site		Large Site	
	Easy	Difficult	Easy	Difficult
COST PER SQUARE FOOT	$2	$7	$0.42	$1
COST PER CUBIC FOOT	$18	$66	$4	$14
COST PER CUBIC METER	$626	$2,322	$147	$483
COST PER CUBIC YARD	$479	$1,775	$112	$369

Typical In Situ Phytoremediation System



Technology>> Soil, Sediment, Bedrock and Sludge

>>3.10 In Situ Physical/Chemical Treatment

>>4.4 Chemical Oxidation

Introduction>> Oxidation chemically converts hazardous contaminants to non-hazardous or less toxic compounds that are more stable, less mobile, and/or inert. The oxidizing agents most commonly used are ozone, hydrogen peroxide, hypochlorites, chlorine, and chlorine dioxide.

Description:

The Chemical oxidants most commonly employed to date include peroxide, ozone, and permanganate. These oxidants have been able to cause the rapid and complete chemical destruction of many toxic organic chemicals; other organics are amenable to partial degradation as an aid to subsequent bioremediation. In general the oxidants have been capable of achieving high treatment efficiencies (*e.g.*, > 90 percent) for unsaturated aliphatic (*e.g.*, trichloroethylene [TCE]) and aromatic compounds (*e.g.*, benzene), with very fast reaction rates (90 percent destruction in minutes). Field applications have clearly affirmed that matching the oxidant and *in situ* delivery system to the contaminants of concern (COCs) and the site conditions is the key to successful implementation and achieving performance goals.

Ozone addition

Ozone gas can oxidize contaminants directly or through the formation of hydroxyl radicals. Like peroxide, ozone reactions are most effective in systems with acidic pH. The oxidation reaction proceeds with extremely fast, pseudo first order kinetics. Due to ozone's high reactivity and instability, O_3 is produced onsite, and it requires closely spaced delivery points (*e.g.*, air sparging wells). *In situ* decomposition of the ozone can lead to beneficial oxygenation and biostimulation.

Peroxide

Oxidation using liquid hydrogen peroxide (H_2O_2) in the presence of native or supplemental ferrous iron (Fe^{+2}) produces Fenton's Reagent which yields free hydroxyl

TOP radicals (OH^-). These strong, nonspecific oxidants can rapidly degrade a variety of organic compounds. Fenton's Reagent oxidation is most effective under very acidic pH (e.g., pH 2 to 4) and becomes ineffective under moderate to strongly alkaline conditions. The reactions are extremely rapid and follow second-order kinetics.

Permanganate

The reaction stoichiometry of permanganate (typically provided as liquid or solid $KMnO_4$, but also available in Na, Ca, or Mg salts) in natural systems is complex. Due to its multiple valence states and mineral forms, Mn can participate in numerous reactions. The reactions proceed at a somewhat slower rate than the previous two reactions, according to second order kinetics. Depending on pH, the reaction can include destruction by direct electron transfer or free radical advanced oxidation—permanganate reactions are effective over a pH range of 3.5 to 12.

TOP Synonyms:

DSERTS Code: N13 (Chemical Reduction/Oxidation).

Applicability:

The rate and extent of degradation of a target COC are dictated by the properties of the chemical itself and its susceptibility to oxidative degradation as well as the matrix conditions, most notably, pH, temperature, the concentration of oxidant, and the concentration of other oxidant-consuming substances such as natural organic matter and reduced minerals as well as carbonate and other free radical scavengers. Given the relatively indiscriminate and rapid rate of reaction of the oxidants with reduced substances, the method of delivery and distribution throughout a subsurface region is of paramount importance. Oxidant delivery systems often employ vertical or horizontal injection wells and sparge points with forced advection to rapidly move the oxidant into the subsurface.

Permanganate is relatively more stable and relatively more persistent in the subsurface; as a result, it can migrate by diffusive processes. Consideration also must be given to the effects of oxidation on the system. All three oxidation reactions can decrease the pH if the system is not buffered effectively. Other potential oxidation-induced effects include: colloid genesis leading to reduced permeability; mobilization of redox-sensitive and exchangeable sorbed metals; possible formation of toxic byproducts; evolution of heat and gas; and biological perturbation

TOP

Limitations:

The following factors may limit the applicability and effectiveness of chemcial oxidation include:

- Requirement for handling large quantities of hazardous oxidizing chemicals due to the oxidant demand of the target organic chemicals and the unproductive oxidant consumption of the formation.
- Some COCs are resistant to oxidation.
- There is a potential for process-induced detrimental effects. Further research and development is ongoing to advance the science and engineering of *in situ* chemical oxidation and to increase its overall cost effectiveness.

TOP

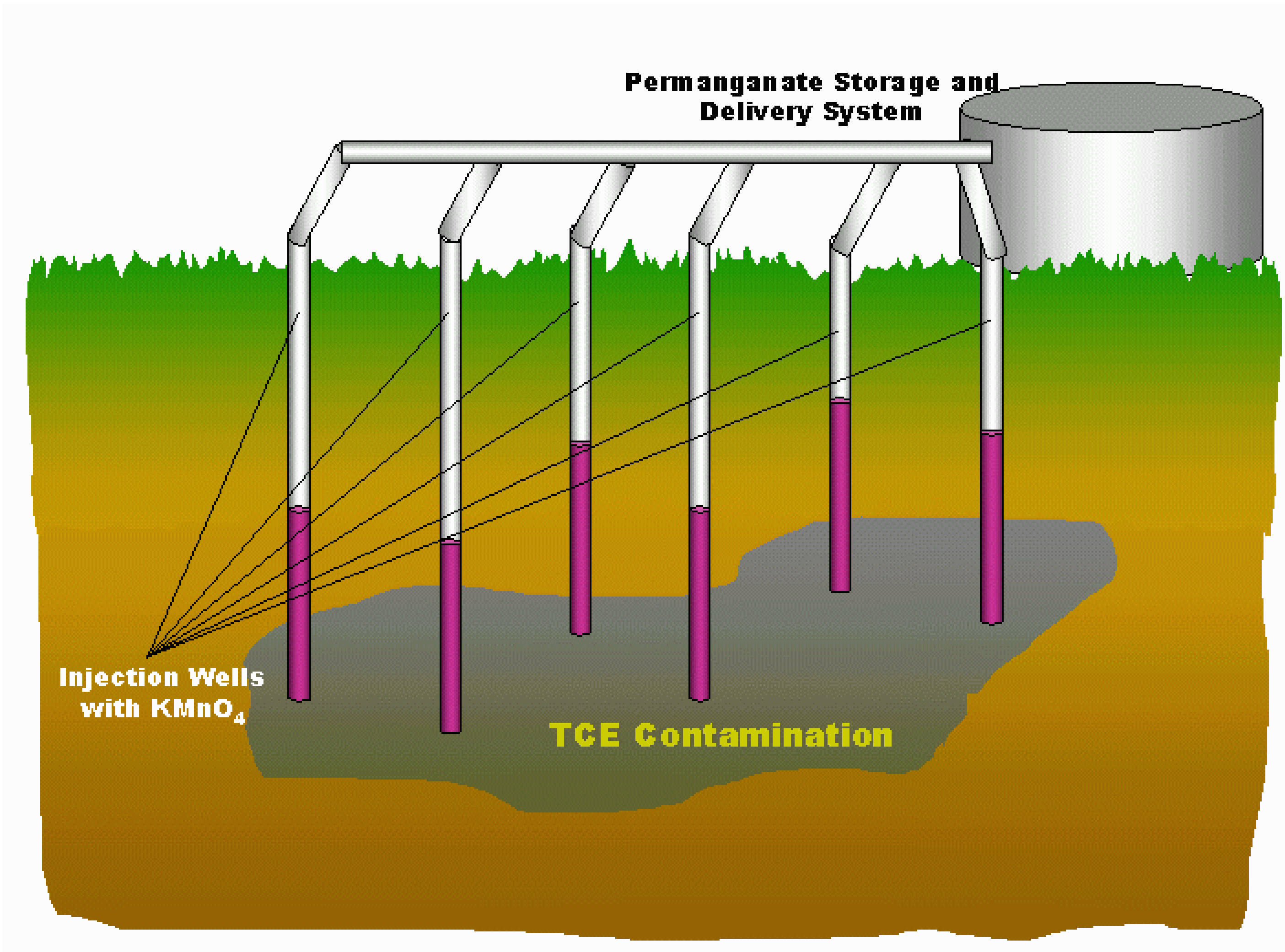
Data Needs:

Engineering of *in situ* chemical oxidation must be done with due attention paid to reaction chemistry and transport processes. It is also critical that close attention be paid to worker training and safe handling of process chemicals as well as proper management of remediation wastes. The design and implementation process should rely on an integrated effort involving screening level characterization tests and reaction transport modeling, combined with treatability studies at the lab and field scale.

Performance Data:

In situ chemical oxidation is a viable remediation technology for mass reduction in source areas as well as for plume treatment. The potential benefits of *in situ* oxidation include the rapid and extensive reactions with various COCs applicable to many bio-recalcitrant organics and subsurface environments. Also, *in situ* chemical oxidation can be tailored to a site and implemented with relatively simple, readily available equipment. Some potential limitations exist including the requirement for handling large quantities of hazardous oxidizing chemicals due to the oxidant demand of the target organic chemicals and the unproductive oxidant consumption of the formation; some COCs are resistant to oxidation; and there is a potential for process-induced detrimental effects. Further research and development is ongoing to advance the science and engineering of *in situ* chemical oxidation and to increase its overall cost effectiveness

Typical Chemical Oxidation System



Technology>> Soil, Sediment, Bedrock and Sludge

>>3.2 In Situ Physical/Chemical Treatment

>>4.8 Soil Vapor Extraction

Introduction>> Vacuum is applied through extraction wells to create a pressure/concentration gradient that induces gas-phase volatiles to be removed from soil through extraction wells. This technology also is known as in situ soil venting, in situ volatilization, enhanced volatilization, or soil vacuum extraction.

TOP Description:

Soil vapor extraction (SVE) is an in situ unsaturated (vadose) zone soil remediation technology in which a vacuum is applied to the soil to induce the controlled flow of air and remove volatile and some semivolatile contaminants from the soil. The gas leaving the soil may be treated to recover or destroy the contaminants, depending on local and state air discharge regulations. Vertical extraction vents are typically used at depths of 1.5 meters (5 feet) or greater and have been successfully applied as deep as 91 meters (300 feet). Horizontal extraction vents (installed in trenches or horizontal borings) can be used as warranted by contaminant zone geometry, drill rig access, or other site-specific factors.

For the soil surface, geomembrane covers are often placed over soil surface to prevent short circuiting and to increase the radius of influence of the wells.

Ground water depression pumps may be used to reduce ground water upwelling induced by the vacuum or to increase the depth of the vadose zone. Air injection is effective for facilitating extraction of deep contamination, contamination in low permeability soils, and contamination in the saturated zone (see Treatment Technology Profile 4.32, Air Sparging).

The duration of operation and maintenance for in situ SVE is typically medium- to long-term.

TOP Synonyms:

In situ soil venting; In situ volatilization; Enhanced volatilization.
DSERTS Code: M11 (Soil Vapor Extraction).

Applicability:

The target contaminant groups for in situ SVE are VOCs and some fuels. The technology is typically applicable only to volatile compounds with a Henry's law constant greater than 0.01 or a vapor pressure greater than 0.5 mm Hg (0.02 inches Hg). Other factors, such as the moisture content, organic content, and air permeability of the soil, will also affect in situ SVE's effectiveness. In situ SVE will not remove heavy oils, metals, PCBs, or dioxins. Because the process involves the continuous flow of air through the soil, however, it often promotes the in situ biodegradation of low-volatility organic compounds that may be present.

Limitations:

Factors that may limit the applicability and effectiveness of the process include:

- Soil that has a high percentage of fines and a high degree of saturation will require higher vacuums (increasing costs) and/or hindering the operation of the in situ SVE system.
- Large screened intervals are required in extraction wells for soil with highly variable permeabilities or stratification, which otherwise may result in uneven delivery of gas flow from the contaminated regions.
- Soil that has high organic content or is extremely dry has a high sorption capacity of VOCs, which results in reduced removal rates.
- Exhaust air from in situ SVE system may require treatment to eliminate possible harm to the public and the environment.
- As a result of off-gas treatment, residual liquids may require treatment/disposal. Spent activated carbon will definitely require regeneration or disposal.
- SVE is not effective in the saturated zone; however, lowering the water table can expose more media to SVE (this may address concerns regarding LNAPLs).

Data Needs:

A detailed discussion of these data elements is provided in Subsection 2.2.1 (Data Requirements for Soil, Sediment, and Sludge). Data requirements include the depth and areal extent of contamination, the concentration of the contaminants, depth to water table, and soil type and properties (e.g., structure, texture, permeability, and moisture content).

Pilot studies should be performed to provide design information, including extraction well, radius of influence, gas flow rates, optimal applied vacuum, and contaminant mass removal rates.

Performance Data:

A field pilot study is necessary to establish the feasibility of the method as well as to obtain information necessary to design and configure the system. During full-scale operation, in situ SVE can be run intermittently (pulsed operation) once the extracted mass

TOP removal rate has reached an asymptotic level. This pulsed operation can increase the cost-effectiveness of the system by facilitating extraction of higher concentrations of contaminants. After the contaminants are removed by in situ SVE, other remedial measures, such as biodegradation, can be investigated if remedial action objectives have not been met. In situ SVE projects are typically completed in 1 to 3 years.

Cost:

The key cost driver information and cost analysis was developed in 2006 using the Remedial Action Cost Engineering and Requirements (RACER) software.

Key Cost Drivers

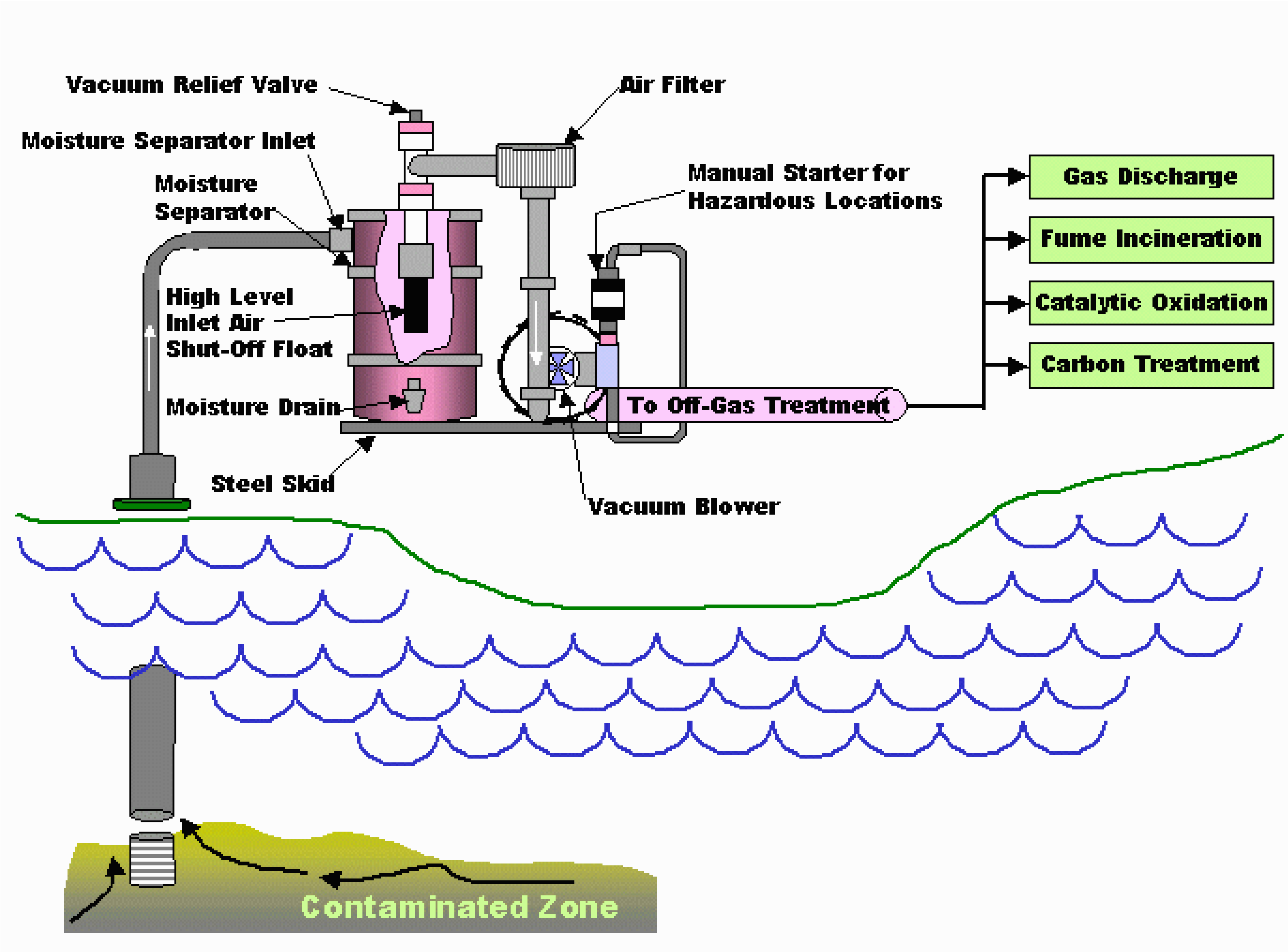
- Economy of Scale
    - Quantity of material treated has a large impact
- Soil Type
    - Based on the number of wells required
- Can be radically different if no airflow treatment is required

Cost Analysis

The following table represents estimated costs (by common unit of measure) to apply soil vapor extraction technology at sites of varying size and complexity.   A more detailed cost estimate table which includes specific site characteristics and significant cost elements that contributed to the final costs can be viewed by clicking on the link below.

SOIL TECHNOLOGY:	Soil Vapor Extraction			
RACER PARAMETERS	Scenario A	Scenario B	Scenario C	Scenario D
	Small Site		Large Site	
	Easy	Difficult	Easy	Difficult
COST PER CUBIC FOOT	$36	$42	$11	$27
COST PER CUBIC METER	$1,275	$1,485	$405	$975
COST PER CUBIC YARD	$944	$1,100	$300	$722

Typical In Situ Soil Vapor Extraction System



Technology>> Soil, Sediment, Bedrock and Sludge
>>3.5 Ex Situ Physical/Chemical Treatment (assuming excavation)
>>4.19 Soil Washing

Introduction>> Contaminants sorbed onto fine soil particles are separated from bulk soil in an aqueous-based system on the basis of particle size. The wash water may be augmented with a basic leaching agent, surfactant, pH adjustment, or chelating agent to help remove organics and heavy metals.

Description:

Ex situ soil separation processes (often referred to as "soil washing"), mostly based on mineral processing techniques, are widely used in Northern Europe and America for the treatment of contaminated soil. Soil washing is a water-based process for scrubbing soils ex situ to remove contaminants. The process removes contaminants from soils in one of the followingtwo ways:

- By dissolving or suspending them in the wash solution (which can be sustained by chemical manipulation of pH for a period of time); or
- By concentrating them into a smaller volume of soil through particle size separation, gravity separation, and attrition scrubbing (similar to those techniques used in sand and gravel operations).

Soil washing systems incorporating most of the removal techniques offer the greatest promise for application to soils contaminated with a wide variety of heavy metal, radionuclides, and organic contaminants. Commercialization of the process, however, is not yet extensive.

The concept of reducing soil contamination through the use of particle size separation is based on the finding that most organic and inorganic contaminants tend to bind, either chemically or physically, to clay, silt, and organic soil particles. The silt and clay, in turn, are attached to sand and gravel particles by physical processes, primarily compaction and adhesion. Washing processes that separate the fine (small) clay and silt particles from the coarser sand and gravel soil particles effectively separate and concentrate the contaminants into a smaller volume of soil that can be further treated or disposed of. Gravity separation is effective for removing high or low specific gravity particles such as heavy metal-containing compounds (lead, radium oxide, etc.). Attrition scrubbing removes adherent contaminant films from coarser particles. However, attrition washing can increase the fines in soils processed. The clean, larger fraction can be returned to the site for continued use.

Complex mixture of contaminants in the soil (such as a mixture of metals, nonvolatile organics, and SVOCs) and heterogeneous contaminant compositions throughout the soil mixture make it difficult to formulate a single suitable washing solution that will consistently and reliably remove all of the different types of contaminants. for these cases, sequential washing, using different wash formulations and/or different soil to wash fluid ratios, may be required.

Soil washing is generally considered a media transfer technology. The contaminated water generated from soil washing are treated with the technology(s) suitable for the contaminants.

The duration of soil washing is typically short- to medium-term.

Synonyms:

DSERTS Code: N15 (Soil Washing).

Applicability:

The target contaminant groups for soil washing are SVOCs, fuels, and heavy metals. The technology can be used on selected VOCs and pesticides. The technology offers the ability for recovery of metals and can clean a wide range of organic and inorganic contaminants from coarse-grained soils.

Limitations:

Factors that may limit the applicability and effectiveness of the process include:

- Complex waste mixtures (e.g., metals with organics) make formulating washing fluid difficult.
- High humic content in soil may require pretreatment.
- The aqueous stream will require treatment at demobilization.
- Additional treatment steps may be required to address hazardous levels of washing solvent remaining in the treated residuals.
- It may be difficult to remove organics adsorbed onto clay-size particles.

Data Needs:

A detailed discussion of these data elements is provided in Subsection 2.2.1 (Data

Requirements for Soil, Sediment, and Sludge). Particle size distribution (0.24 to 2 mm optimum range); soil type, physical form, handling properties, and moisture content; contaminant type and concentration; texture; organic content; cation exchange capacity; pH and buffering capacity. A complete bench scale treatability study should always be completed before applying this technology as a remedial solution.

Performance Data:

At the present time, soil washing is used extensively in Europe but has had limited use in the United States. During 1986-1989, the technology was one of the selected source control remedies at eight Superfund sites.

Soil washing provides a cost effective and environmentally proactive alternative to stabilization and landfilling. Two pilot scale demonstrations were carried out at Fort Polk, Louisiana in 1996. These employed commercially available unit processes - physical separation/acid leaching systems. The system employed acetic acid as the leaching agent, and the other, hydrochloric acid. Input soil had a lead content of approximately 3500 mg/kg. The hydrochloric acid system was most effective. Processed soil had total lead concentration of 200 mg/kg and TCLP levels for lead of approximately 2 mg/L. The through put rate was approximately 6 tons per hour. Choice of acid leaching agent is a function of specific soil chemistry and degree of solubility required.

Cost:

The key cost driver information and cost analysis was developed in 2006 using the Remedial Action Cost Engineering and Requirements (RACER) software.

Key Cost Drivers

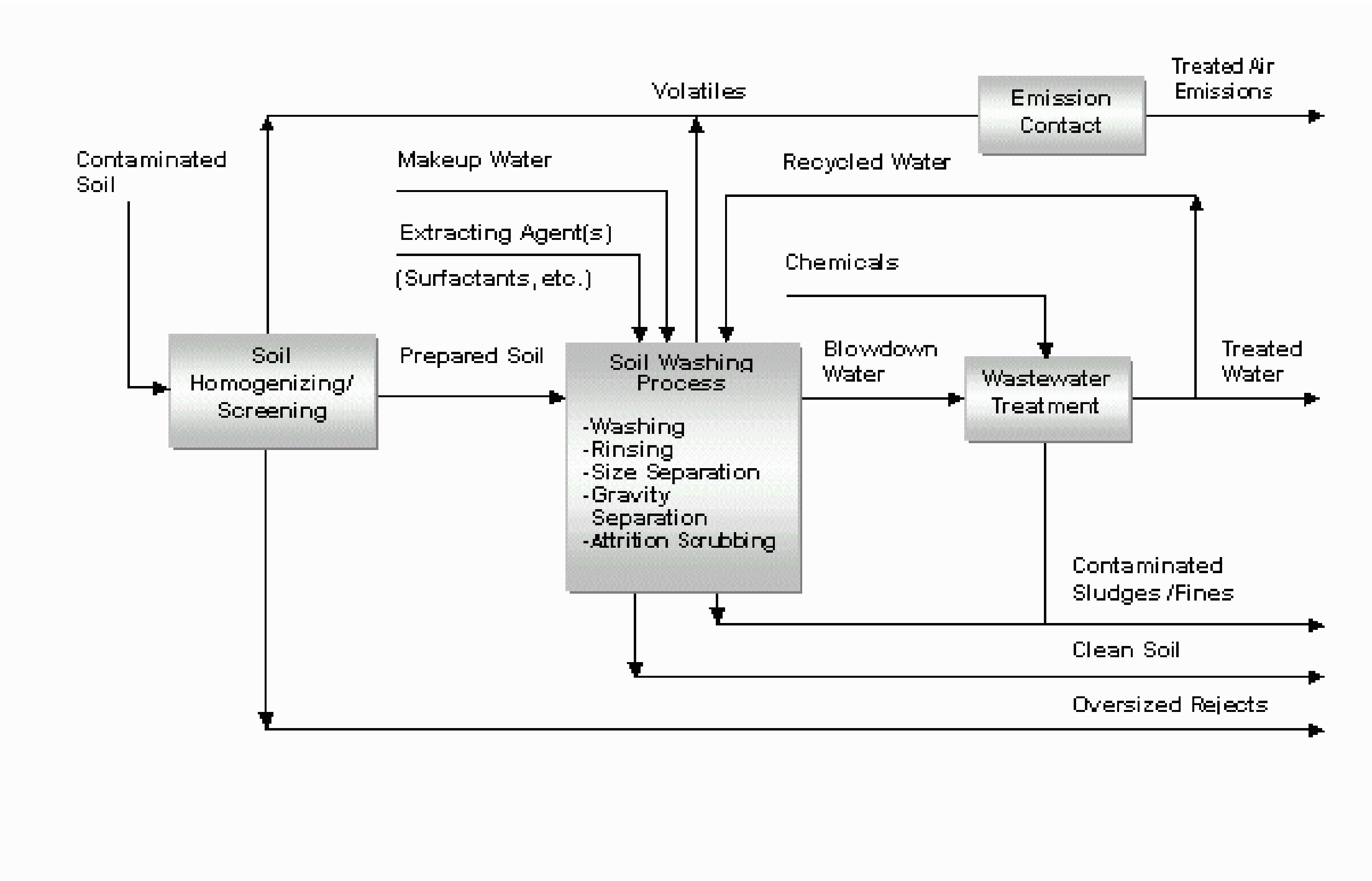
- Economy of Scale
  - Quantity of material treated has a large impact
- Processor speed
  - Also depends on the amount of waste being processed

Cost Analysis

The following table represents estimated costs (by common unit of measure) to apply soil washing technology at sites of varying size and complexity. A more detailed cost estimate table which includes specific site characteristics and significant cost elements that contributed to the final costs can be viewed by clicking on the link below.

SOIL TECHNOLOGY:	Soil Washing	
RACER PARAMETERS	Scenario A	Scenario B
	Small Site	Large Site
COST PER CUBIC FOOT	$5	$2
COST PER CUBIC METER	$187	$70
COST PER CUBIC YARD	$142	$53

Typical Soil Washing Process



Technology>> Soil, Sediment, Bedrock and Sludge

>>3.2 In Situ Physical/Chemical Treatment

>>4.9 Solidification/Stabilization

Introduction>> Contaminants are physically bound or enclosed within a stabilized mass (solidification), or chemical reactions are induced between the stabilizing agent and contaminants to reduce their mobility (stabilization).

Description:

Solidification/stabilization (S/S) reduces the mobility of hazardous substances and contaminants in the environment through both physical and chemical means. Unlike other remedial technologies, S/S seeks to trap or immobilize contaminants within their "host" medium (i.e., the soil, sand, and/or building materials that contain them) instead of removing them through chemical or physical treatment. Leachability testing is typically performed to measure the immobilization of contaminants. S/S techniques can be used alone or combined with other treatment and disposal methods to yield a product or material suitable for land disposal or, in other cases, that can be applied to beneficial use. These techniques have been used as both final and interim remedial measures.

Auger/caisson systems and injector head systems are techniques used in soil S/S. They apply S/S agents to soils to trap or immobilize contaminants.

Bottom barriers are horizontal subsurface barriers that prevent vertical migration by providing a floor of impermeable material beneath the waste. The installation of a grout injection bottom barrier involves directional drilling with forced grout injection. Implementation of this technology is highly dependent on the physical properties of soil.

In Situ Vitrification (ISV)

In situ vitrification (ISV) is another in situ S/S process which uses an electric current to melt soil or other earthen materials at extremely high temperatures (1,600 to 2,000 °C or 2,900 to 3,650 °F) and thereby immobilize most inorganics and destroy organic pollutants by pyrolysis. Inorganic pollutants are incorporated within the vitrified glass and crystalline mass. Water vapor and organic pyrolysis combustion products are captured in a hood, which draws the contaminants into an off-gas treatment system that removes particulates and other pollutants from the gas. The vitrification product is a chemically stable, leach-resistant, glass and crystalline material similar to obsidian or basalt rock. The process

TOP destroys and/or removes organic materials. Radionuclides and heavy metals are retained within the molten soil.

The timeframe for in situ S/S is short- to medium-term, while in situ ISV process is typically short-term.

Synonyms:

In Situ Vitrification

DSERTS Codes:

M13 (Vitrification).
N11 (Solidification/Stabilization)

TOP

TOP Applicability:

The target contaminant group for in situ S/S is generally inorganics (including radionuclides).

The Auger/Caisson and Reagent/Injector Head Systems have limited effectiveness against SVOCs and pesticides and no expected effectiveness against VOCs; however, systems designed to be more effective in treating organics are being developed and tested.

The ISV process can destroy or remove organics and immobilize most inorganics in contaminated soils, sludge, or other earthen materials. The process has been tested on a broad range of VOCs and SVOCs, other organics including dioxins and PCBs, and on most priority pollutant metals and radionuclides.

Limitations:

Factors that may limit the applicability and effectiveness of the in situ S/S include:

- Depth of contaminants may limit some types of application processes.
- Future usage of the site may "weather" the materials and affect ability to maintain immobilization of contaminants.
- Some processes result in a significant increase in volume (up to double the original volume).
- Certain wastes are incompatible with variations of this process. Treatability studies are generally required.
- Reagent delivery and effective mixing are more difficult than for ex situ applications.
- Like all in situ treatments, confirmatory sampling can be more difficult than for ex situ treatments.
- The solidified material may hinder future site use.
- Processing of contamination below the water table may require dewatering.

TOP

TOP Data Needs:

A detailed discussion of these data elements is provided in Subsection 2.2.1 (Data Requirements for Soil, Sediment, and Sludge). Data needs include particle size, Atterberg limits, moisture content, metal concentrations, sulfate content, organic content, density, permeability, unconfined compressive strength, leachability, pH, and microstructure analysis. For ISV, a minimum alkali content in soil (sodium and potassium oxides) of 1.4 wt% is necessary to form glass. The composition of most soils is well within the range of processability.

TOP Performance Data:

Auger/Caisson and Reagent/Injector Head Systems processes are well demonstrated, can be applied to the most common site and waste types, require conventional materials handling equipment, and are available competitively from a number of vendors. Most reagents and additives are also widely available and relatively inexpensive industrial commodities.

Auger/Caisson and Reagent/Injector Head Systems processes have demonstrated the capability to reduce the mobility of contaminated waste by greater than 95%. The effects, over the long term, of weathering (e.g., freeze-thaw cycles, acid precipitation, and wind erosion), ground water infiltration, and physical disturbance associated with uncontrolled future land use can significantly affect the integrity of the stabilized mass and contaminant mobility in ways that cannot be predicted by laboratory tests.

There have been few, if any, commercial applications of ISV. The ISV process has been operated for test and demonstration purposes at the pilot scale and at full scale at the following sites: (1) Geosafe Corporation's test site, (2) DOE's Hanford Nuclear Reservation, (3) DOE's Oak Ridge National Laboratory, and (4) DOE's Idaho National Engineering Laboratory. More than 170 tests at various scales have been performed on a broad range of waste types in soils and sludge. A demonstration will take place at the Parsons/ETM site in Grand Ledge, Michigan, where the process is currently operating.

Process depths up to 6 meters (19 ft) have been achieved in relatively homogeneous soils. The achievable depth is limited under certain heterogeneous conditions.

Cost:

Costs for Auger/Caisson and Reagent/Injector Head Systems processes vary widely according to materials or reagents used, their availability, project size, and chemical nature of contaminants (e.g., types and concentration levels for shallow applications). The in situ soil mixing/auger techniques average $50 to $80 per cubic meter ($40 to $60 per cubic yard) for the shallow applications and $190 to $330 per cubic meter ($150 to $250 per cubic yard) for the deeper applications.

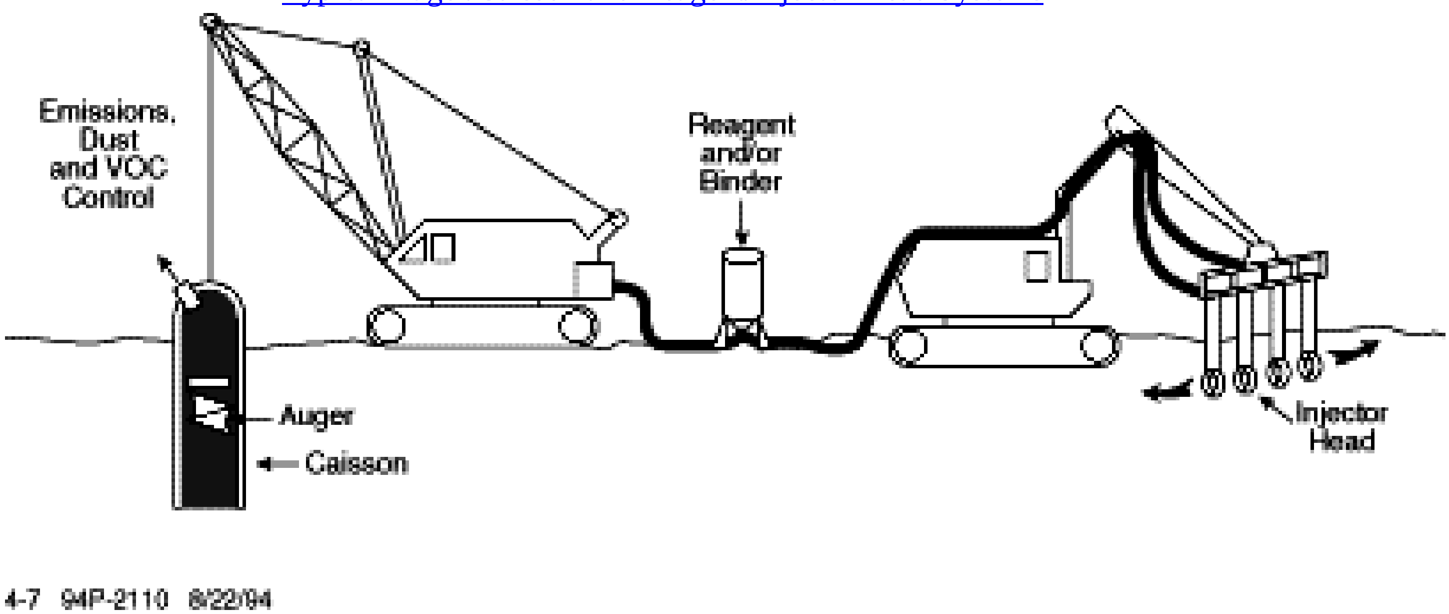
The shallow soil mixing technique processes 36 to 72 metric tons (40 to 80 tons) per hour on average, and the deep soil mixing technique averages 18 to 45 metric tons (20 to 50 tons) per hour.

The major factor driving the selection process beyond basic waste compatibility is the availability of suitable reagents. Auger/Caisson and Reagent/Injector Head Systems processes require that potentially large volumes of bulk reagents and additives be transported to project sites. Transportation costs can dominate project economics and can quickly become uneconomical in cases where local or regional material sources are unavailable.

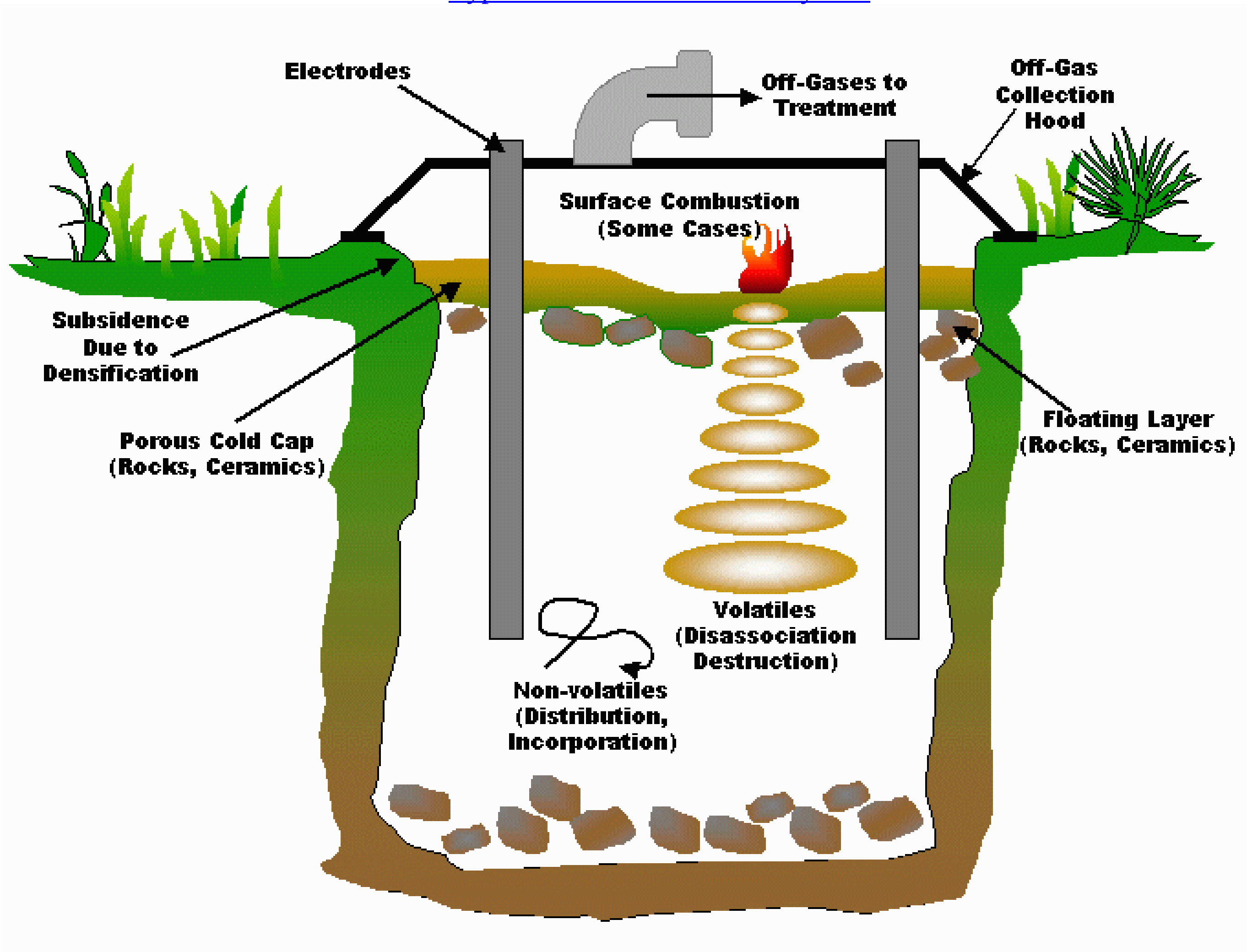
The cost for grout injection varies depending on site-specific conditions. Costs for drilling can range from $50 to $150/ft and grouting from $50 to $75/ft, not including mobilization, wash disposal, or adverse site condition expenses.

For ISV, average costs for treatability tests (all types) are $25K plus analytical fees; for PCBs and dioxins, the cost is $30K plus analytical. Equipment mobilization and demobilization costs are $200K to $300K combined. Vitrification operation cost varies with electricity costs, quantity of water, and depth of process. One recent study on the west coast estimated vitrification costs at $375-425 per ton of soil treated; while another study in the midwest estimated vitrification costs at $267 per cubic yard.

Typical Auger/Caisson and Reagent/Injector Head Systems



Typical In Situ Vitrification System



Technology>> Soil, Sediment, Bedrock and Sludge

>>3.5 Ex Situ Physical/Chemical Treatment (assuming excavation)

>>4.15 Chemical Extraction

Introduction>> Waste contaminated soil and extractant are mixed in an extractor, thereby dissolving the contaminants. The extracted solution is then placed in a separator, where the contaminants and extractant are separated for treatment and further use.

Description:

Chemical extraction does not destroy wastes but is a means of separating hazardous contaminants from soils, sludges, and sediments, thereby reducing the volume of the hazardous waste that must be treated. The technology uses an extracting chemical and differs from soil washing, which generally uses water or water with wash-improving additives. Commercial-scale units are in operation. They vary in regard to the chemical employed, type of equipment used, and mode of operation.

Physical separation steps are often used before chemical extraction to grade the soil into coarse and fine fractions, with the assumption that the fines contain most of the contamination. Physical separation can also enhance the kinetics of extraction by separating out particulate heavy metals, if these are present in the soil.

Acid Extraction

Acid can also be used as the extractant. Acid extraction uses hydrochloric acid to extract heavy metal contaminants from soils. In this process, soils are first screened to remove coarse solids. Hydrochloric acid is then introduced into the soil in the extraction unit. The residence time in the unit varies depending on the soil type, contaminants, and contaminant concentrations, but generally ranges between 10 and 40 minutes. The soil-extractant mixture is continuously pumped out of the mixing tank, and the soil and extractant are separated using hydrocyclones.

When extraction is complete, the solids are transferred to the rinse system. The soils are rinsed with water to remove entrained acid and metals. The extraction solution and rinse waters are regenerated using comercially available precipitants, such as sodium hydroxide, lime, or other proprietary formulations, along with a flocculent that removes the metals and reforms the acid. The heavy metals are concentrated in a form potentially suitable for recovery. During the final step, the soils are dewatered and mixed with lime and fertilizer

TOP to neutralize any residual acid.

Solvent Extraction

Solvent extraction is a common form of chemical extraction using organic solvent as the extractant. It is commonly used in combination with other technologies, such as solidification/stabilization, incineration, or soil washing, depending upon site-specific conditions. Solvent extraction also can be used as a stand alone technology in some instances. Organically bound metals can be extracted along with the target organic contaminants, thereby creating residuals with special handling requirements. Traces of solvent may remain within the treated soil matrix, so the toxicity of the solvent is an important consideration. The treated media are usually returned to the site after having met Best Demonstrated Available Technology (BDAT) and other standards.

The duration of operations and maintenance for chemical extraction is medium-term.

TOP Synonyms:

DSERTS Codes:

N16 (Acid Extraction)
N17 (Solvent Extraction)

TOP Applicability:

Solvent extraction has been shown to be effective in treating sediments, sludges, and soils containing primarily organic contaminants such as PCBs, VOCs, halogenated solvents, and petroleum wastes. The process has been shown to be applicable for the separation of the organic contaminants in paint wastes, synthetic rubber process wastes, coal tar wastes, drilling muds, wood-treating wastes, separation sludges, pesticide/insecticide wastes, and petroleum refinery oily wastes.

Acid extraction is suitable to treat sediments, sludges, and soils contaminated by heavy metals.

Limitations:

Factors that may limit the applicability and effectiveness of the process include:

- Some soil types and moisture content levels will adversely impact process performance.
- Higher clay content may reduce extraction efficiency and require longer contact times.
- Organically bound metals can be extracted along with the target organic pollutants, which restricts handling of the residuals.
- The presence of detergents and emulsifiers can unfavorably influence the

extraction performance.
- Traces of solvent may remain in the treated solids; the toxicity of the solvent is an important consideration.
- Solvent extraction is generally least effective on very high molecular weight organic and very hydrophilic substances.
- After acid extraction, any residual acid in treated soil needs to be neutralized.
- Capital costs can be relatively high and the technology may be more economical at larger sites.
- Meeting highly stringent heavy metals criteria (e.g., passing the California WET test) may prove uneconomical.

TOP Data Needs:

A detailed discussion of these data elements is provided in Subsection 2.2.1 (Data Requirements for Soil, Sediment, and Sludge). It is important to determine whether mass transfer or equilibrium will be controlling. The controlling factor is critical to the design of the unit and to the determination of whether the technology is appropriate for the waste.

Soil properties that should be determined include particle size; pH; partition coefficient; cation exchange capacity; organic content; TCLP; moisture content; and the presence of metals, volatiles, clays, and complex waste mixtures.

TOP Performance Data:

The performance data currently available are mostly from Resource Conservation Company (RCC). The ability of RCC's full-scale B.E.S.T.™ process to separate oily feedstock into product fractions was evaluated by EPA at the General Refining Superfund site near Savannah, Georgia, in February 1987. The treated soils from this unit were backfilled to the site, product oil was recycled as a fuel oil blend, and the recovered water was pH-adjusted and transported to a local industrial wastewater treatment facility.

Cost:

The key cost driver information and cost analysis was developed in 2006 using the Remedial Action Cost Engineering and Requirements (RACER) software.

Key Cost Drivers

- Economy of Scale
    - Quantity of material treated has a large impact
- Moisture content in waste

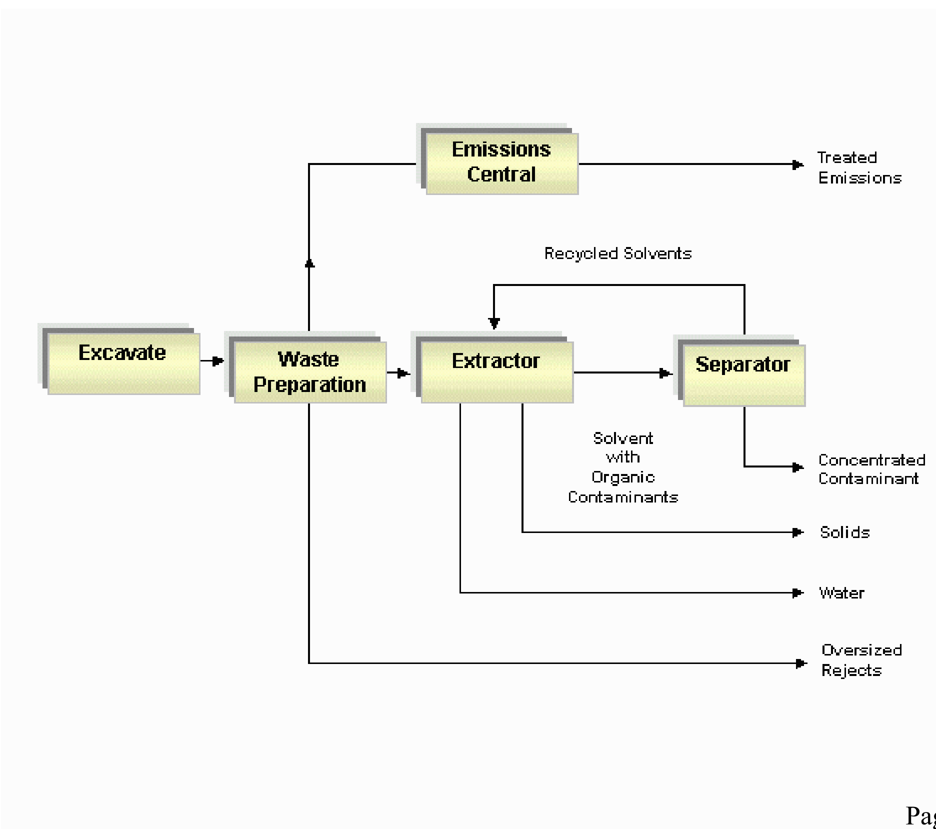
- o Slight increase in costs between soil and sludge

Cost Analysis

The following table represents estimated costs (by common unit of measure) to apply chemical extraction technology at sites of varying size and complexity. A more detailed cost estimate table which includes specific site characteristics and significant cost elements that contributed to the final costs can be viewed by clicking on the link below.

SOIL TECHNOLOGY:	Chemical Extraction			
RACER PARAMETERS	Scenario A	Scenario B	Scenario C	Scenario D
	Small Site		Large Site	
	Easy	Difficult	Easy	Difficult
COST PER CUBIC FOOT	$45	$49	$10	$10
COST PER CUBIC METER	$1,582	$1,717	$358	$361
COST PER CUBIC YARD	$1,202	$1,305	$272	$275

Typical Chemical Extraction Process



Technology>> Soil, Sediment, Bedrock and Sludge

>>3.2 In Situ Physical/Chemical Treatment

>>4.5 Electrokinetic Separation

Introduction>> The Electrokinetic Remediation (ER) process removes metals and organic contaminants from low permeability soil, mud, sludge, and marine dredging. ER uses electrochemical and electrokinetic processes to desorb, and then remove, metals and polar organics. This in situ soil processing technology is primarily a separation and removal technique for extracting contaminants from soils.

Description:

The principle of electrokinetic remediation relies upon application of a low-intensity direct current through the soil between ceramic electrodes that are divided into a cathode array and an anode array. This mobilizes charged species, causing ions and water to move toward the electrodes. Metal ions, ammonium ions, and positively charged organic compounds move toward the cathode. Anions such as chloride, cyanide, fluoride, nitrate, and negatively charged organic compounds move toward the anode. The current creates an acid front at the anode and a base front at the cathode. This generation of acidic condition in situ may help to mobilize sorbed metal contaminants for transport to the collection system at the cathode.

The two primary mechanisms transport contaminants through the soil towards one or the other electrodes: electromigration and electroosmosis. In electromigration, charged particles are transported through the substrate. In contrast, electroosmosis is the movement of a liquid containing ions relative to a stationary charged surface. Of the two, electromigration is the main mechanism for the ER process. The direction and rate of movement of an ionic species will depend on its charge, both in magnitude and polarity, as well as the magnitude of the electroosmosis-induced flow velocity. Non-ionic species, both inorganic and organic, will also be transported along with the electroosmosis induced water flow.

Two approaches are taken during electrokinetic remediation: "Enhanced Removal" and "Treatment without Removal".

"Enhanced Removal" is achieved by electrokinetic transport of contaminants toward the polarized electrodes to concentrate the contaminants for subsequent removal and ex-situ treatment. Removal of contaminants at the electrode may be accomplished by several means among which are: electroplating at the electrode; precipitation or co-precipitation at the electrode; pumping of water near the electrode; or complexing with ion exchange

TOP resins. Enhanced removal is widely used on remediation of soils contaminated metals.

"Treatment without Removal" is achieved by electro-osmotic transport of contaminants through treatment zones placed between electrodes. The polarity of the electrodes is reversed periodically, which reverses the direction of the contaminants back and forth through treatment zones. The frequency with which electrode polarity is reversed is determined by the rate of transport of contaminants through the soil. This approach can be used on in-situ remediation of soils contaminated with organic species.

TOP Synonyms:

Electrokinetics; Electromigration.

TOP Applicability:

Targeted contaminants for electrokinetics are heavy metals, anions, and polar organics in soil, mud, sledge, and marine dredging. Concentrations that can be treated range from a few parts per million (ppm) to tens of thousands ppm. Electrokinetics is most applicable in low permeability soils. Such soils are typically saturated and partially saturated clays and silt-clay mixtures, and are not readily drained.

Limitations:

Factors that may limit the applicability and effectiveness of this process include:

- Effectiveness is sharply reduced for wastes with a moisture content of less than 10 percent. Maximum effectiveness occurs if the moisture content is between 14 and 18 percent.
- The presence of buried metallic or insulating material can induce variability in the electrical conductivity of the soil, therefore, the natural geologic spatial variability should be delineated. Additionally, deposits that exhibit very high electrical conductivity, such as ore deposits, cause the technique to be inefficient.
- Inert electrodes, such as carbon, graphite, or platinum, must be used so that no residue will be introduced into the treated soil mass. Metallic electrodes may dissolve as a result of electrolysis and introduce corrosive products into the soil mass.
- Electrokinetics is most effective in clays because of the negative surface charge of TOP clay particles. However, the surface charge of the clay is altered by both charges in the pH of the pore fluid and the adsorption of contaminants. Extreme pH at the electrodes and reduction-oxidation changes induced by the process electrode reactions many inhibit ER’s effectiveness, although acidic conditions (i.e., low pH) may help to remove metals.
- Oxidation/reduction reactions can form undesirable products (e.g., chlorine gas).

TOP Data Needs:

A detailed discussion of data elements is provided in Subsection 2.2.1 (Data Requirements for Soil, Sediment and Sludge).

TOP Performance Data:

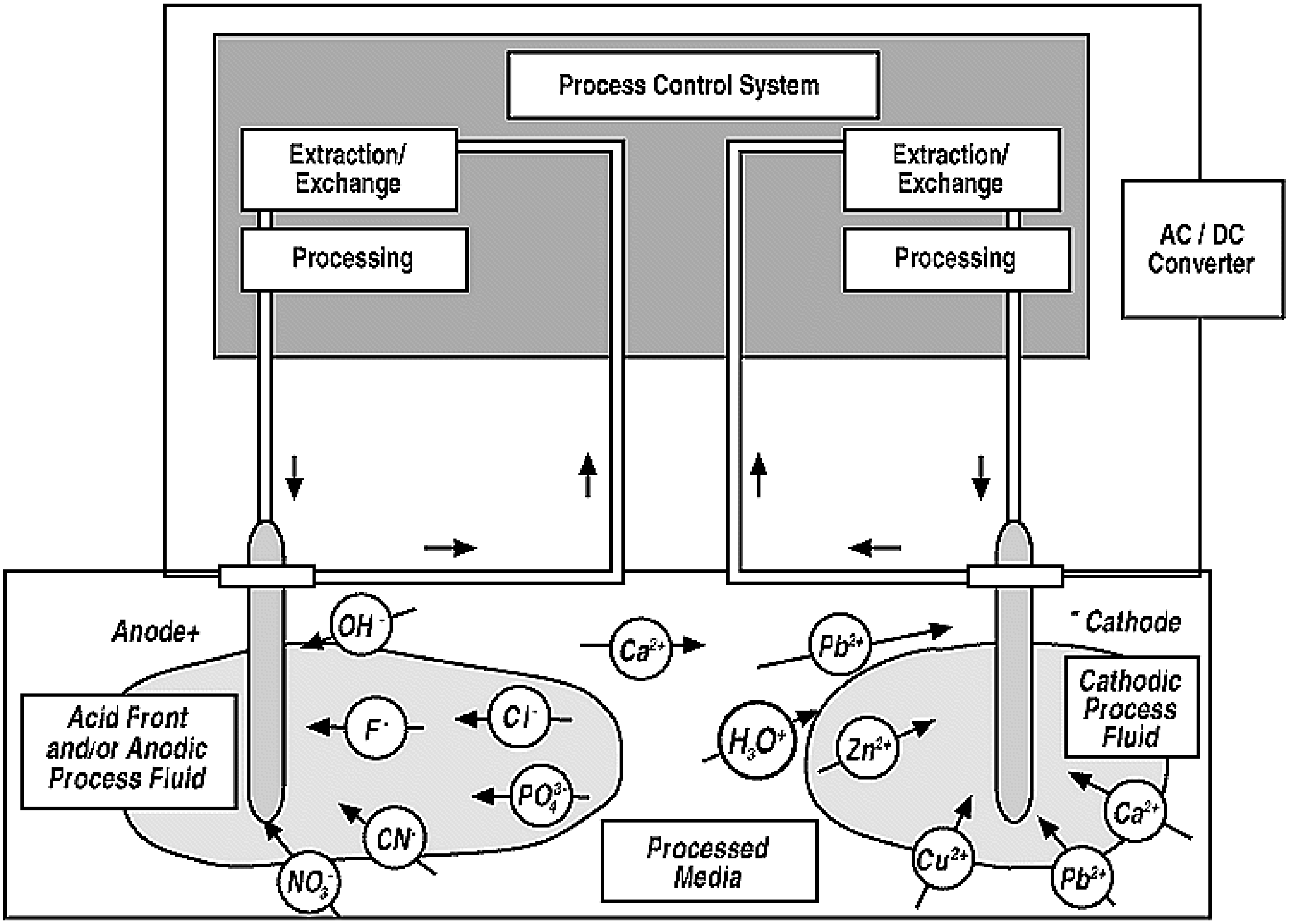
There have been few, if any, commercial applications of electrokinetic remediation in the United States. The electrokinetic technology has been operated for test and demonstration purposes at the pilot scale and at full scale at the following sites: (1) Louisiana State University, (2) Electrokinetics, Inc., (3) Geokinetics International, Inc., and (4) Battelle Memorial Institute. Geokinetics International, Inc.(GII) has successfully demonstrated the in situ electrokinetic remediation process in five field sites in Europe.

In 1996, a comprehensive demonstration study of lead extraction at a U.S.Army firing range in Louisiana was conducted by DoD's Small Business Innovative Research Program and Electrokinetics, Inc. The EPA taking part in independent assessments of the results, found pilot-scale studies have demonstrated that concentrations of lead decreased to less than 300 mg/kg in 30 weeks of electrokinetic processing when the soils where originally contaminated as high as 4,500 mg/kg of lead.

Cost:

Costs will vary with the amount of soil to be treated, the conductivity of the soil, the type of contaminant, the spacing of electrodes, and the type of process design employed. Ongoing pilot-scale studies using "real-world" soils indicate that the energy expenditures in extraction of metals from soils may be 500 kWh/m^3 or more at electrode spacing of 1.0m to 1.5m. Direct costs estimates of about $\$15/m^3$ for a suggested energy expenditure of $0.03 per kilowatt hours, together with the cost of enhancement, could result in direct costs of $\$50/m^3$ or more. A recent study estimated full scale costs at $117 per cubic meter. If no other efficient in situ technology is available to remediate fine-grained and heterogeneous subsurface deposits contaminated with metals, this technique would remain potentially competitive.

Typical In Situ Electrokinetic Separation System



Technology>> Soil, Sediment, Bedrock and Sludge

>>3.3 In Situ Thermal Treatment

>>4.10 Thermal Treatment

Introduction>> Steam/hot air injection or electrical resistance/electromagnetic/fiber optic/radio frequency heating is used to increase the volatilization rate of semi-volatiles and facilitate extraction.

Description:

Thermally enhanced SVE is a full-scale technology that uses electrical resistance/electromagnetic/fiber optic/radio frequency heating or hot-air/steam injection to increase the volatilization rate of semi-volatiles and facilitate extraction. The process is otherwise similar to standard SVE (Treatment Technology Profile 4.7), but requires heat resistant extraction wells.

Thermally enhanced SVE is normally a short- to medium-term technology.

Electrical Resistance Heating

Electrical resistance heating uses an electrical current to heat less permeable soils such as clays and fine-grained sediments so that water and contaminants trapped in these relatively conductive regions are vaporized and ready for vacuum extraction. Electrodes are placed directly into the less permeable soil matrix and activated so that electrical current passes through the soil, creating a resistance which then heats the soil. The heat dries out the soil causing it to fracture. These fractures make the soil more permeable allowing the use of SVE to remove the contaminants. The heat created by electrical resistance heating also forces trapped liquids to vaporize and move to the steam zone for removal by SVE. Six-phase soil heating (SPSH) is a typical electrical resistance heating which uses low-frequency electricity delivered to six electrodes in a circular array to heat soils. With SPSH, the temperature of the soil and contaminant is increased, thereby increasing the contaminant's vapor pressure and its removal rate. SPSH also creates an in situ source of steam to strip contaminants from soil. At this time SPSH is in the demonstration phase, and all large scale in situ projects utilize three-phase soil heating.

Radio Frequency/Electromagnetic Heating

Radio frequency heating (RFH) is an in situ process that uses electromagnetic energy to

TOP heat soil and enhance soil vapor extraction (SVE). RFH technique heats a discrete volume of soil using rows of vertical electrodes embedded in soil (or other media). Heated soil volumes are bounded by two rows of ground electrodes with energy applied to a third row midway between the ground rows. The three rows act as a buried triplate capacitor. When energy is applied to the electrode array, heating begins at the top center and proceeds vertically downward and laterally outward through the soil volume. The technique can heat soils to over 300 °C.

RFH enhances SVE in four ways: (1) contaminant vapor pressure and diffusivity are increased by heating, (2) the soil permeability is increased by drying, (3) an increase in the volatility of the contaminant from in situ steam stripping by the water vapor; and, (4) a decrease in the viscosity which improves mobility. The technology is self limiting; as the soil heats and dries, current will stop flowing. Extracted vapor can then be treated by a variety of existing technologies, such as granular activated carbon or incineration.

Hot Air/Steam Injection

Hot air or steam is injected below the contaminated zone to heat up contaminated soil. The heating enhances the release of contaminants form soil matrix. Some VOCs and SVOCs are stripped from contaminated zone and brought to the surface through soil vapor extraction.

TOP Synonyms:

DSERTS Code: M14 (Thermally Enhanced Soil Vapor Extraction).

TOP Applicability:

High moisture content is a limitation of standard SVE that thermally enhancement may help overcome. Heating, especially radio frequency heating and electrical resistance heating can improve air flow in high moisture soils by evaporating water. The system is designed to treat SVOCs but will consequently treat VOCs. Thermally enhanced SVE technologies also are effective in treating some pesticides and fuels, depending on the temperatures achieved by the system. After application of this process, subsurface conditions are excellent for biodegradation of residual contaminants.

Limitations:

The following factors may limit the applicability and effectiveness of the process:

- Debris or other large objects buried in the media can cause operating difficulties.
- Performance in extracting certain contaminants varies depending upon the maximum temperature achieved in the process selected.
- Soil that is tight or has high moisture content has a reduced permeability to air, hindering the operation of thermally enhanced SVE and requiring more energy input to increase vacuum and temperature.

TOP

- Soil with highly variable permeabilities may result in uneven delivery of gas flow to the contaminated regions.
- Soil that has a high organic content has a high sorption capacity of VOCs, which results in reduced removal rates.
- Air emissions may need to be regulated to eliminate possible harm to the public and the environment. Air treatment and permitting will increase project costs.
- Residual liquids and spent activated carbon may require further treatment.
- Thermally enhanced SVE is not effective in the saturated zone; however, lowering the aquifer can expose more media to SVE (this may address concerns regarding LNAPLs).
- Hot air injection has limitations due to low heat capacity of air.

TOP Data Needs:

A detailed discussion of these data elements is provided in Subsection 2.2.1 (Data Requirements for Soil, Sediment, and Sludge). Data requirements include the depth and areal extent of contamination, the concentration of the contaminants, depth to water table, and soil type and properties (e.g., structure, texture, permeability, and moisture content).

TOP Performance Data:

The thermally enhanced SVE processes are notably different and should be investigated individually for more detailed information. Because thermally enhanced SVE is an in situ remedy and all contaminants are under a vacuum during operation, the possibility of contaminant release is greatly reduced.

As with SVE, remediation projects using thermally enhanced SVE systems are highly dependent upon the specific soil and chemical properties of the contaminated media. The typical site consisting of 18,200 metric tons (20,000 tons) of contaminated media would require approximately 9 months.

DOE has developed and tested several thermally enhanced SVE processes. Dynamic underground stripping integrates steam injection and direct electric heating. Six phase soil heating is a pilot-scale technology that delivers six separate electric phases through electrodes placed in a circle around a soil vent. Thermally enhanced vapor extraction system combines conventional SVE with both powerline frequency and radio frequency soil heating.

Cost:

The key cost driver information and cost analysis was developed using the 2006 version of the Remedial Action Cost Engineering and Requirements (RACER) software.

Key Cost Drivers

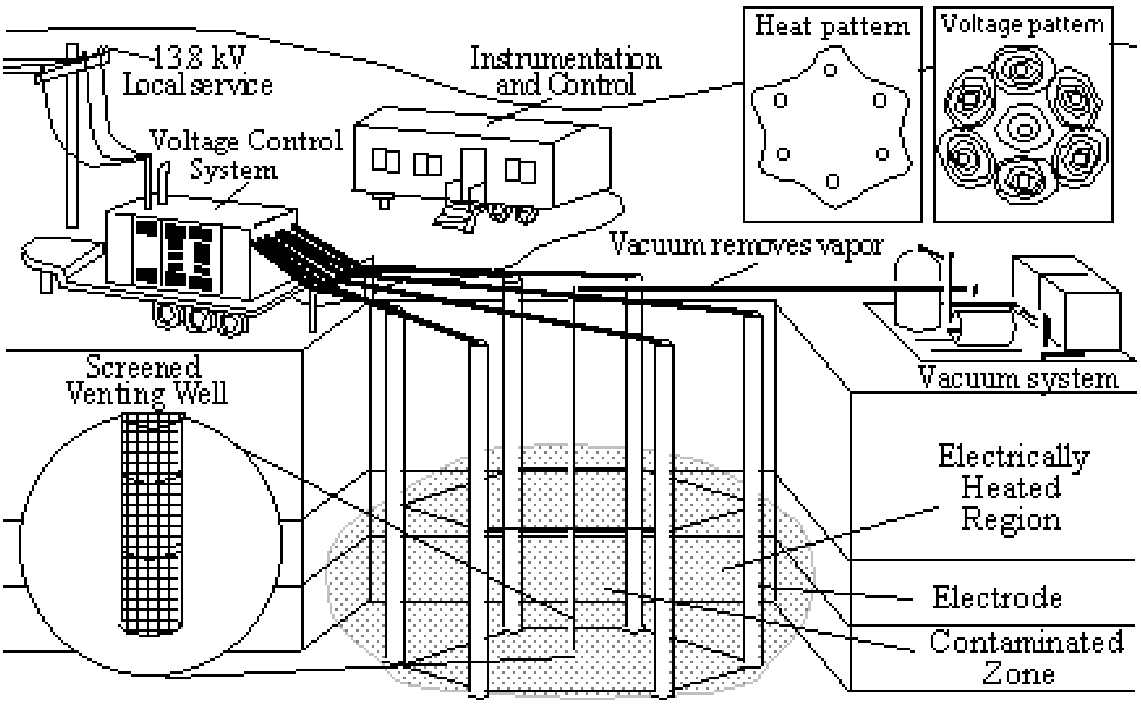
- Soil Type
  - The primary cost driver is soil type, which once again determines soil permeability. For thermal treatment, soils of lower permeability (silts/silty-clays) are less expensive to remediate as they require less gas flow.
- Depth to Top/Thickness of Contaminated Area
  - The secondary cost drivers are depth to the top and thickness of the contaminated zone. A deeper and thicker region of contaminated soils has higher remedial costs.

Cost Analysis

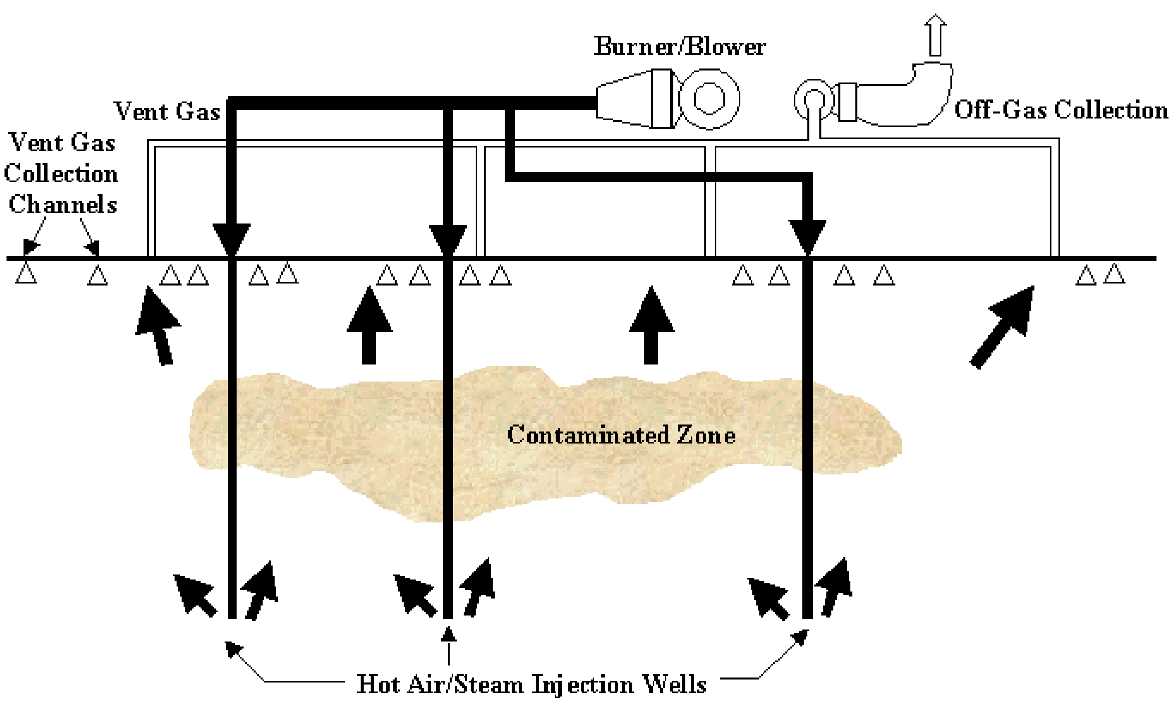
The following table represents estimated costs (by common unit of measure) to apply thermal treatment technology at sites of varying size and complexity. A more detailed cost estimate table which includes specific site characteristics and significant cost elements that contributed to the final costs can be viewed by clicking on the link below.

SOIL TECHNOLOGY:	Thermal Treatment			
RACER PARAMETERS	Scenario A	Scenario B	Scenario C	Scenario D
	Small Site		Large Site	
	Easy	Difficult	Easy	Difficult
CUBIC YARDS PROCESSED	5,550	5,550	16,650	16,650
COST PER CUBIC YARD	$51	$62	$29	$38
COST PER 1000 CUBIC YARDS	$50,947	$61,502	$29,174	$37,634

Typical Six-Phase Soil Heating System.



Typical Hot Air Injection System



Technology>> Soil, Sediment, Bedrock and Sludge
>>3.6 Ex Situ Thermal Treatment (assuming excavation)
>>4.22 Incineration

Introduction>> High temperatures, 870-1,200 °C (1,600- 2,200 °F), are used to combust (in the presence of oxygen) organic constituents in hazardous wastes.

Description:

High temperatures, 870 to 1,200 °C (1,400 to 2,200 °F), are used to volatilize and combust (in the presence of oxygen) halogenated and other refractory organics in hazardous wastes. Often auxiliary fuels are employed to initiate and sustain combustion. The destruction and removal efficiency (DRE) for properly operated incinerators exceeds the 99.99% requirement for hazardous waste and can be operated to meet the 99.9999% requirement for PCBs and dioxins. Off gases and combustion residuals generally require treatment.

Circulating Bed Combustor (CBC)

Circulating bed combustor (CBC) uses high velocity air to entrain circulating solids and create a highly turbulent combustion zone that destroys toxic hydrocarbons. The CBC operates at lower temperatures than conventional incinerators (1,450 to 1,600 °F). The CBC's high turbulence produces a uniform temperature around the combustion chamber and hot cyclone. The CBC also completely mixes the waste material during combustion. Effective mixing and low combustion temperature reduce operating costs and potential emissions of such gases as nitrogen oxide (NOx) and carbon monoxide (CO).

Fluidized Bed

The circulating fluidized bed (CFB), uses high-velocity air to circulate and suspend the waste particles in a combustion loop and operates at temperatures up to 870 °F (1,600 °F). Another experimental unit, the infrared unit uses electrical resistance heating elements or indirect-fired radiant U-tubes to heat material passing through the chamber on a conveyor belt and operates at temperatures up to 870 °F (1,600 °F).

Infrared Combustion

The infrared combustion technology is a mobile thermal processing system that uses electrically-

TOP powered silicon carbide rods to heat organic wastes to combustion temperatures. Waste is fed into the primary chamber and exposed to infrared radiant heat (up to 1,850 °F) provided by silicon carbide rods above the conveyor belt. A blower delivers air to selected locations along the belt to control the oxidation rate of the waste feed. Any remaining combustibles are incinerated in an afterburner.

Rotary Kilns

Commercial incinerator designs are rotary kilns, equipped with an afterburner, a quench, and an air pollution control system. The rotary kiln is a refractory-lined, slightly-inclined, rotating cylinder that serves as a combustion chamber and operates at temperatures up to 980 °F (1,800 °F).

Incinerator off-gas requires treatment by an air pollution-control system to remove particulates and neutralize and remove acid gases (HCl, NO_x, and SO_x). Baghouses, venturi scrubbers, and wet electrostatic precipitators remove particulates; packed-bed scrubbers and spray driers remove acid gases.

Incineration, primarily off-site, has been selected or used as the remedial action at more than 150 Superfund sites. Incineration is subject to a series of technology-specific regulations, including the following federal requirements: CAA (air emissions), TSCA (PCB treatment and disposal), RCRA (hazardous waste generation, treatment, storage, and disposal), NPDES (discharge to surface waters), and NCA (noise).

The duration of incineration technology ranges from short- to long-term.

TOP Synonyms:

DSERTS Code: D1 (Incineration).

TOP Applicability:

Incineration is used to remediate soils contaminated with explosives and hazardous wastes, particularly chlorinated hydrocarbons, PCBs, and dioxins.

Limitations:

Factors that may limit the applicability and effectiveness of the process include:

- Only one off-site incinerator is permitted to burn PCBs and dioxins.
- There are specific feed size and materials handling requirements that can impact applicability or cost at specific sites.
- Heavy metals can produce a bottom ash that requires stabilization.
- Volatile heavy metals, including lead, cadmium, mercury, and arsenic, leave the combustion unit with the flue gases and require the installation of gas cleaning systems for removal.
- Metals can react with other elements in the feed stream, such as chlorine or sulfur, forming

more volatile and toxic compounds than the original species. Such compounds are likely to be short-lived reaction intermediates that can be destroyed in a caustic quench.

- Sodium and potassium form low melting point ashes that can attack the brick lining and form a sticky particulate that fouls gas ducts.

Data Needs:

A detailed discussion of these data elements is provided in Subsection 2.2.1 (Data Requirements for Soil, Sediment, and Sludge). In addition to identifying soil contaminants and their concentrations, information necessary for engineering thermal systems to specific applications includes soil moisture content and classification , the soil fusion temperature, and the soil heating value. A sieve analysis is required to accurately estimate the dust loading in the system for proper design of the air pollution control equipment.

Performance Data:

If an off-site incinerator is used, the potential risk of transporting the hazardous waste through the community must be considered. Approximately 20 commercial RCRA-permitted hazardous waste incinerators and approximately 10 transportable high temperature units are operating. The commercial units are large capacity rotary kilns with afterburners and sophisticated air pollution control systems.

Cost:

The key cost driver information and cost analysis was developed in 2006 using the Remedial Action Cost Engineering and Requirements (RACER) software.

Key Cost Drivers

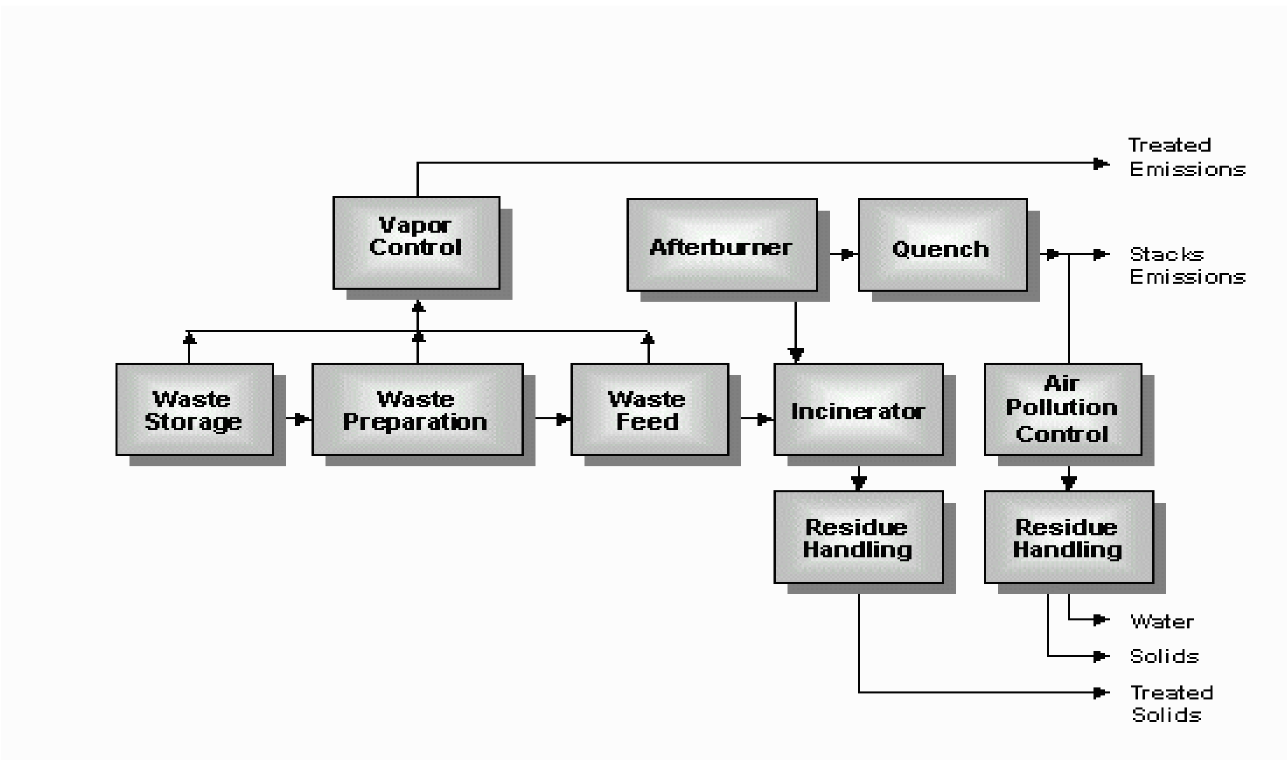
- Type of waste
  - Debris < Soil < Sludge < Sediment
- Quantity
  - There is only a $300 - $400 gap in cost for quantities ranging from 5,000 – 100,000.

Cost Analysis

The following table represents estimated costs (by common unit of measure) to apply incineration technology at sites of varying size and complexity. A more detailed cost estimate table which includes specific site characteristics and significant cost elements that contributed to the final costs can be viewed by clicking on the link below.

SOIL TECHNOLOGY:	Incineration			
RACER PARAMETERS	Scenario A	Scenario B	Scenario C	Scenario D
	Small Site		Large Site	
	Easy	Difficult	Easy	Difficult
COST PER CUBIC FOOT	$30	$44	$26	$40
COST PER CUBIC METER	$1,047	$1,540	$914	$1,399
COST PER CUBIC YARD	$796	$1,171	$695	$1,063

Typical Mobile/Transportable Incineration Process



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>>3.5 Ex Situ Physical/Chemical Treatment (assuming excavation)

>>4.17 Dehalogenation

Introduction>> Reagents are added to soils contaminated with halogenated organics. The dehalogenation process is achieved by either the replacement of the halogen molecules or the decomposition and partial volatilization of the contaminants.

Description:

Contaminated soil is screened, processed with a crusher and pug mill, and mixed with reagents. The mixture is heated in a reactor. The dehalogenation process is achieved by either the replacement of the halogen molecules or the decomposition and partial volatilization of the contaminants.

Base-catalyzed Decomposition (BCD)

Base-catalyzed decomposition (BCD) process was developed by EPA's Risk Reduction Engineering Laboratory (RREL), in cooperation with the Naval Facilities Engineering Services Center (NFESC) to remediate soils and sediments contaminated with chlorinated organic compounds, especially PCBs, dioxins, and furans. Contaminated soil is screened, processed with a crusher and pug mill, and mixed with sodium bicarbonate. The mixture is heated to above 330 °C (630°F) in a reactor to partially decompose and volatilize the contaminants. The volatilized contaminants are captured, condensed, and treated separately.

Glycolate/Alkaline Polyethylene Glycol (APEG)

Glycolate is a full-scale technology in which an alkaline polyethylene glycol (APEG) reagent is used. Potassium polyethylene glycol (KPEG) is the most common APEG reagent. Contaminated soils and the reagent are mixed and heated in a treatment vessel. In the APEG process, the reaction causes the polyethylene glycol to replace halogen molecules and render the compound nonhazardous or less toxic. The reagent (APEG) dehalogenates the pollutant to form a glycol ether and/or a hydroxylated compound and an alkali metal salt, which are water-soluble byproducts. Dehalogenation (APEG/KPEG) is generally considered a stand alone technology; however, it can be used in combination with other technologies. Treatment of the wastewater generated by the process may include chemical oxidation, biodegradation, carbon adsorption, or precipitation.

Dehalogenation is normally a short- to medium-term process. The contaminant is partially decomposed rather than being transferred to another medium.

Synonyms:

DSERTS Code: N14 (Dehalogenation).

Applicability:

The target contaminant groups for dehalogenation treatment are halogenated SVOCs and pesticides. APEG dehalogenation is one of the few processes available other than incineration that has been successfully field tested in treating PCBs.The technology can be used but may be less effective against selected halogenated VOCs. The technology is amenable to small-scale applications. The BCD can be also used to treat halogenated VOCs but will generally be more expensive than other alternative technologies.

Limitations:

Factors that may limit the applicability and effectiveness of the process include:

- High clay and moisture content will increase treatment costs.
- The APEG/KPEG technology is generally not cost-effective for large waste volumes.
- Concentrations of chlorinated organics greater than 5% require large volumes of reagent.
- With the BCD process, capture and treatment of residuals (volatilized contaminants captured, dust, and other condensates) may be difficult, especially when the soil contains high levels of fines and moisture.

Data Needs:

A detailed discussion of these data elements is provided in Subsection 2.2.1 (Data Requirements for Soil, Sediment, and Sludge). Treatability tests should be conducted to identify parameters such as water, alkaline metals, and humus content in the soils; the presence of multiple phases; and total organic halides that could affect processing time and cost.

Performance Data:

NFESC and EPA have been jointly developing the BCD process since 1990. Data from the Koppers Superfund site in North Carolina are inconclusive regarding technology performance because of analytical difficulties. There have been no commercial applications of this technology to date. The BCD process has received approval by EPA's

TOP Office of Toxic Substances under the Toxic Substances Control Act for PCB treatment. Complete design information is available from NFESC, formerly NCEL and NEESA. Predeployment testing was completed at Naval Communications Station Stockton in November 1991. The research, development, testing, and evaluation stages were planned for Guam during the first two quarters of FY93. A successful test run with 15 tons of PCB soil was conducted in February 1994.

Glycolate process has been used to successfully treat contaminant concentrations of PCBs from less than 2 ppm to reportedly as high as 45,000 ppm. This technology has received approval from the EPA's Office of Toxic Substances under the Toxic Substances Control Act for PCB treatment.

The APEG process has been selected for cleanup of PCB-contaminated soils at three Superfund sites: Wide Beach in Erie County, New York (September 1985); Re-Solve in Massachusetts (September 1987); and Sol Lynn in Texas (March 1988).

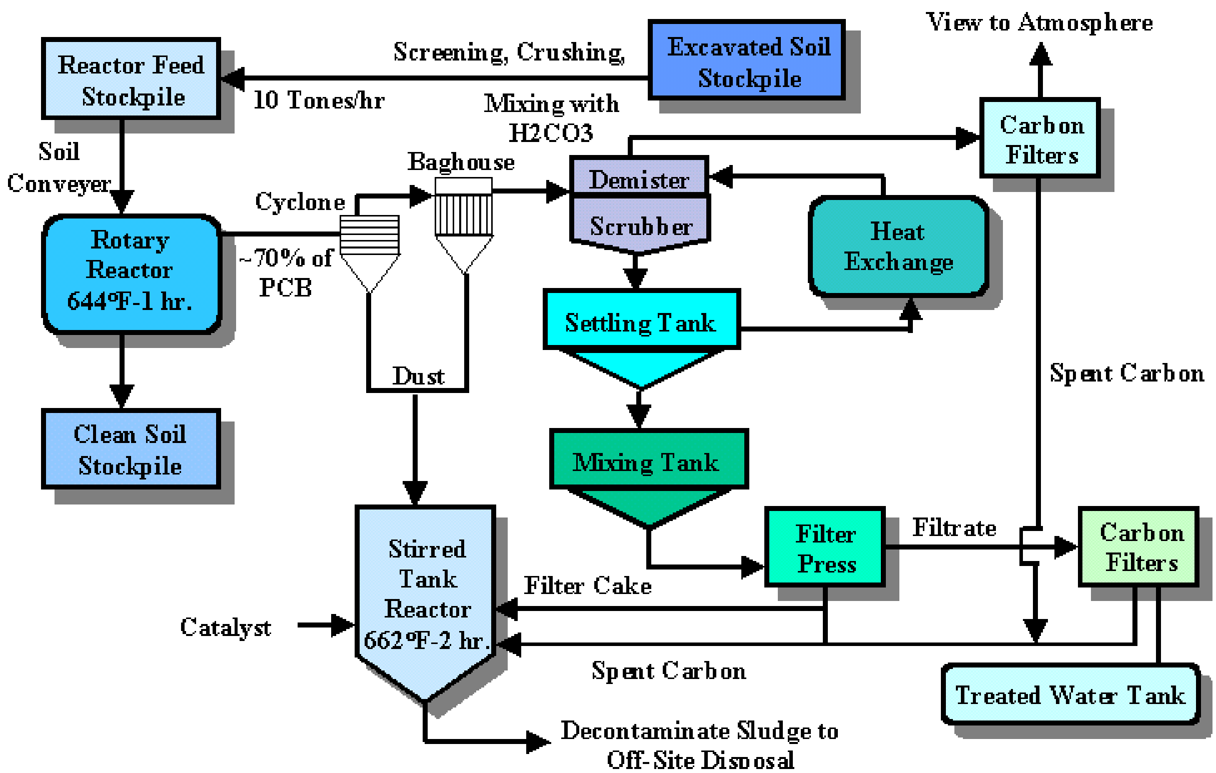
This technology uses standard equipment. The reaction vessel must be equipped to mix and heat the soil and reagents. A detailed engineering design for a continuous feed, full-scale PCB treatment system for use in Guam is currently being completed. It is estimated that a full-scale system can be fabricated and placed in operation in 6 to 12 months.

The concentrations of PCBs that have been treated are reported to be as high as 45,000 ppm. Concentrations were reduced to less than 2 ppm per individual PCB congener. PCDDs and PCDFs have been treated to nondetectable levels at part per trillion sensitivity. The process has successfully destroyed PCDDs and PCDFs contained in contaminated pentachlorophenol oil. For a contaminated activated carbon matrix, direct treatment was less effective, and the reduction of PCDDs/PCDFs to concentrations less than 1 ppb was better achieved by first extracting the carbon matrix with a solvent and then treating the extract.

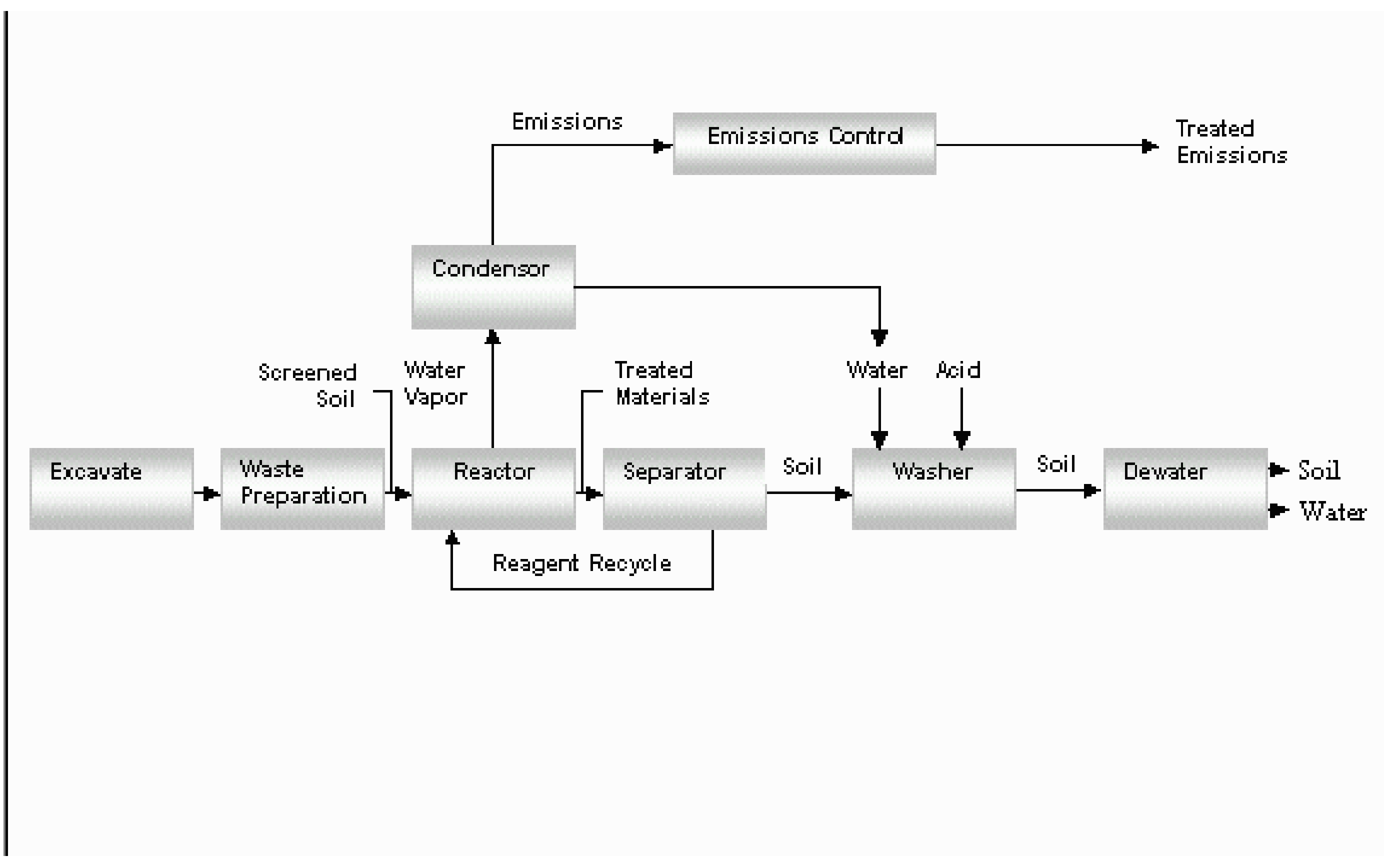
Cost:

The cost for full-scale operation is estimated to be in a range of $220 to $550 per metric ton ($200 to $500 per ton) and does not include excavation, refilling, residue disposal, or analytical costs. Factors such as high clay or moisture content may raise the treatment cost slightly.

Typical BCD Dehalogenation Process



Typical APEG Dehalogenation Process



Technology>> Soil, Sediment, Bedrock and Sludge

>>3.6 Ex Situ Thermal Treatment (assuming excavation)

>>4.25 Thermal Desorption

Introduction>> Wastes are heated to volatilize water and organic contaminants. A carrier gas or vacuum system transports volatilized water and organics to the gas treatment system.

Description:

Thermal desorption is a physical separation process and is not designed to destroy organics. Wastes are heated to volatilize water and organic contaminants. A carrier gas or vacuum system transports volatilized water and organics to the gas treatment system. The bed temperatures and residence times designed into these systems will volatilize selected contaminants but will typically not oxidize them.

Two common thermal desorption designs are the rotary dryer and thermal screw. Rotary dryers are horizontal cylinders that can be indirect- or direct-fired. The dryer is normally inclined and rotated. For the thermal screw units, screw conveyors or hollow augers are used to transport the medium through an enclosed trough. Hot oil or steam circulates through the auger to indirectly heat the medium. All thermal desorption systems require treatment of the off-gas to remove particulates and contaminants. Particulates are removed by conventional particulate removal equipment, such as wet scrubbers or fabric filters. Contaminants are removed through condensation followed by carbon adsorption, or they are destroyed in a secondary combustion chamber or a catalytic oxidizer. Most of these units are transportable.

Three types of thermal desorption are available and briefly described as following:

1. Direct Fired: Fire is applied directly upon the surface of contaminated media. The main purpose of the fire is to desorb contaminants from the soil though some contaminants may be thermally oxidized.
2. Indirect Fired: A direct-fired rotary dryer heats an air stream which, by direct contact, desorbs water and organic contaminants from the soil. The Low Temperature Thermal Aeration (LTTA®) developed by Canonie Environmental Services Corporation is a good example of indirect fired system which has been successfully used to remove DDT family compounds from soil.
3. Indirect Heated: An externally fired rotary dryer volatilizes the water and organics

TOP from the contaminated media into an inert carrier gas stream. The carrier gas is later treated to remove or recover the contaminants. XTRAX™ thermal Desorption System is a process using indirect heated desorption followed by a high-energy scrubber gas treatment, which successfully removed >99% of PCB from contaminated soil.

Based on the operating temperature of the desorber, thermal desorption processes can be categorized into two groups: high temperature thermal desorption (HTTD) and low temperature thermal desorption (LTTD).

High Temperature Thermal Desorption (HTTD)

HTTD is a full-scale technology in which wastes are heated to 320 to 560 °C (600 to 1,000 °F). HTTD is frequently used in combination with incineration, solidification/stabilization, or dechlorination, depending upon site-specific conditions. The technology has proven it can produce a final contaminant concentration level below 5 mg/kg for the target contaminants identified.

Low Temperature Thermal Desorption (LTTD)

In LTTD, wastes are heated to between 90 and 320 °C (200 to 600 °F). LTTD is a full-scale technology that has been proven successful for remediating petroleum hydrocarbon contamination in all types of soil. Contaminant destruction efficiencies in the afterburners of these units are greater than 95%. The same equipment could probably meet stricter requirements with minor modifications, if necessary. Decontaminated soil retains its physical properties. Unless being heated to the higher end of the LTTD temperature range, organic components in the soil are not damaged, which enables treated soil to retain the ability to support future biological activity.

TOP Synonyms:

DSERTS Code: N12 (Thermal Desorption). Low Temperature Thermal Desorption (LTTD).

Applicability:

Thermal desorption systems have varying degrees of effectiveness against the full spectrum of organic contaminants.

The target contaminant groups for LTTD systems are nonhalogenated VOCs and fuels. The technology can be used to treat SVOCs at reduced effectiveness.

The target contaminants for HTTD are SVOCs, PAHs, PCBs, and pesticides; however, VOCs and fuels also may be treated, but treatment may be less cost-effective. Volatile metals may be removed by HTTD systems. The presence of chlorine can affect the volatilization of some metals, such as lead. The process is applicable for the separation of organics from refinery wastes, coal tar wastes, wood-treating wastes, creosote-

TOP contaminated soils, hydrocarbon-contaminated soils, mixed (radioactive and hazardous) wastes, synthetic rubber processing waste, pesticides and paint wastes.

TOP Limitations:

Factors that may limit the applicability and effectiveness of the process include:

- There are specific particle size and materials handling requirements that can impact applicability or cost at specific sites.
- Dewatering may be necessary to achieve acceptable soil moisture content levels.
- Highly abrasive feed potentially can damage the processor unit.
- Heavy metals in the feed may produce a treated solid residue that requires stabilization.
- Clay and silty soils and high humic content soils increase reaction time as a result of binding of contaminants.

TOP Data Needs:

A detailed discussion of these data elements is provided in Subsection 2.2.1 (Data Requirements for Soil, Sediment, and Sludge). In addition to identifying soil contaminants and their concentrations, information necessary for engineering thermal systems to specific applications include soil moisture content and classification, determination of boiling points for various compounds to be removed, and treatability tests to determine the efficiency of thermal desorption for removing various contaminants at various temperatures and residence times. A sieve analysis is needed to determine the dust loading in the system to properly design and size the air pollution control equipment.

Performance Data:

Most of the hardware components for thermal desorption systems are readily available off the shelf. All ex situ soil thermal treatment systems employ similar feed systems consisting of a screening device to separate and remove materials greater than 5 centimeters (2 inches), a belt conveyor to move the screened soil from the screen to the first thermal treatment chamber, and a weight belt to measure soil mass. Occasionally, augers are used rather than belt conveyors, but either type of system requires daily maintenance and is subject to failures that shut the system down. Soil conveyors in large systems seem more prone to failure than those in smaller systems. Size reduction equipment can be incorporated into the feed system, but its installation is usually avoided to minimize shutdown as a result of equipment failure.

Many vendors offer LTTD units mounted on a single trailer. Soil throughput rates are typically 13 to 18 metric tons (15 to 20 tons) per hour for sandy soils and less than 6 metric tons (7 tons) per hour for clay soils when more than 10% of the material passes a 200-mesh screen. Units with capacities ranging from 23 to 46 metric tons (25 to 50 tons) per hour require four or five trailers for transport and 2 days for setup.

TOP The time to complete cleanup of the "standard" 18,200-metric ton (20,000-ton) site using HTTD is just over 4 months.

Soil storage piles and feed equipment are generally covered as protection from rain to minimize soil moisture content and material handling problems. Soils and sediments with water contents greater than 20 to 25% may require the installation of a dryer in the feed system to increase the throughput of the desorber and to facilitate the conveying of the feed to the desorber. Some volatilization of contaminants occurs in the dryer, and the gases are routed to a thermal treatment chamber.

Cost:

The key cost driver information and cost analysis was developed in 2006 using the Remedial Action Cost Engineering and Requirements (RACER) software.

Key Cost Drivers

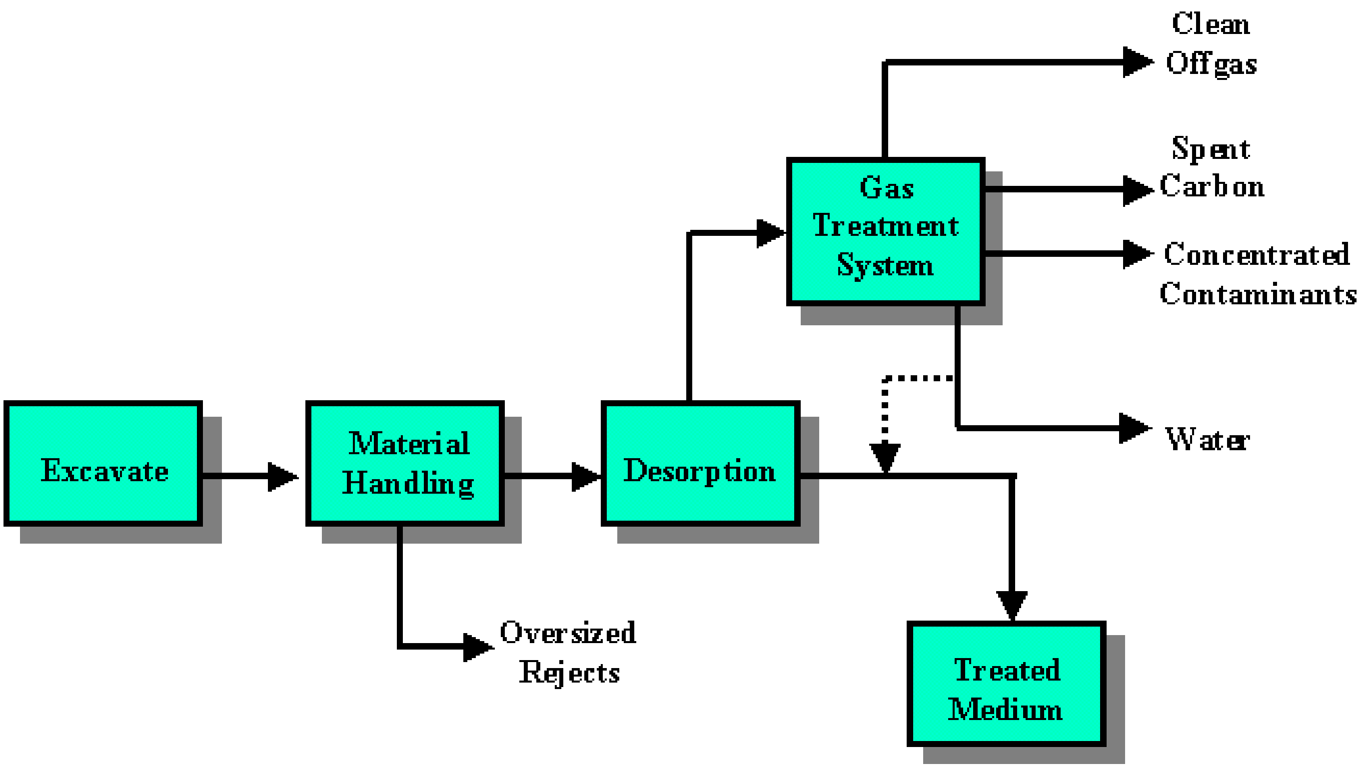
- Economy of Scale
  - Quantity of material treated has a large impact
- Moisture content
  - Increases required heat input (increasing fuel costs)

Cost Analysis

The following table represents estimated costs (by common unit of measure) to apply thermal desorption technology at sites of varying size and complexity. A more detailed cost estimate table which includes specific site characteristics and significant cost elements that contributed to the final costs can be viewed by clicking on the link below.

SOIL TECHNOLOGY: Thermal Desorption				
RACER PARAMETERS	Scenario A	Scenario B	Scenario C	Scenario D
	Small Site		Large Site	
	Easy	Difficult	Easy	Difficult
COST PER CUBIC FOOT	$2	$7	$1	$3
COST PER CUBIC METER	$81	$252	$44	$110
COST PER CUBIC YARD	$75	$232	$40	$101

Typical Low Temperature Thermal Desorption Process



Technology>> Soil, Sediment, Bedrock and Sludge

>>3.7 Containment

>>4.26 Landfill Cap

Introduction>> Landfill caps are used for contaminant source control.

Description:

Landfill caps can be used to:

- Minimize exposure on the surface of the waste facility.
- Prevent vertical infiltration of water into wastes that would create contaminated leachate.
- Contain waste while treatment is being applied.
- Control gas emissions from underlying waste.
- Create a land surface that can support vegetation and/or be used for other purposes.

Landfill Capping is the most common form of remediation because it is generally less expensive than other technologies and effectively manages the human and ecological risks associated with a remediation site.

The design of landfill caps is site specific and depends on the intended functions of the system. Landfill Caps can range from a one-layer system of vegetated soil to a complex multi-layer system of soils and geosynthetics. In general, less complex systems are required in dry climates and more complex systems are required in wet climates. The material used in the construction of landfill caps include low-permeability and high-permeability soils and low-permeability geosynthetic products. The low-permeability materials divert water and prevent its passage into the waste. The high permeability materials carry water away that percolates into the cap. Other materials may be used to increase slope stability.

The most critical components of a landfill cap are the barrier layer and the drainage layer. The barrier layer can be low-permeability soil (clay) and/or geosynthetic clay liners (GCLs). A flexible geomembrane liner is placed on top of the barrier layer. Geomembranes are usually supplied in large rolls and are available in several thickness (20 to 140 mil), widths (15 to 100 ft), and lengths (180 to 840 ft). The candidate list of

TOP polymers commonly used is lengthy, which includes polyvinyl chloride (PVC), polyethylenes of various densities, reinforced chlorosulfonated polyethylene (CSPE-R), polypropylene, ethylene interpolymer alloy (EIA), and many newcomers. Soils used as barrier materials generally are clays that are compacted to a hydraulic conductivity no greater than 1 x 10^{-6} cm/sec. Compacted soil barriers are generally installed in 6-inch minimum lifts to achieve a thickness of 2 feet or more. A composite barrier uses both soil and a geomembrane, taking advantage of the properties of each. The geomembrane is essentially impermeable, but, if it develops a leak, the soil component prevents significant leakage into the underlying waste.

For facilities on top of putrescible wastes, the collection and control of methane and carbon dioxide, potent greenhouse gases, must be part of facility design and operation.

Asphalt/Concrete Cap

The most effective single-layer caps are composed of concrete or bituminous asphalt. It is used to form a surface barrier between landfill and the environment. An asphalt concrete cap would reduce leaching through the landfill into an adjacent aquifer.

RCRA Subtitle C Cap

The RCRA C multilayered landfill cap is a baseline design that is suggested for use in RCRA hazardous waste applications. These caps generally consist of an upper vegetative (topsoil) layer, a drainage layer, and a low permeability layer which consists of a synthetic liner over 2 feet of compacted clay. The compacted clay liners are effective if they retain a certain moisture content but are susceptible to cracking if the clay material is desiccated. As a result alternate cap designs are usually considered for arid environments.

RCRA Subtitle D Cap

RCRA Subtitle D requirements are for non-hazardous waste landfills. The design of a landfill cover for a RCRA Subtitle D facility is generally a function of the bottom liner system or natural subsoils present. The cover must meet the following specifications:

- the material must have a permeability no greater than 1 x 10-5 cm/s, or equivalent permeability of any bottom liner or natural subsoils present, whichever is less.
- The infiltration layer must contain at least 45 cm of earthen material.
- The erosion control layer must be at least 15 cm of earthen material capable of sustaining native plant growth.

Alternative design can be considered, but must be of equivalent performance as the specifications outlined above. All covers should be designed to prevent the "bathtub" effect. The bathtub effect occurs when a more permeable cover is placed over a less permeable bottom liner or natural subsoil. The landfill then fills up like a bathtub.

Synonyms:

Cap; Landfill cover; Surface cover.

DSERTS Codes:

I0 (Containment)
I1 (Capping)

Applicability:

Landfill Caps may be temporary or final. Temporary caps can be installed before final closure to minimize generation of leachate until a better remedy is selected. They are usually used to minimize infiltration when the underlying waste mass is undergoing settling. A more stable base will thus be provided for the final cover, reducing the cost of the post-closure maintenance. Landfill caps also may be applied to waste masses that are so large that other treatment is impractical. At mining sites for example, caps can be used to minimize the infiltration of water to contaminated tailings piles and to provide a suitable base for the establishment of vegetation. In conjunction with water diversion and detention structures, landfill caps may be designed to route surface water away from the waste area while minimizing erosion.

Limitations:

Landfilling does not lessen toxicity, mobility, or volume of hazardous wastes, but does mitigate migration. Landfill caps are most effective where most of the underlying waste is above the water table. A cap, by itself, cannot prevent the horizontal flow of ground water through the waste, only the vertical entry of water into the waste. In many cases landfill caps are used in conjunction with vertical walls to minimize horizontal flow and migration. The effective life of landfill components (including cap) can be extended by long-term inspection and maintenance. Vegetation, which has a tendency for deep root penetration, must be eliminated from the cap area. In addition, precautions must be taken to assume that the integrity of the cap is not compromised by land use activities.

Data Needs:

A detailed discussion of these data elements is provided in Subsection 2.2.1 (Data Requirements for Soil, Sediment, and Sludge). Many laboratory tests are needed to ensure that the materials being considered for each of the landfill cap components are suitable. Tests to determine the suitability of soil include grain size analysis, Atterberg limits, and compaction characteristics. Landfill instability can be solved by understanding interface friction properties between all material layers, natural or synthetic. The major engineering soil properties that must be defined are the shear strength and hydraulic conductivity. Shear strength may be determined with the unconfined compression test, direct shear test, or triaxial compression test. Hydraulic conductivity of soils may be measured in the laboratory by the constant head permeability test or the falling head permeability test. Field hydraulic conductivity tests on test pads are generally recommended prior to actual cover construction to ensure that the low-permeability requirements can actually be met under construction conditions.

TOP Laboratory tests are also needed to ensure that geosynthetic materials will meet the cap requirements, For example, geosynthetics in caps may be subjected to tensile stresses caused by subsidence and by the gravitational tendency of a geomembrane or material adjacent to it to slide or be pulled down slopes.

Since facility performance is a function of quality construction more so than selection of materials, construction quality assurance of caps are critical. EPA has generated a technical guidance document on this subject. The technical guidance should be strictly followed during design and construction.

TOP Performance Data:

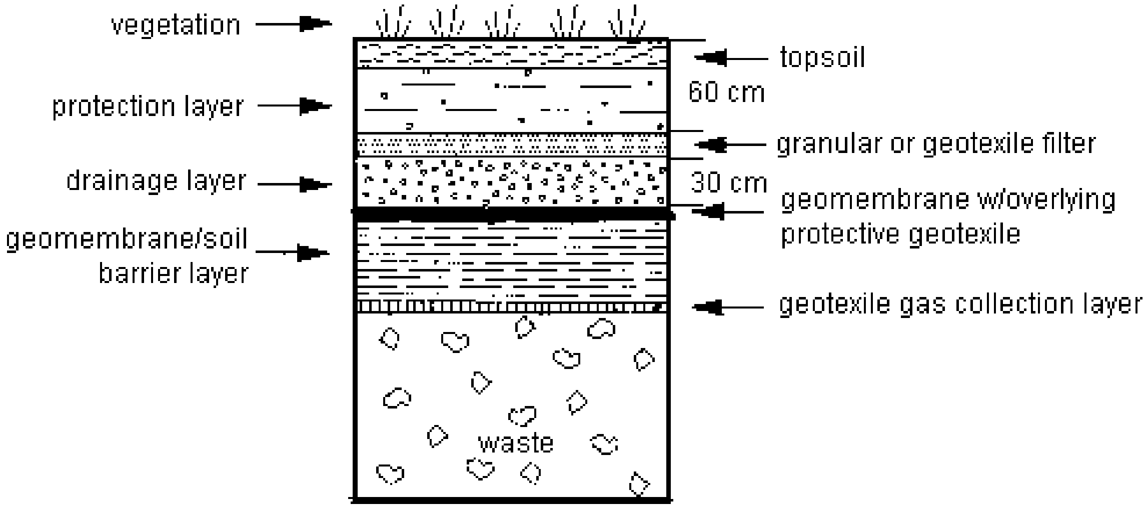
Previously installed caps are hard to monitor for performance. Monitoring well systems or infiltration monitoring systems can provide some information, but it is often not possible to determine whether the water or leachate originated as surface water or ground water. Performance can be monitored much more effectively by including pan lysimeter in future caps.

Cost:

Landfill caps are generally the least expensive way to manage the human health and ecological risks effectively. Rough industry cost are $175k/acre for RCRA Subtitle D, and $225k/acre for RCRA Subtitle C.

Additional cost information can be found in the Hazardous, Toxic, and Radioactive Wastes (HTRW) Historical Cost Analysis System (HCAS) developed by Environmental Historical Cost Committee of Interagency Cost Estimation Group.

Typical RCRA Subtitle C Landfill Cap System



Technology>> Soil, Sediment, Bedrock and Sludge

>>3.8 Other Treatment

>>4.28 Excavation, Retrieval, and Off-Site

Introduction>> Contaminated material is removed and transported to permitted off-site treatment and disposal facilities. Pretreatment may be required.

TOP Description:

Contaminated material is removed and transported to permitted off-site treatment and/or disposal facilities. Some pretreatment of the contaminated media usually is required in order to meet land disposal restrictions.

Confined disposal facilities (CDFs) are engineered structure enclosed by dikes and designed to retain dredged materials. A CDF may have a large cell for material disposal, and adjoining cells for retention and decantation of turbid, supernatant water. A variety of linings have been used to prevent seepage through the dike walls. The most effective are clay or bentonite-cement slurries, but sand, soil, and sediment linings have also been used.

Location and design are two important CDF consideration. Terms to consider in the location of a CDF are the physical aspects (size, proximity to a navigable waterway), the design/construction (geology/hydrology), and the environmental (current use of the area, environmental value, and environmental effects). The primary goal of a CDF design is minimization of contaminant loss. Caps are the most effective way to minimize contaminant loss from CDFs, but selection of proper liner material is also an important control on CDFs. Finally, CDFs require continuous monitoring to ensure structural integrity.

Operation and maintenance duration lasts as long as the life of the facility.

Synonyms:

DSERTS Codes:

E0 (Removal)

E1 (Waste Removal-Soils)
R1 (Waste Removal-Sludges)
S1 (Waste Removal-Non-soil Solids)

TOP

TOP Applicability:

Excavation and off-site disposal is applicable to the complete range of contaminant groups with no particular target group. Excavation and off-site by relocating the waste to a different (and presumably safer) site.

TOP Limitations:

Factors that may limit the applicability and effectiveness of the process include:

- Generation of fugitive emissions may be a problem during operations.
- The distance from the contaminated site to the nearest disposal facility with the required permit(s) will affect cost.
- Depth and composition of the media requiring excavation must be considered.
- Transportation of the soil through populated areas may affect community acceptability.
- Disposal options for certain waste (e.g., mixed waste or transuranic waste) may be limited. There is currently only one licensed disposal facility for radioactive and mixed waste in the United States.
- Contaminants can potentially migrate from CDF from several pathways, including effluent discharge to surface water, rainfall surface runoff, leachate into ground water, volatilization to the atmosphere, and dike uptake.
- CDFs can develop odor problems as well as mosquito and insect problems without proper design and maintenance.

TOP Data Needs:

A detailed discussion of these data elements is provided in Subsection 2.2.1 (Data Requirements for Soil, Sediment, and Sludge).

The type of contaminant and its concentration will impact off-site disposal requirements. Soil characterization as dictated by land disposal restrictions (LDRs) are required. Most hazardous wastes must be treated to meet either RCRA or non-RCRA treatment standards prior to land disposal. Radioactive wastes would have to meet disposal facility waste form requirements based on waste classification.

Performance Data:

Excavation and off-site disposal is a well proven and readily implementable technology. Prior to 1984, excavation and off-site disposal was the most common method for cleaning up hazardous waste sites. Excavation is the initial component in all ex situ treatments.

TOP The rate of excavation depends on a number of factors, including the number of loaders and trucks operating. The excavation of 18,200 metric tons (20,000 tons) of contaminated soil would typically require about 2 months. Disposal of the contaminated media is dependent upon the availability of adequate containers to transport the hazardous waste to a permitted facility.

CERCLA includes a statutory preference for treatment of contaminants, and excavation and off-site disposal is now less acceptable than in the past. The disposal of hazardous wastes is governed by RCRA (40 CFR Parts 261-265), and the U.S. Department of Transportation (DOT) regulates the transport of hazardous materials (49 CFR Parts 172-179, 49 CFR Part 1387, and DOT-E 8876).

DOE has demonstrated a cryogenic retrieval of buried waste system, which uses liquid nitrogen (LN2) to freeze soil and buried waste to reduce the spread of contamination while the buried material is retrieved with a series of remotely operated tools. Other excavation/retrieval systems that DOE is currently developing include a remote excavation system, a hydraulic impact end effector, and a high pressure waterjet dislodging and conveyance end effector using confined sluicing.

Cost:

Cost estimates for excavation and disposal range from $300 to $510 per metric ton ($270 to $460 per ton) depending on the nature of hazardous materials and methods of excavation. These estimates include excavation/removal, transportation, and disposal at a RCRA permitted facility. Additional cost of treatment at disposal facility may also be required. Excavation and off-site disposal is a relatively simple process, with proven procedures. It is a labor-intensive practice with little potential for further automation. Additional costs may include soil characterization and treatment to meet land ban requirements.

Technology>> Ground Water, Surface Water, and Leachate

>>3.9 In Situ Biological Treatment

>>4.30 Monitored Natural Attenuation

Introduction>> Natural subsurface processes—such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials—are allowed to reduce contaminant concentrations to acceptable levels.

Description:

Natural subsurface processes such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials are allowed to reduce contaminant concentrations to acceptable levels. Natural attenuation is not a "technology" per se, and there is significant debate among technical experts about its use at hazardous waste sites. Consideration of this option usually requires modeling and evaluation of contaminant degradation rates and pathways and predicting contaminant concentration at down gradient receptor points, especially when plume is still expanding/migrating. The primary objective of site modeling is to demonstrate that natural processes of contaminant degradation will reduce contaminant concentrations below regulatory standards or risk-based levels before potential exposure pathways are completed. In addition, long term monitoring must be conducted throughout the process to confirm that degradation is proceeding at rates consistent with meeting cleanup objectives.

Natural attenuation is not the same as "no action," although it often is perceived as such. CERCLA requires evaluation of a "no action" alternative but does not require evaluation of natural attenuation. Natural attenuation is considered in the Superfund program on a case-by-case basis, and guidance on its use is still evolving.

Compared with other remediation technologies, natural attenuation has the following advantages:

- Less generation or transfer of remediation wastes;
- Less intrusive as few surface structures are required;
- May be applied to all or part of a given site, depending on site conditions and cleanup objectives;
- Natural attenuation may be used in conjunction with, or as a follow-up to, other

TOP (active) remedial measures; and

- Overall cost will likely be lower than active remediation.

TOP Synonyms:

Intrinsic Remediation; Bioattenuation; Intrinsic Bioremediation; Monitored Natural Attenuation (MNA).
DSERTS Code: F3 (Natural Attenuation)

TOP Applicability:

Target contaminants for natural attenuation are VOCs and SVOCs and fuel hydrocarbons. Fuel and halogenated VOCs are commonly evaluated for natural attenuation. Pesticides also can be allowed to naturally attenuate, but the process may be less effective and may be applicable to only some compounds within the group. Additionally, natural attenuation may be appropriate for some metals when natural attenuation processes result in a change in the valence state of the metal that results in immobilization (e.g., chromium).

TOP Limitations:

Factors that may limit applicability and effectiveness include:

- Data used as input parameters for modeling need be collected.
- Intermediate degradation products may be more mobile and more toxic than the original contaminant.
- Natural attenuation is not appropriate where imminent site risks are present.
- Contaminants may migrate before they are degraded.
- Institutional controls may be required, and the site may not be available for reuse until contaminant levels are reduced.
- If free product exists, it may have to be removed.
- Some inorganics can be immobilized, such as mercury, but they will not be degraded.
- Long term monitoring and associated costs.
- Longer time frames may be required to achieve remediation objectives, compared to active remediation.
- The hydrologic and geochemical conditions amenable to natural attenuation are likely to change over time and could result in renewed mobility of previously stabilized contaminants and may adversely impact remedial effectiveness; and
- More extensive outreach efforts may be required in order to gain public acceptance of natural attenuation.

Data Needs:

A detailed discussion of these data elements is provided in Subsection 2.2.2. (Data

TOP Requirements for Groundwater, Surface Water, and Leachate).

The extent of contaminant degradation depends on a variety of parameters, such as contaminant types and concentrations, temperature, moisture, and availability of nutrients/electron acceptors (e.g., oxygen, nitrate).

Although many potential suppliers perform the modeling, sampling, and sample analysis required for monitoring natural attenuation, the evaluation of natural attenuation is often not straightforward and will require expertise in several technical areas including microbiology/bioremediation, hydrogeology, and geochemistry. When available, information to be obtained during data review includes:

- Soil and ground water quality data:
    - Three-dimensional distribution of residual-, free-, and dissolved-phase contaminants. The distribution of residual- and free-phase contaminants will be used to define the dissolved-phase plume source area.
    - Historical water quality data showing variations in contaminant concentrations through time.
    - Chemical and physical characteristics of the contaminants.
    - Geochemical data to assess the potential for biodegradation of the contaminants.

- Location of potential receptors:
    - Ground water wells.
    - Surface water discharge points.

The operation and maintenance (O&M) duration is determined from natural attenuation evaluation and regulatory requirements. The process is expected to continue for several years until desired degradation levels are achieved. The duration of O&M is dependent on all of the data and information listed above.

TOP Performance Data:

Natural attenuation has been selected by AFCEE for remediation at 45 sites.

Cost:

There are costs for modeling and monitoring. Modeling determines whether natural attenuation is a feasible remedial alternative. The most significant costs associated with natural attenuation are most often due to monitoring requirements, which include two major parts - site characterization and performance monitoring. Site characterization determines the extent of contamination and contaminant degradation rates. Performance monitoring tracks down contaminants migration and degradation and cleanup status.

Institutional Controls and Transfer of Real Property under CERCLA Section 120(h)(3)(A), (B) or (C)

Summary

This document provides guidance to the U.S. Environmental Protection Agency (EPA) on the exercise of EPA's discretion under CERCLA section 120(h)(3)(A),(B), or (C) when EPA is called upon to evaluate institutional controls as part of a remedial action. also informs the public and the regulated community on how EPA intends to exercise its discretion in this context. designed to implement the President's policy of promoting, encouraging, and facilitating the redevelopment and reuse of closing military bases while continuing to protect human health and the environment. ay change this guidance in the future, as appropriate.

EPA's evaluation of federal property transfers is contingent on the receipt of information establishing that the institutional controls will be effective in preventing human or environmental exposure to hazardous substances that remain on site above levels which allow unrestricted use. guidance requires that the transferring federal agency demonstrate prior to transfer that certain procedures are in place, or will be put in place, that will provide EPA with sufficient basis for determining that the institutional controls will perform as expected in the future. Such procedures, which are listed in Section 5.0 below, include the means for:

- Monitoring the institutional controls' effectiveness and integrity.
- Reporting the results of such monitoring, including notice of any violation or failure of the controls.
- Enforcing the institutional controls should such a violation or failure occur.

1.0 Background of the Guidance

What are institutional controls?

Institutional controls are nonengineering measures designed to prevent or limit exposure to hazardous substances left in place at a site, or assure effectiveness of the chosen remedy. Institutional controls are usually, but not always, legal controls, such as easements, restrictive covenants, and zoning ordinances.

What is the historical basis for this guidance?

The Department of Defense's (DoD) base closure program and the Department of Energy's reuse and reindustrialization of surplus facilities are just two examples of programs where federal properties with hazardous substances remaining on site are being transferred outside of federal control. These property transfers will often require the implementation of institutional controls to ensure that human health and the environment are protected. Such property transfers highlight the need to ensure that institutional controls are clearly defined, oversight and monitoring roles are understood, and appropriate enforcement mechanisms are in place to ensure that human health and the environment are protected.

What is the statutory basis for this guidance?

Section 120(h)(3)(A) of CERCLA requires that a federal agency transferring real property (hereafter, transferring federal agency - by "transferring federal agency" EPA means the federal agency responsible for cleanup) to a nonfederal entity include a covenant in the deed of transfer warranting that all remedial action necessary to protect human health and the environment has been taken prior to the date of transfer with respect to any hazardous substances remaining on the property. In addition, CERCLA section 120(h)(3)(B) requires, under certain circumstances, that a federal agency demonstrate to the EPA Administrator that a remedy is "operating properly and successfully" before the federal agency can provide the "all remedial action has been taken" covenant. Under CERCLA section 120(h)(3)(C), the covenant can be deferred so that property may be transferred before all necessary remedial actions have been taken if regulators agree that the property is suitable for the intended use and the intended use is consistent with protection of human health and the environment.

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2.0 Purpose and Scope of the Guidance

What is the purpose of this guidance?

This guidance establishes criteria for EPA to evaluate the effectiveness of institutional controls that are part of a remedy or are a sole remedy for property to be transferred subject to CERCLA section 120(h)(3)(A),(B), or (C). Accordingly, this institutional control guidance provides guidelines applicable to property transfers in general and, more specifically, to support "operating properly and successfully determinations" under CERCLA section 120(h)(3)(B).

This guidance does not substitute for EPA regulations, nor is it a regulation itself. Thus, it cannot impose legally binding requirements on EPA, states, or the regulated community, and may not apply to a particular situation based upon the circumstances.

What does the guidance not address?

This guidance does not address the issue of whether an institutional control is appropriate for a particular site. That decision is made as part of the remedy selection process. If, however, it becomes clear that the criteria set forth in this guidance cannot be met, the scope, effectiveness, or even the use of an institutional control should be reconsidered. This guidance does not change EPA's preference for active and permanent remedies as stated in CERCLA section 121 (See also 55 FR, page 8706 [March 8, 1990]), or any of the requirements for selecting remedies in CERCLA or the NCP (See CERCLA section 121 and 40 CFR 300.430).

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3.0 Applicability of the Guidance

Under what circumstances does the guidance apply?

The guidance applies in the following situations:

- When EPA approves "operating properly and successfully demonstrations" for ongoing remedies under CERCLA section 120(h)(3)(B). (See Section 7.0 for more information.)
- When EPA evaluates a federal agency's determination under 120(h)(3)(A) that all remedial actions have been taken, such as when commenting on a "finding of suitability of transfer," in the consultative process established by DoD.
- When EPA approves a Covenant Deferral Request under 120 (h)(3)(C) for an early transfer (For more information, see EPA Guidance on the Transfer of Federal Property by Deed Before All Necessary Remedial Action Has Been Taken Pursuant to CERCLA Section 120(h)(3), June 16, 1998).

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4.0 General Guidelines for Institutional Controls

Who is responsible for implementing institutional controls?

The decision to clean up a site to less than unrestricted use or to otherwise restrict the use of the site must be balanced by the assurance that a system will be in place to monitor and enforce any required institutional controls. This assurance is necessary to ensure the long term effectiveness and permanence of the remedy (For more information, see 55 FR section 300.430 (e)(9) (iii)(C)(2)). In EPA's view, the transferring federal agency is responsible for ensuring that the institutional controls are implemented. Even if implementation of the institutional controls is delegated in the transfer documents, the ultimate responsibility for monitoring, maintaining, and enforcing the institutional controls remains with the federal agency responsible for cleanup.

The transferring agency should clearly identify and define the institutional controls and set forth their purpose and method of implementation in a Record of Decision (ROD) or other decision document. Generally referring to or identifying an institutional control in a ROD is only one step in achieving the objective of an institutional control. An institutional control must be implemented in much the same way as an engineered remedy described in a ROD is designed and constructed.

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5.0 Specific Guidelines for Institutional Controls

What information does EPA need?

EPA's review of federal property transfers requiring institutional controls should focus on whether the institutional controls, when in place, will be reliable and will remain in place after initiation of operation and maintenance. The information should document that the transferring federal agency will ensure that appropriate actions will be taken if a remedy is compromised. EPA should work with the transferring agency to obtain and evaluate the information described below as a precondition for EPA's support of federal property transfers under 120 (h)(3)(A),(B) or (C). At a minimum, EPA should expect to obtain the following information from the transferring federal agency:

1. A legal description of the real property or other geographical information sufficient to clearly identify the property where the institutional controls will be implemented.

2. A description of the anticipated future use(s) for the parcel.

3. Identification of the residual hazard or risk present on the parcel requiring the institutional control. In addition, the specific activities that are prohibited on the parcel should be identified, including prohibitions against certain land use activities that might affect the integrity of the remedy, such as well drilling and construction.

4. The specific institutional control language in substantially the same form as it will appear in the transfer document and a description of the legal authority for the implementation of these controls, such as state statutes, regulations, ordinances or other legal authority including case law.

5. A statement from the transferring federal agency that, in their best professional judgement, the institutional controls conform or will conform with the legal requirements of the applicable state and/or local jurisdiction. This statement should also explain how the institutional controls will be enforceable against future transferees and successors. Compliance with the institutional control should be enforceable against whoever might have ownership or control of the property. For Base Realignment and Closure properties, the majority of the transfers which EPA reviews, this statement could be included in a

memorandum transmitting the final institutional control language for the deed of transfer from a DoD component attorney to the Commanding Officer. The memorandum could state that, based upon a review of the particular state's real estate laws, the component attorney believes that the institutional control is binding in perpetuity and enforceable in state court, and if it is not, he/she will revisit the institutional control or the entire remedy decision. This memorandum could be included in DoD's "operating properly and successfully demonstration" letter to EPA (This is consistent with DoD's own requirement in their guidance Responsibility for Additional Environmental Cleanup after Transfer of Real Property, which states "The DoD component disposal agent will also ensure that appropriate institutional controls and other implementation and enforcement mechanisms, appropriate to the jurisdiction where the property is located, are either in place prior to the transfer or will be put in place by the transferee.").

6. A description of who will be responsible for monitoring the integrity and effectiveness of the institutional controls and the frequency of monitoring. If this is a party other than the transferring federal agency, the transferring federal agency should provide documentation that the party accepts or will accept the responsibility. The transferring agency should also describe which specific party or office will be responsible for overseeing the institutional controls. The transferring agency might, for example, provide details of the types of assistance that other government agencies will provide in preventing the drilling of drinking water wells as well as the frequency of monitoring to ensure that drilling is not occurring.

7. A description of the procedure that will be used to report violations or failures of the institutional controls to the appropriate EPA and/or state regulator, local or tribal government, and the designated party or entity responsible for reporting.

8. A description of the procedure that will be used to enforce against violations of an institutional control, an identification of the party or parties that will be responsible for such enforcement, and a description of the legal authority for this enforcement procedure, such as state statutes, regulations, ordinances, or other legal authority including case law.

9. Assurance that the transferring federal agency will verify maintenance of the institutional control on a periodic basis unless other arrangements have been made. In the latter case, where another party is performing the monitoring function, that party should provide such assurances. In addition, the transferring federal agency must commit to verify the reports on a regular basis in this case.

10. A description of the recording requirements in the jurisdiction where the site is located. The transferring agency also must describe the methods it will use to provide notice of the institutional controls at the site to subsequent owners or lessees.

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6.0 Documentation of Institutional Controls

What remedy selection documentation should EPA expect from the transferring federal agency?

EPA may base its evaluation of the institutional control on information found in the following remedy selection, remedy design, or other documents:

- RODs that contain sufficient information regarding institutional controls.
- Other post-ROD documents that are completed following the selection of a remedy, such as a Remedial Design, Remedial Action Plan, or Operation and Maintenance Plan. This applies in cases where the ROD requires the use of an institutional control but fails to provide sufficient information regarding purpose, implementation, or enforcement (such as in older RODs).

What if existing documents do not provide sufficient information on institutional controls?

If none of the documents mentioned above provide sufficient detail on the implementation of the institutional control, the transferring federal agency should develop an "Institutional Control Implementation Plan" (ICIP) to assist EPA in evaluating the effectiveness of the institutional control. The ICIP should adhere to the following conditions:

- The ICIP should be a comprehensive strategy for the implementation of institutional controls.
- The ICIP should identify the parties responsible for implementing and monitoring the institutional controls.
- The ICIP should document that procedures adequate for effectively implementing and monitoring the institutional control are in place or will be put in place.
- The level of detail in the ICIP should be commensurate with the risk at the site. Depending on the residual risk posed by the site, for instance, EPA may require that the plan be agreed upon by both EPA and state regulators and/or that the plan be structured as an agreement among all the parties involved via a Memorandum of Agreement, amendment of a ROD or Federal Facilities Agreement, or an operation and maintenance plan.

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7.0 "Operating Properly and Successfully Demonstrations"

How does this guidance apply to demonstrations that remedial actions are "operating properly and successfully"?

In August 1996, EPA issued guidance to EPA's Regional Federal Facility programs describing the approach EPA should use in evaluating a federal agency's demonstration that a remedial action is "operating properly and successfully" as a precondition to the deed transfer of federally-owned property, as required in CERCLA section 120(h)(3)(B). In that guidance, entitled Guidance for Evaluation of Federal Agency Demonstrations that Remedial Actions are Operating Properly and Successfully under CERCLA Section 120(h)(3), EPA directed Regional decision-makers to consider a number of factors in evaluating an “operating properly and successfully demonstration” of ongoing remedial actions, including institutional controls. With respect to institutional controls, EPA stated generally that:

“If the integrity of the remedial action depends on institutional controls (e.g., deed restrictions, well drilling prohibitions) these controls should be clearly identified and agreed upon.”

Additionally, under the more specific criteria that must be demonstrated for groundwater remedies, the 1996 guidance included “appropriate institutional controls are in place” as a criterion, but did not describe how federal agencies should meet this requirement. For ongoing remedial actions involving institutional controls and for which EPA must evaluate a transferring federal agency’s demonstration that a remedial action is operating properly and successfully, the information listed in Section 5.0 of this guidance should be submitted as part of the data requirements for the remedial action.

What documentation does EPA need to evaluate “operating properly and successfully demonstrations”?

The following documentation is needed for all “operating properly and successfully demonstrations”:

- The transferring federal agency should research, assemble, and analyze the information to demonstrate to EPA that the remedy is operating properly and successfully.
- The cover letter forwarding the information to EPA should request EPA’s approval of the demonstration and include a statement by a Commanding Officer or senior official similar to the following:

  I certify that the information, data, and analysis provided are true and accurate based on a thorough review. To the best of my knowledge, the remedy is operating properly and successfully, in accordance with CERCLA 120(h)(3)(B).

Generally, where institutional controls are a component of a remedy, EPA should not consider “operating properly and successfully demonstrations” that are not consistent with the requirements described above in Sections 5.0 and 6.0.

When should information for “operating properly and successfully” demonstrations be provided?

EPA should encourage federal agencies preparing “operating properly and successfully demonstrations” to work closely with EPA in planning the scope and presentation of the documentation. A minimum of 45 days is needed for EPA to review all “operating properly and successfully demonstrations.”

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8.0 Coordination with State, Local, and Tribal Governments

What organizations should be involved in the development

of institutional controls?

Successful management of institutional controls is critical to protecting the human health and environment of the communities where federal properties are located. For this reason, EPA encourages early communication and cooperation among federal, state, local, and tribal governments in the development of institutional controls and implementation plans. Where the viability of the institutional control is contingent on state property law or where state institutional control-related laws may apply (e.g., documentation of institutional controls in a state registry), it is particularly important to coordinate with the state. As a matter of policy, therefore, EPA will forward all institutional control information received for federal property transfers to the appropriate state, local, and tribal governments. EPA also will solicit comments from these organizations as appropriate.

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9.0 Executive Order 13132, “Federalism”

Does this Guidance have Federalism Implications?

Executive Order 13132, entitled “Federalism” (64 FR 43255, August 10, 1999), requires EPA to develop an accountable process to ensure “meaningful and timely input by State and local officials in the development of regulatory policies that have federalism implications.” “Policies that have federalism implications” is defined in the Executive Order to include regulations and regulatory policies that have “substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government.

This guidance does not have federalism implications. This guidance aids EPA in implementing its responsibilities under CERCLA section 120(h)(3)(A), (B) or (C). This guidance also encourages Federal agencies to coordinate the development and implementation of institutional controls with state, local and tribal governments. Neither such coordination, nor any other aspect of this guidance, however, will have substantial direct effects on the states, on the relationship between the national government and the states, or on the distribution of power and responsibilities among the various levels of government, as specified in Executive Order 13132. Thus, the requirements of the Executive Order do not apply to this guidance.

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10.0 Conclusion

How will EPA evaluate institutional controls?

EPA prefers to work with federal agencies early in the remedy selection process to assure full and consistent consideration of the long term effectiveness of the institutional controls. For this reason, it is imperative that these discussions begin prior to remedy selection. Although the federal government has had less experience designing and implementing institutional controls than engineered remedies, EPA will use its professional judgement in evaluating institutional control plans, as it does in evaluating other aspects of remedies and operations and maintenance. The basis for that judgment may vary depending on the site characteristics. EPA understands the importance of rapid reuse to the surrounding communities and is committed to supporting this effort while maintaining the Agency's primary goal of protecting human health and the environment.

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Technology>> Ground Water, Surface Water, and Leachate

>>3.9 In Situ Biological Treatment [Nutrient Amendment]

>>4.29 Enhanced Bioremediation

Introduction>> The rate of bioremediation of organic contaminants by microbes is enhanced by increasing the concentration of electron acceptors and nutrients in ground water, surface water, and leachate. Oxygen is the main electron acceptor for aerobic bioremediation. Nitrate serves as an alternative electron acceptor under anoxic conditions.

Description:

Bioremediation is a process in which indigenous or inoculated micro-organisms (i.e., fungi, bacteria, and other microbes) degrade (metabolize) organic contaminants found in soil and/or ground water.

Bioremediation is a process that attempts to accelerate the natural biodegradation process by providing nutrients, electron acceptors, and competent degrading microorganisms that may otherwise be limiting the rapid conversion of contamination organics to innocuous end products.

Oxygen enhancement can be achieved by either sparging air below the water table or circulating hydrogen peroxide (H_2O_2) throughout the contaminated ground water zone. Under anaerobic conditions, nitrate is circulated throughout the ground water contamination zone to enhance bioremediation. Additionally, solid-phase peroxide products (e.g., oxygen releasing compound (ORC)) can also be used for oxygen enhancement and to increase the rate of biodegradation.

Oxygen Enhancement with Air Sparging

Air sparging below the water table increases ground water oxygen concentration and enhances the rate of biological degradation of organic contaminants by naturally occurring microbes. (VOC stripping enhanced by air sparging is addressed in Technology Profile 4.34). Air sparging also increases mixing in the saturated zone, which increases the contact between ground water and soil. The ease and low cost of installing small-diameter air injection points allows considerable flexibility in the design and construction of a remediation system. Oxygen enhancement with air sparging is typically used in conjunction with SVE or bioventing to enhance removal of the volatile component under consideration.

Oxygen Enhancement with Hydrogen Peroxide

During hydrogen peroxide enhancement, a dilute solution of hydrogen peroxide is circulated through the contaminated ground water zone to increase the oxygen content of ground water and enhance the rate of aerobic biodegradation of organic contaminants by naturally occurring microbes.

Nitrate Enhancement

Solubilized nitrate is circulated throughout ground water contamination zones to provide an alternative electron acceptor for biological activity and enhance the rate of degradation of organic contaminants. Development of nitrate enhancement is still at the pilot scale. This technology enhances the anaerobic biodegradation through the addition of nitrate.

Fuel has been shown to degrade rapidly under aerobic conditions, but success often is limited by the inability to provide sufficient oxygen to the contaminated zones as a result of the low water solubility of oxygen and because oxygen is rapidly consumed by aerobic microbes. Nitrate also can serve as an electron acceptor and is more soluble in water than oxygen. The addition of nitrate to an aquifer results in the anaerobic biodegradation of toluene, ethylbenzene, and xylenes. The benzene component of fuel has been found to biodegrade slower under strictly anaerobic conditions. A mixed oxygen/nitrate system would prove advantageous in that the addition of nitrate would supplement the demand for oxygen rather than replace it, allowing for benzene to be biodegraded under microaerophilic conditions.

These technologies may be classified as long-term technologies, which may take several years for plume clean-up.

Synonyms:

Biostimulation, bioaugmentation.
DSERTS Codes:

F11 (Bioremediation - In Situ Groundwater)
H1 (Bioremediation)
H12 (Bioremediation - In Situ)

Applicability:

Target contaminants for enhanced biodegradation processes are nonhalogenated VOCs, nonhalogenated SVOCs, and fuels. Pesticides also should have limited treatability. Nitrate enhancement has primarily been used to remediate ground water contaminated by BTEX.

Limitations:

Factors that may limit the applicability and effectiveness of these processes include:

- Where the subsurface is heterogeneous, it is very difficult to deliver the nitrate or hydrogen peroxide solution throughout every portion of the contaminated zone. Higher permeability zones will be cleaned up much faster because ground water flow rates are greater.
- Safety precautions must be used when handling hydrogen peroxide.
- Concentrations of hydrogen peroxide greater than 100 to 200 ppm in ground water are inhibiting to microorganisms.
- Microbial enzymes and high iron content of subsurface materials can rapidly reduce concentrations of hydrogen peroxide and reduce zones of influence.
- A ground water circulation system must be created so that contaminants do not escape from zones of active biodegradation.
- Because air sparging increases pressure in the vadose zone, vapors can build up in building basements, which are generally low pressure areas.

- Many states prohibit nitrate injection into ground water because nitrate is regulated through drinking water standards.
- A surface treatment system, such as air stripping or carbon adsorption, may be required to treat extracted ground water prior to re-injection or disposal.

Data Needs:

A detailed discussion of these data elements is provided in Subsection 2.2.2 (Data Requirements for Ground Water, Surface Water, and Leachate).

Characteristics that should be investigated prior to system design include aquifer permeability, site hydrology, dissolved oxygen content, pH, and depth, type, concentration, redox conditions, temperature, biodegradability of contaminants, and the presence of a competent biodegrading population of microorganisms.

Performance Data:

As with other in situ biodegradation processes, the success of this technology is highly dependent upon soil properties and biodegradability of the contaminants.

Although oxygen enhancement with air sparging is relatively new, the related technology, bioventing (Treatment Technology Profile 4.1), is rapidly receiving increased attention from remediation consultants. This technology employs the same concepts as bioventing, except that air is injected below the water table to promote the remediation of ground water.

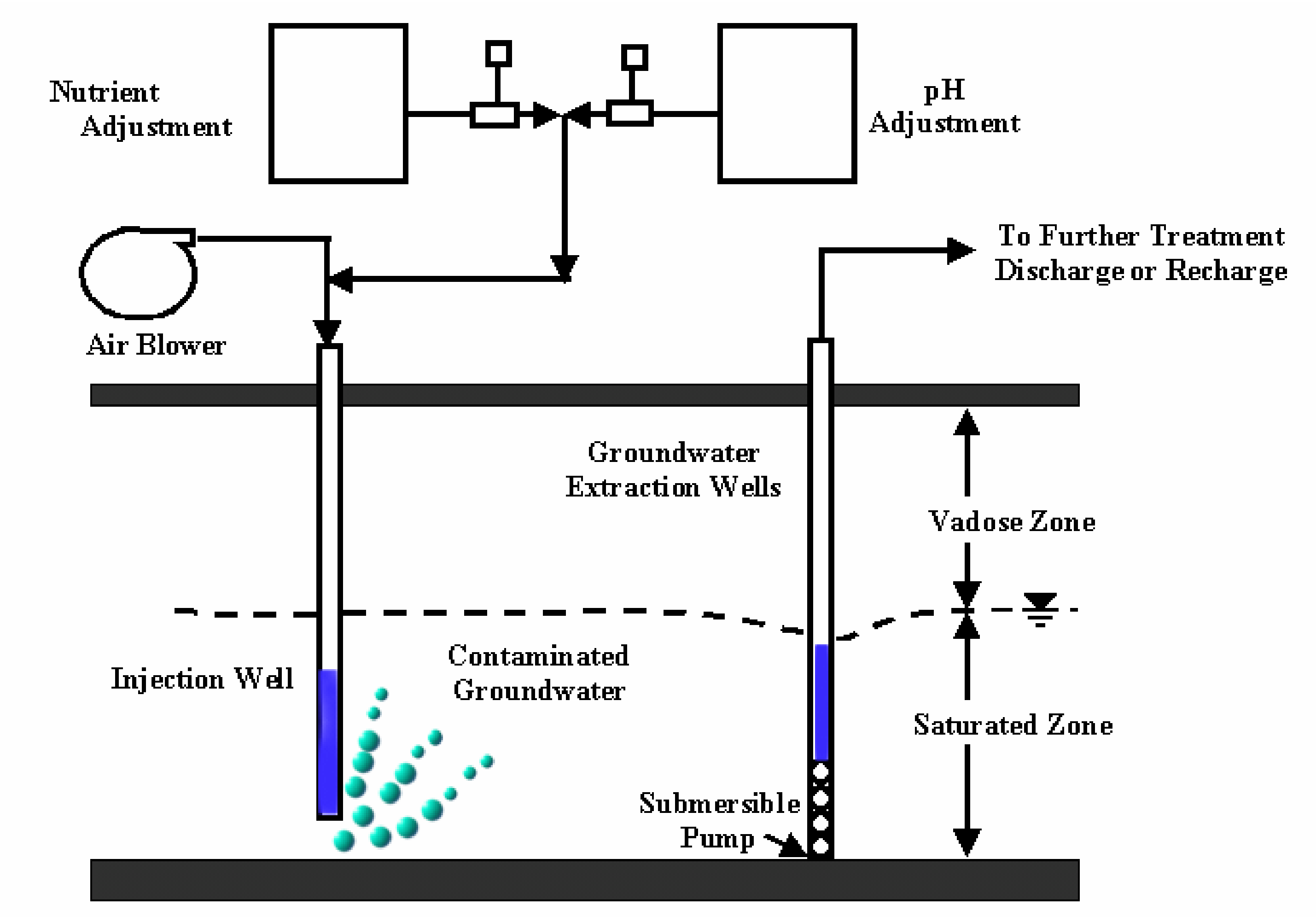
Cost:

For oxygen enhancement with air sparging, typical costs are $10 to $20 per 1,000 liters ($40 to $80 per 1,000 gallons) of ground water treated. Variables affecting the cost are the nature and depth of the contaminants, use of bioaugmentation and/or hydrogen peroxide or nitrate addition, and ground water pumping rates.

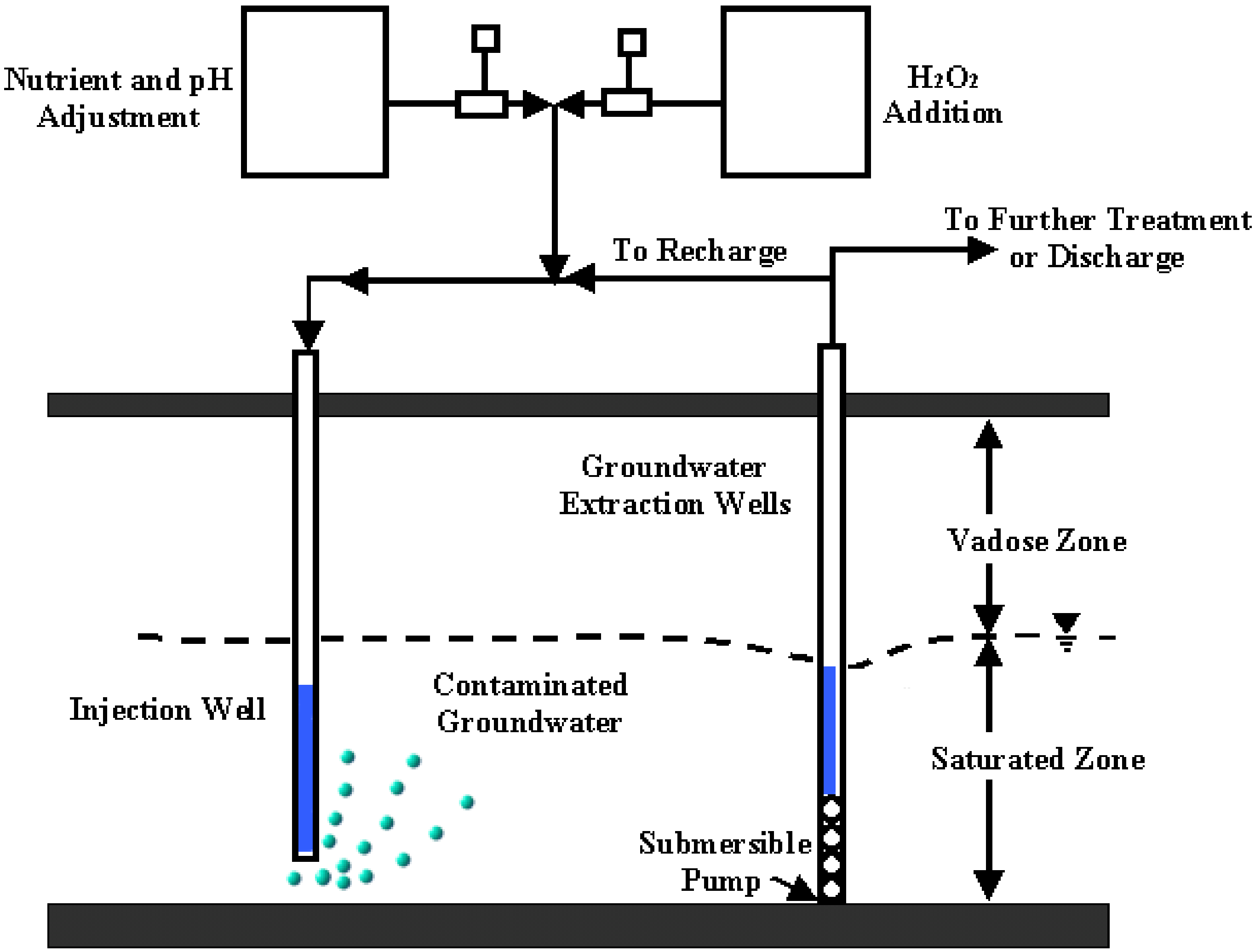
For nitrate enhanced treatment, one cost estimate is in the range of $40 to $60 per liter ($160 to $230 per gallon) of residual fuel removed from the aquifer.

For hydrogein peroxide enhanced treatment, costs are an order of magnitude more expensive than other methods of oxygen enhancement. O&M cost of hydrogen peroxide enhancement can be significant because a continuous source of hydrogen peroxide must be delivered to the contaminated ground water.

Typical Oxygen-Enhanced Bioremediation System for Contaminated Ground water with Air Sparging



Oxygen-Enhanced H_2O_2 Bioremediation System



Technology>> Ground Water, Surface Water, and Leachate

>>3.10 In Situ Physical/Chemical Treatment

>>4.32 Air Sparging

Introduction>> Air is injected into saturated matrices to remove contaminants through volatilization.

Description:

Air sparging is an in situ technology in which air is injected through a contaminated aquifer. Injected air traverses horizontally and vertically in channels through the soil column, creating an underground stripper that removes contaminants by volatilization. This injected air helps to flush (bubble) the contaminants up into the unsaturated zone where a vapor extraction system is usually implemented in conjunction with air sparging to remove the generated vapor phase contamination. This technology is designed to operate at high flow rates to maintain increased contact between ground water and soil and strip more ground water by sparging.

Oxygen added to contaminated ground water and vadose zone soils can also enhance biodegradation of contaminants below and above the water table.

Air sparging has a medium to long duration which may last, generally, up to a few years.

Synonyms:

In-situ air sparging, in-situ aeration.
DSERTS Code: F14 (Air Sparging)

Applicability:

The target contaminant groups for air sparging are VOCs and fuels. Only limited information is available on the process. Methane can be used as an amendment to the sparged air to enhance cometabolism of chlorinated organics.

Limitations:

Factors that may limit the applicability and effectiveness of the process include:

- Air flow through the saturated zone may not be uniform, which implies that there can be uncontrolled movement of potentially dangerous vapors.
- Depth of contaminants and specific site geology must be considered.
- Air injection wells must be designed for site-specific conditions.
- Soil heterogeneity may cause some zones to be relatively unaffected.

Data Needs:

A detailed discussion of these data elements is provided in Subsection 2.2.2. (Data Requirements for Ground Water, Surface Water, and Leachate). Characteristics that should be determined include vadose zone gas permeability, depth to water, ground water flow rate, radial influence of the sparging well, aquifer permeability and heterogeneities, presence of low permeability layers, presence of DNAPLs, depth of contamination, and contaminant volatility and solubility. Additionally, it is often useful to collect air-saturation data, in the saturated zone, during an air sparging test, using a neutron probe.

Performance Data:

This technology is demonstrated at numerous sites, though only a few sites are well documented. Air sparging has demonstrated sensitivity to minute permeability changes, which can result in localized stripping between the sparge and monitoring wells.

Cost:

The key cost driver information and cost analysis was developed in 2006 using the Remedial Action Cost Engineering and Requirements (RACER) software.

Key Cost Drivers

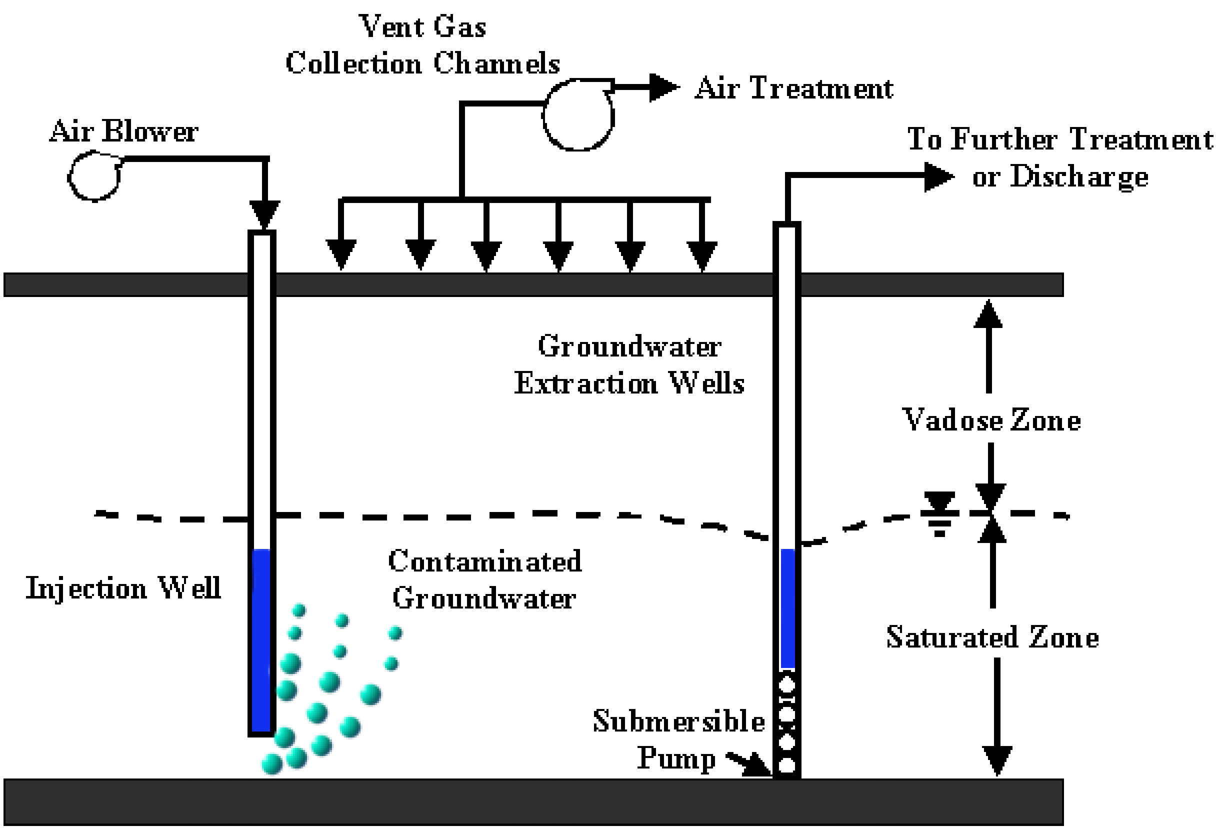
- Surface area (contaminant orientation)
  - Surface area of contamination is the primary cost driver, and directly affects the quantity of air sparge points.
- Depth to Contamination
  - Depth is the secondary cost driver. Cost increases with depth since it impacts the drilling costs.

Cost Analysis

The following table represents estimated costs (by common unit of measure) to apply air sparging technology at sites of varying size and complexity. A more detailed cost estimate table which includes specific site characteristics and significant cost elements that contributed to the final costs can be viewed by clicking on the link below.

GW TECHNOLOGY:	Air Sparging			
RACER PARAMETERS	Scenario A	Scenario B	Scenario C	Scenario D
	Small Site		Large Site	
	Easy	Difficult	Easy	Difficult
COST PER CUBIC FOOT	$2	$1	$0.67	$0.75
COST PER CUBIC METER	$84	$37	$24	$27
COST PER CUBIC YARD	$64	$28	$18	$20

Typical Air Sparging System



Technology>> Ground Water, Surface Water, and Leachate

>>3.10 In Situ Physical/Chemical Treatment

>>4.39 In-Well Air Stripping

Introduction>> Air is injected into a double screened well, lifting the water in the well and forcing it out the upper screen. Simultaneously, additional water is drawn in the lower screen. Once in the well, some of the VOCs in the contaminated ground water are transferred from the dissolved phase to the vapor phase by air bubbles. The contaminated air rises in the well to the water surface where vapors are drawn off and treated by a soil vapor extraction system.

Description:

In-well air stripping technology air is injected into a vertical well that has been screened at two depths. The lower screen is set in the groundwater saturated zone, and the upper screen is in the unsaturated zone, often called as vadose zone. Pressurized air is injected into the well below the water table, aerating the water. The aerated water rises in the well and flows out of the system at the upper screen. Contaminated groundwater is drawn into the system at the lower screen. The volatile organic compounds (VOCs) vaporize within the well at the top of the water table, as the air bubbles out of the water. The vapors are drawn off by a soil vapor extraction (SVE) system. The partially treated ground water is never brought to the surface; it is forced into the unsaturated zone, and the process is repeated as water follows a hydraulic circulation pattern or cell that allows continuous cycling of ground water. As ground water circulates through the treatment system *in situ,* contaminant concentrations are gradually reduced. In-well air stripping is a pilot-scale technology.

Modifications to the basic in-well stripping process may involve additives injected into the stripping well to enhance biodegradation (e.g., nutrients, electron acceptors, etc.). In addition, the area around the well affected by the circulation cell (radius of influence) can be modified through the addition of certain chemicals to allow in situ stabilization of metals originally dissolved in ground water.

The duration of in-well air stripping is short- to long-term, depending contaminant concentrations, Henry's law constants of the contaminants, the radius of influence, and site hydrogeology.

Circulating Wells

Circulating wells (CWs) provide a technique for subsurface remediation by creating a three-dimensional circulation pattern of the ground water. Ground Water is drawn into a well through one screened section and is pumped through the well to a second screened section where it is reintroduced to the aquifer. The flow direction through the well can be specified as either upward or downward to accommodate site-specific conditions. Because ground water is not pumped above ground, pumping costs and permitting issues are reduced and eliminated, respectively. Also, the problems associated with storage and discharge are removed. In addition to ground water treatment, CW systems can provide simultaneous vadose zone treatment in the form of bioventing or soil vapor extraction.

CW systems can provide treatment inside the well, in the aquifer, or a combination of both. For effective in-well treatment, the contaminants must be adequately soluble and mobile so they can be transported by the circulating ground water. Because CW systems provide a wide range of treatment options, they provide some degree of flexibility to a remediation effort.

Synonyms:

Vacuum vapor extraction; In-well aeration; Vacuum vaporizer well; ground water circulating wells.

Applicability:

The target contaminant groups for vacuum vapor extraction are halogenated VOCs, SVOCs, and fuels. Variations of the technology may allow for its effectiveness against some nonhalogenated VOCs, SVOCs, pesticides, and inorganics. Typically, in-well air stripping systems are a cost-effective approach for remediating VOC-contaminated ground water at sites with deep water tables because the water does not need to be brought to the surface.

CW systems are most effective at treating sites with volatile contaminants with relatively high aqueous solubility and strong biodegradation potential, e.g., halogenated and non-halogenated VOCs. CWs operate more efficiently with horizontal conductivities greater that 10^{-3} cm/sec and a ratio of horizontal to vertical conductivities between 3 and 10. A ratio of less than 3 indicates short circulation times and a small radius of influence. If the ratio is greater that 10, the circulation time may be unacceptably long.

Limitations:

The following factors may limit the applicability and effectiveness of the process:

- UVB-type systems only treat the water in the stripping well.
- In general, in-well air strippers are more effective at sites containing high concentrations of dissolved contaminants with high Henry's law constants.
- Fouling of the system may occur by infiltrating precipatation containing oxidized constituents.
- Shallow aquifers may limit process effectiveness.
- Effective CW installations require a well-defined contaminant plume to prevent

the spreading or smearing of the contamination. They should not be applied to sites containing NAPLs to prevent the possibility of smearing the contaminants.

- CWs are limited to sites with horizontal hydraulic conductivities greater that 10^{-5} cm/sec and should not be utilized at sites that have lenses of low-conductivity deposits.
- In well air stripping may not be efficient in sites with strong natural flow patterns.

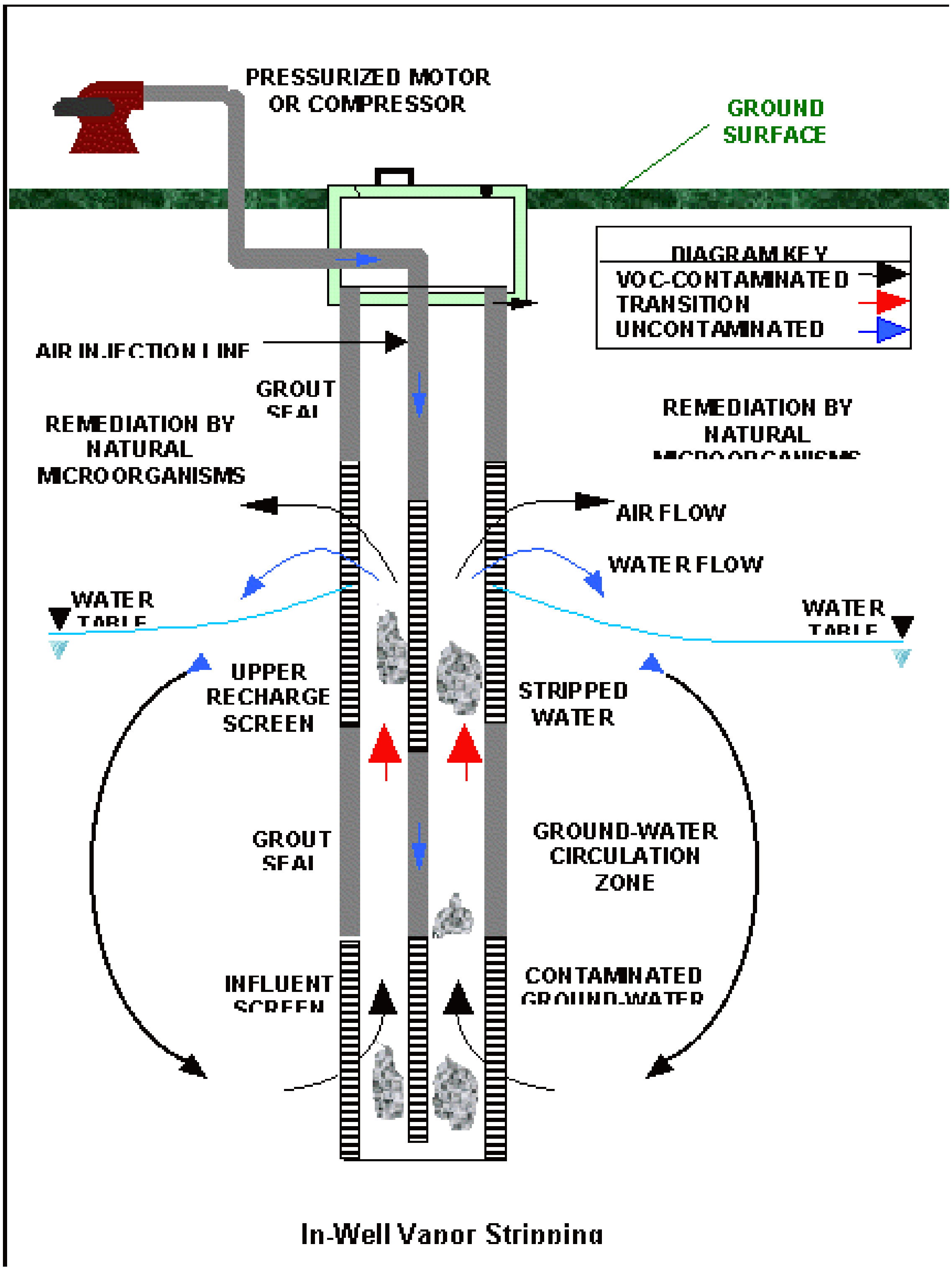
Data Needs:

A detailed discussion of these data elements is provided in Subsection 2.2.2 (Data Requirements for Ground Water, Surface Water, and Leachate).

Performance Data:

A variation of this process, called Unterdruck-Verdampfer Brunner (UVB), has been used at numerous sites in Germany and has been introduced recently into the United States. Stanford University has developed another variation of this process, called NoVOCs, an in-well sparging system, which is currently being evaluated as part of DOE's Integrated Technology Demonstration Program. The Stanford system combines air-lift pumping with a vapor stripping technique. Wasatch Environmental, Inc. has also developed and patented another type of in-well vapor stripping system known as Denstiy Driven Convection (DDC). The DDC system emphasizes the enhancement of bioremediation and involves the dishcharge of extracted vapors into the vadose zone for degradation by naturally-occurring microorganisms. Awareness of this process is limited in the United States but can be expected to increase as development and demonstration of technologies based on the process continue.

Typical DDC system



Technology>> Ground Water, Surface Water, and Leachate

>>3.12 Ex Situ Physical/Chemical Treatment (assuming pumping)

>>4.46 Granulated Activated Carbon (GAC)/Liquid Phase Carbon Adsorption

Introduction>> Ground water is pumped through a series of canisters or columns containing activated carbon to which dissolved organic contaminants adsorb. Periodic replacement or regeneration of saturated carbon is required.

Description:

Liquid phase carbon adsorption is a full-scale technology in which ground water is pumped through one or more vessels containing activated carbon to which dissolved organic contaminants adsorb. When the concentration of contaminants in the effluent from the bed exceeds a certain level, the carbon can be regenerated in place; removed and regenerated at an off-site facility; or removed and disposed. Carbon used for explosives- or metals-contaminated ground water probably cannot be regenerated and should be removed and properly disposed. Adsorption by activated carbon has a long history of use in treating municipal, industrial, and hazardous wastes.

The two most common reactor configurations for carbon adsorption systems are the fixed bed (see figure) and the pulsed or moving bed. The fixed-bed configuration is the most widely used for adsorption from liquids. Pretreatment for removal of suspended solids from streams to be treated is an important design consideration. If not removed suspended solids in a liquid stream may accumulate in the column, causing an increase in pressure drop. When the pressure drop becomes too high, the accumulated solids must be removed, for example, by backwashing. The solids removal process necessitates adsorber downtime and may result in carbon loss and disruption of the mass transfer zone.

Modification of GAC, such as silicone impregnated carbon, could increase removal efficiency and extend the length of operation. It may also be safer to regenerate.

The duration of GAC is usually short-term; however, if concentrations are low enough, the duration may be long-term. The duration of operation and maintenance is dependent on contaminant type, concentration, and volume; regulatory cleanup requirements; and metal concentrations.

Synonyms:

Activated carbon; Carbon filtration.
DSERTS Code: F20 (Carbon Absorption)

Applicability:

The target contaminant groups for carbon adsorption are hydrocarbons, SVOCs and explosives. Limited effectiveness may be achieved on halogenated VOCs and pesticides. Liquid phase carbon adsorption is effective for removing contaminants at low concentrations (less than 10 mg/L) from water at nearly any flow rate, and for removing higher concentrations of contaminants from water at low flow rates (typically 2 to 4 liters per minute or 0.5 to 1 gpm). Carbon adsorption is particularly effective for polishing water discharges from other remedial technologies to attain regulatory compliance. Carbon adsorption systems can be deployed rapidly, and contaminant removal efficiencies are high. Logistic and economic disadvantages arise from the need to transport and decontaminate spent carbon.

Limitations:

The following factors may limit the applicability and effectiveness of the process:

- The presence of multiple contaminants can impact process performance. Single component isotherms may not be applicable for mixtures. Bench tests may be conducted to estimate carbon usage for mixtures.
- Streams with high suspended solids (> 50 mg/L) and oil and grease (> 10 mg/L) may cause fouling of the carbon and may require frequent treatment. In such cases, pretreatment is generally required.
- Costs are high if used as the primary treatment on wastestreams with high contaminant concentration levels.
- Type, pore size, and quality of the carbon, as well as the operating temperature, will impact process performance. Vendor expertise for carbon selection should be consulted.
- Carbon used for explosives- or metals-contaminated ground water is not regenerated.
- Highly Water-soluble compounds and small molecules are not adsorbed well.
- All spent carbon eventually need to be properly disposed.

Data Needs:

A detailed discussion of these data elements is provided in Subsection 2.2.2 (Data Requirements for Ground Water, Surface Water, and Leachate).

The major design variables for liquid phase carbon applications are empty bed contact time (EBCT), usage rate, and system configuration. Particle size and hydraulic loading are often chosen to minimize pressure drop and reduce or eliminate backwashing. System configuration and EBCT have an impact on carbon usage rate. When the bed life is longer than 6 months and the treatment objective is stringent (ratio of effluent concentration, C_e, to influent concentration, C_o, <0.05), a combination of single beds operating in parallel is preferred. For a single adsorber, the EBCT is normally chosen to be large enough to minimize carbon usage rate. When less stringent objectives are required ($C_e/C_o<0.3$), blending of effluents from partially saturated adsorbers can be used to reduce carbon replacement rate. When stringent treatment objectives are required ($C_e/C_o<0.05$) and bed life is short (less than 6 months), multiple beds in series may be used to decrease carbon usage rate.

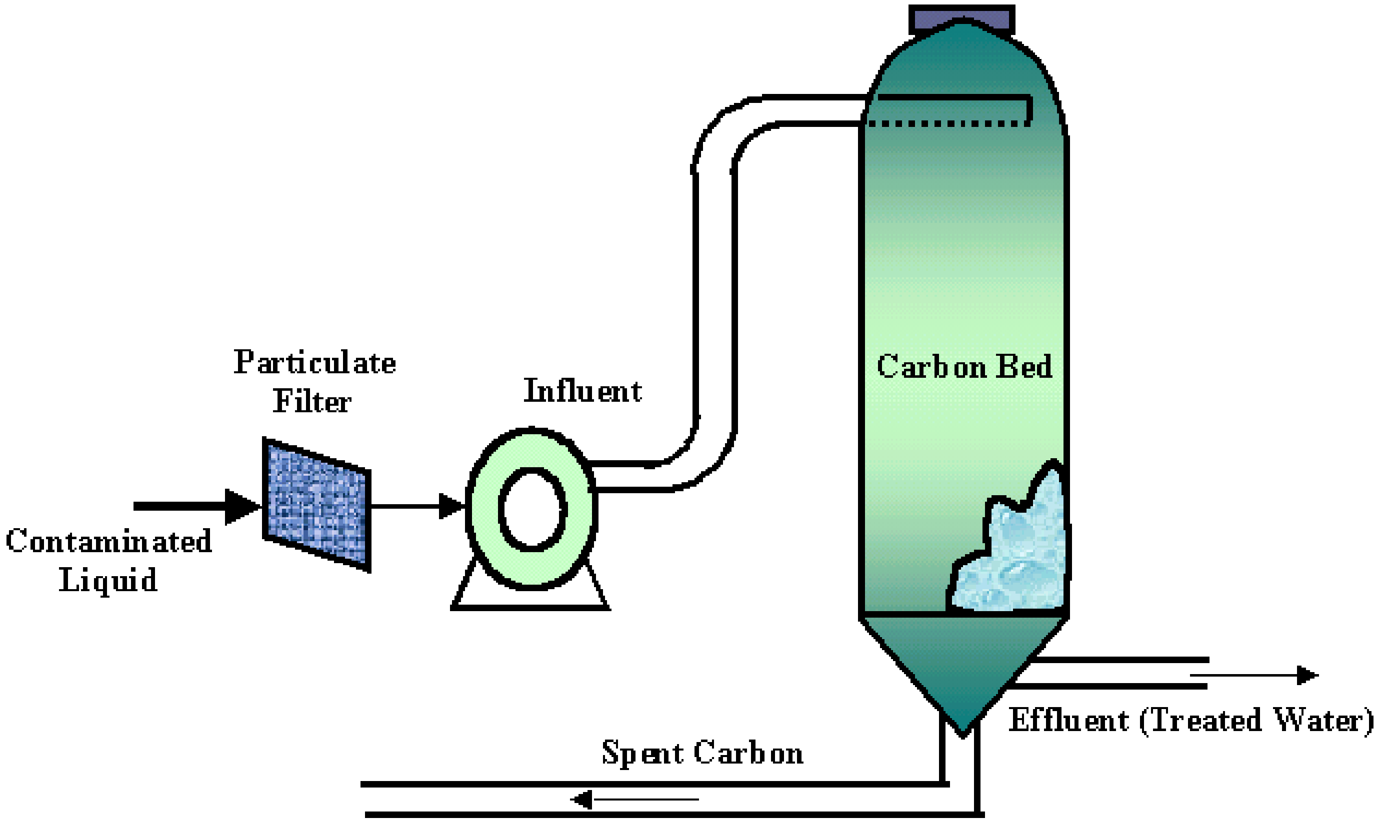
Performance Data:

Adsorption by activated carbon has a long history of use as a treatment for municipal, industrial, and hazardous wastestreams. The concepts, theory, and engineering aspects of the technology are well developed. It is a proven technology with documented performance data. Carbon adsorption is a relatively nonspecific adsorbent and is effective for removing many organic, explosive, and some inorganic contaminants from liquid and gaseous streams.

Cost:

Costs associated with GAC are dependent on wastestream flow rates, type of contaminant, concentration of contaminant, mass loading, required effluent concentration, and site and timing requirements. Costs are lower with lower concentration levels of a contaminant of a given type. Costs are also lower at higher flow rates. At flow rates of 0.4 million liters per day (0.1 mgd), costs increase to $0.32 to $1.70 per 1,000 liters ($1.20 to $6.30 per 1,000 gallons) treated.

Typical Fixed-Bed Carbon Adsorption System



APPENDIX C

DETAILED COST ANALYSES

APPENDIX C – COST ANALYSES BY REMEDIAL ALTERNATIVE

The tables in this appendix present the cost analyses for each alternative that has undergone detailed analysis for this FS. The tables are ordered by remedial alternative. The rough order magnitude (ROM) cost estimates presented in the tables are intended to be within -30 percent and +50 percent. These costs are based on a variety of information including generic unit costs, vendor information, conventional cost estimating guides, and prior experience. The feasibility study level cost estimates shown have been prepared to assist project evaluation and implementation. The actual costs of the project will depend on variable factors that may apply at the time of implementation. A major uncertainty that would affect the cost is the actual volumes of contaminated media. Mobilization/demobilization costs are for making the necessary equipment and labor available in Yakutat to implement the remedial alternative. The capital costs include such items as field treatability studies, installation of treatment components, fencing, etc. Direct capital costs may include construction costs, equipment costs, building and services costs, and disposal costs. Indirect capital costs may include engineering expenses, licensing and/or permitting costs, system startup costs, and contingency allowances. Operation and maintenance (O&M) costs are for treatment monitoring, maintenance, and energy use. Future capital costs are for advancement of confirmation borings and decommissioning treatment components, monitoring wells, and fencing. Capital and O&M costs are calculated to net present value using *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA 2000). The present worth or present value (PV) of a future payment is calculated using the following equation:

$$PV = x_t / (1 + i)^t$$

where x_t is the payment in year t (t = 0 for present or base year) and i is the discount rate. The discount rate used to calculate the net present value of the remedial alternatives for this FS is 7%. For example, suppose an O&M payment of $10,000 is required in Year 10 to implement a remedial alternative. Using a discount rate of 7%, the present value of the O&M payment would be:

$$\$10,000 / (1 + 0.07)^{10} = \$5,080.$$

Therefore, $5,080 would need to be set aside or invested in Year 0, at a discount or interest rate of 7%, in order to have $10,000 in Year 10.

Estimated volumes of impacted soil and/or sediment at the various Areas of Concern (AOCs) range from about 7 cubic yards (cy) to 28,000 cy. The costs presented in the tables of this appendix for implementing Remedial Alternatives 3 through 10 were developed on a per cubic yard basis for a 20 cy, 2,000 cy, and 20,000 cy site and then plotted on a graph. The resulting curve established from this graphical representation of the per cubic yard costs was used to develop the unit cost per cubic yard and total cost for the remedial alternative at the individual AOCs. The costs presented in the tables of this appendix for implementing the remaining remedial alternatives are estimated on a per site basis. The assumptions used to develop the costs presented in the tables of this appendix are identified in the right margin of each table.

LIST OF TABLES IN APPENDIX C

LIST OF GRAPHS IN APPENDIX C

TABLE C.1 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 1 - NO ACTION

Alternative 1 - No Action								**COSTS**
Mobilization/Demobilization Costs								**$0**
Equipment and Personnel Mobilization/Demobilization Effort							$0	
Capital Costs								**$0**
No Action							$0	
Environmental Consultant								
Project Management	0	hours	@	$134	/hour	$0		
Work Plan and Reporting	0	ea	@	$1,750	ea	$0		
Contingency (15%)						$0		
O&M Costs								**$0**
No Action							$0	
Environmental Consultant								
Project Management	0	hours	@	$134	/hour	$0		
Work Plan and Reporting	0	ea	@	$1,750	ea	$0		
Contingency (15%)						$0		
							Alternative 1 - No Action Total:	$0

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST		TOTAL COST PER YEAR		DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE PER CY COST
Mobilization/Demobilization Costs	1	$0		0		1	$0	$0
Capital Cost	1	$0		0		1	$0	$0
Annual O&M Cost	1	$0		0		1	$0	$0
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)							**$0**	**$0**

TABLE C.2 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 2 - INSTITUTIONAL CONTROLS

Alternative 2 - Institutional Controls								**COSTS**
Mobilization/Demobilization Costs								**$0**
Equipment and Personnel Mobilization/Demobilization Effort							$0	
Capital Costs								**$5,060**
IC Implementation							$5,060	
Environmental Consultant								
Project Management	10	hours	@	$140	/hour	$1,400		
Installation of IC	30	hours	@	$100	/hour	$3,000		
Contingency (15%)						$660		
O&M Costs (Per Year)								**$621**
Review and Enforcement							$621	
Environmental Consultant								
Project Management	1	hours	@	$140	/hour	$140		
Review and Enforcement of IC	4	hours	@	$100	/hour	$400		
Contingency (15%)						$81		
							Alternative 2 - Institutional Controls Total:	**$5,681**

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST		TOTAL COST PER YEAR		DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER SITE
Mobilization/Demobilization Costs	1	$0		0		1	$0	$0
Capital Cost	1	$5,060		$5,060		1	$5,060	$5,060
O&M Cost (Annually for 30 years)	1 to 30	$18,630		$621		12.409	$7,706	$7,706
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)							$12,766	$12,766

TABLE C.3A - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 3 - MONITORED NATURAL ATTENUATION (SOIL)

Alternative 3 - Monitored Natural Attenuation (Soil)

Item	Qty	Unit		Unit Cost	Per	Amount	Subtotal	COSTS	Notes
	2,000 Cubic Yards								
Mobilization/Demobilization Costs								**$46,000**	
Equipment and Personnel Mobilization/Demobilization Effort							$46,000		
Drilling Equipment and Personnel									
Tubex Drill Rig Mob/Demob	1	lump sum	@	$32,500	ea	$32,500			Assumes mobilization/demobilization efforts for Years 5, 10, 15,
Driller (1), Helper (1) and Laborer	1	ea	@	$4,500	ea	$4,500			20, and 25 (screening for cleanup) and Year 30 (confirmation of
Environmental Consultant									cleanup) for this technology for 2,000 cy - Present Value Analysis
Engineer/Geologist/Env. Scientist (2)	1	ea	@	$3,000	ea	$3,000			Table shows costs
Contingency (15%)						$6,000			
O&M Costs								**$0**	
Future Capital Costs (Every 5 Years)								**$18,255**	
Screening for Cleanup							$18,255		
Screening Borings									
Tubex Drill Rig (100 feet/day)	0.4	days	@	$1,600	/day	$704			4 borings per event to 11 feet, 1 sample per boring
Per Diem (3)	0.4	days	@	$420	/day	$185			
Driller (1), Helper (1) and Laborer	1	ea	@	$4,500	ea	$4,500			
Change Out Driller (1), Helper (1) and Laborer	0.02	ea	@	$4,500	ea	$94			Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis									
Screening Samples (GRO, DRO, VOCs, SVOCs)	4.0	samples	@	$435	each	$1,740			Assumes 30% of total sample number required for cleanup conf
Environmental Consultant									
Project Management	0.9	hours	@	$134	/hour	$118			2 hours per work day
Monitoring and Sampling (1 person)	0.4	days	@	$900	/day	$396			Same hours as backhoe crew
Per Diem (1) and Vehicle	0.4	days	@	$240	/day	$106			
Change Out Engineer/Geologist/Env. Scientist (1)	0.02	ea	@	$1,500	ea	$31			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$2,381			included in Tables 6.0-2 and 6.0-3
Future Capital Costs (One Time at End of Treatment)								**$61,956**	
Confirmation of Cleanup							$61,956		
Confirmation Borings									
Tubex Drill Rig (100 feet/day)	1.1	days	@	$4,500	/day	$4,950			10 borings to 11 feet deep
Per Diem (3)	1.1	days	@	$420	/day	$462			
Change Out Driller (1), Helper (1) and Laborer	0.1	ea	@	$4,500	ea	$236			Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis									1 sample per 200 cubic yards to 2,000 cy and then 1 sample per
Confirmation Samples (GRO, DRO, VOCs, SVOCs)	12.0	samples	@	$435	each	$5,220			500 cubic yards plus 20% QC; Minimum 4 samples
Environmental Consultant									
Project Management	2.2	hours	@	$134	/hour	$295			2 hours per work day
Monitoring and Sampling (2 person)	1.1	days	@	$1,800	/day	$1,980			Same hours as drill crew
Per Diem (2) and Vehicle	1.1	days	@	$380	/day	$418			
Change Out Engineer/Geologist/Env. Scientist (2)	0.1	ea	@	$3,000	ea	$314			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	400	hours	@	$100	/hour	$40,000			Assumes work plan effort shared with multiple sites and stand
Contingency (15%)						$8,081			alone cleanup report combined with decom report for each site
Alternative 3 - Monitored Natural Attenuation (Soil) Total:								**$126,211**	

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST		TOTAL COST PER YEAR		DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER CY*
Mobilization/Demobilization Costs	5	$46,000		$46,000		0.713	$32,797	
Mobilization/Demobilization Costs	10	$46,000		$46,000		0.508	$23,384	-
Mobilization/Demobilization Costs	15	$46,000		$46,000		0.362	$16,673	
Mobilization/Demobilization Costs	20	$46,000		$46,000		0.258	$11,887	-
Mobilization/Demobilization Costs	25	$46,000		$46,000		0.184	$8,475	-
Mobilization/Demobilization Costs	30	$46,000		$46,000		0.131	$6,043	-
O&M Cost	0	$0		$0		1.000	$0	$0
Future Capital Costs (Every 5 Years)	5	$18,255		$18,255		0.713	$13,016	$7
Future Capital Costs (Every 5 Years)	10	$18,255		$18,255		0.508	$9,280	$5
Future Capital Costs (Every 5 Years)	15	$18,255		$18,255		0.362	$6,617	$3
Future Capital Costs (Every 5 Years)	20	$18,255		$18,255		0.258	$4,717	$2
Future Capital Costs (Every 5 Years)	25	$18,255		$18,255		0.184	$3,363	$2
Future Capital Costs (One time)	30	$61,956		$61,956		0.131	$8,139	$4
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)							**$45,132**	**$23**

* Average cost per cubic yard is for treating a site having an estimated volume of 2000 cubic yards of impacted soil.

TABLE C.3A - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 3 - MONITORED NATURAL ATTENUATION (SOIL)

Alternative 3 - Monitored Natural Attenuation (Soil)

								COSTS	
	20 Cubic Yards								
Mobilization/Demobilization Costs								**$4,140**	
Equipment and Personnel Mobilization/Demobilization Effort							$4,140		
Test Pit Equipment and Personnel									
Excavator/Backhoe - Local	1.0	lump sum	@	$500	ea	$500			Assumes mobilization/demobilization efforts for Years 5, 10, 15, 20, and 25 (screening for cleanup) and Year 30 (confirmation of cleanup) for this technology for 20 cy - Present Value Analysis Table shows costs
Operator - Local	1.0	lump sum	@	$100	ea	$100			
Environmental Consultant									
Engineer/Geologist/Env. Scientist (2)	1	ea	@	$3,000	ea	$3,000			
Contingency (15%)						$540			
O&M Costs								**$0**	
Future Capital Costs (Every 5 Years)								**$10,342**	
Screening for Cleanup							$10,342		
Test Pits									
Backhoe & Operator - Local (100 feet/day)	0.04	days	@	$1,600	/day	$64			1 Test Pit per event to 4 feet - assumes multiple sites
Laboratory Analytical Sample Analysis									
Screening Samples (GRO, DRO, VOCs, SVOCs)	2.0	samples	@	$435	each	$870			Assumes 30% of total sample number required for cleanup confirmation (minimum of 2 samples)
Environmental Consultant									
Project Management	0.1	hours	@	$134	/hour	$11			2 hours per work day
Monitoring and Sampling (1 person)	0.04	days	@	$900	/day	$36			Same hours as backhoe crew
Per Diem (1) and Vehicle	0.04	days	@	$240	/day	$10			Assumes shared between sites
Change Out Engineer/Geologist/Env. Scientist (1)	0.002	ea	@	$1,500	ea	$3			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites included in Tables 6.0-2 and 6.0-3
Contingency (15%)						$1,349			
Future Capital Costs (One Time at End of Treatment)								**$12,842**	
Confirmation of Cleanup							$12,842		
Test Pits									
Backhoe & Operator - Local (100 feet/day)	0.04	days	@	$1,600	/day	$64			1 Test Pit per event to 4 feet - assumes multiple sites
Laboratory Analytical Sample Analysis									
Screening Samples (GRO, DRO, VOCs, SVOCs)	2.4	samples	@	$435	each	$1,044			2 samples per 250 sf, 1 for each additional 250 sf, plus 20% QC (minimum of 2 samples) - QC shared with multiple sites
Environmental Consultant									
Project Management	0.1	hours	@	$134	/hour	$11			2 hours per work day
Monitoring and Sampling (1 person)	0.04	days	@	$900	/day	$36			Same hours as backhoe crew
Per Diem (1) and Vehicle	0.04	days	@	$240	/day	$10			Assumes shared between sites
Change Out Engineer/Geologist/Env. Scientist (1)	0.002	ea	@	$1,500	ea	$3			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	100	hours	@	$100	/hour	$10,000			Assumes work plan effort shared with multiple sites and stand alone cleanup report combined with decom report for each site
Contingency (15%)						$1,675			
							Alternative 3 - Monitored Natural Attenuation (Soil) Total:	**$27,324**	

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST		TOTAL COST PER YEAR		DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER CY*
Mobilization/Demobilization Costs	5	$4,140		$4,140		0.713	$2,952	
Mobilization/Demobilization Costs	10	$4,140		$4,140		0.508	$2,105	-
Mobilization/Demobilization Costs	15	$4,140		$4,140		0.362	$1,501	
Mobilization/Demobilization Costs	20	$4,140		$4,140		0.258	$1,070	-
Mobilization/Demobilization Costs	25	$4,140		$4,140		0.184	$763	-
Mobilization/Demobilization Costs	30	$4,140		$4,140		0.131	$542	-
O&M Cost	0	$0		$0		1.000	$0	$0
Future Capital Costs (Every 5 Years)	5	$10,342		$10,342		0.713	$7,374	$369
Future Capital Costs (Every 5 Years)	10	$10,342		$10,342		0.508	$5,257	$263
Future Capital Costs (Every 5 Years)	15	$10,342		$10,342		0.362	$3,748	$187
Future Capital Costs (Every 5 Years)	20	$10,342		$10,342		0.258	$2,673	$134
Future Capital Costs (Every 5 Years)	25	$10,342		$10,342		0.184	$1,906	$95
Future Capital Costs (One time)	30	$12,842		$12,842		0.131	$1,682	$84
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)							**$22,640**	**$1,132**

* Average cost per cubic yard is for treating a site having an estimated volume of 20 cubic yards of impacted soil.

TABLE C.3A - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 3 - MONITORED NATURAL ATTENUATION (SOIL)

Alternative 3 - Monitored Natural Attenuation (Soil)

20,000 Cubic Yards

Item	Qty	Unit		Rate	Per	Amount	Subtotal	COSTS	Notes
Mobilization/Demobilization Costs								**$46,000**	
Equipment and Personnel Mobilization/Demobilization Effort							$46,000		
Drilling Equipment and Personnel									
Tubex Drill Rig Mob/Demob	1	lump sum	@	$32,500	ea	$32,500			
Driller (1), Helper (1) and Laborer	1	ea	@	$4,500	ea	$4,500			Assumes mobilization/demobilization efforts for Years 5, 10, 15, 20, and 25 (screening for cleanup) and Year 30 (confirmation of cleanup) for this technology for 20,000 cy - Present Value Analysis Table shows costs
Environmental Consultant									
Engineer/Geologist/Env. Scientist (2)	1	ea	@	$3,000	ea	$3,000			
Contingency (15%)						$6,000			
O&M Costs								**$0**	
Future Capital Costs (Every 5 Years)								**$40,876**	
Screening for Cleanup							$40,876		
Screening Borings									
Tubex Drill Rig (100 feet/day)	4.1	days	@	$1,600	/day	$6,480			9 borings per event to 45 feet, 2 samples per boring
Per Diem (3)	4.1	days	@	$420	/day	$1,701			
Driller (1), Helper (1) and Laborer	1	ea	@	$4,500	ea	$4,500			
Change Out Driller (1), Helper (1) and Laborer	0.2	ea	@	$4,500	ea	$868			Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis									
Screening Samples (GRO, DRO, VOCs, SVOCs)	18.4	samples	@	$435	each	$8,004			Assumes 30% of total sample number required for cleanup conf
Environmental Consultant									
Project Management	8.1	hours	@	$134	/hour	$1,085			2 hours per work day
Monitoring and Sampling (1 person)	4.1	days	@	$900	/day	$3,645			Same hours as backhoe crew
Per Diem (1) and Vehicle	4.1	days	@	$240	/day	$972			Assumes shared between sites
Change Out Engineer/Geologist/Env. Scientist (1)	0.2	ea	@	$1,500	ea	$289			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites included in Tables 6.0-2 and 6.0-3
Contingency (15%)						$5,332			
Future Capital Costs (One Time at End of Treatment)								**$211,562**	
Confirmation of Cleanup							$211,562		
Confirmation Borings									
Tubex Drill Rig (100 feet/day)	10.4	days	@	$4,500	/day	$46,575			23 borings to 45 feet deep 2 samples per boring
Per Diem (3)	10.4	days	@	$420	/day	$4,347			
Change Out Driller (1), Helper (1) and Laborer	0.5	ea	@	$4,500	ea	$2,218			Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis									1 sample per 200 cubic yards to 2,000 cy and then 1 sample per 500 cubic yards plus 20% QC; Minimum 4 samples
Confirmation Samples (GRO, DRO, VOCs, SVOCs)	55.2	samples	@	$435	each	$24,012			
Environmental Consultant									
Project Management	20.7	hours	@	$134	/hour	$2,774			2 hours per work day
Monitoring and Sampling (2 person)	10.4	days	@	$1,800	/day	$18,630			Same hours as drill crew
Per Diem (2) and Vehicle	10.4	days	@	$380	/day	$3,933			Assumes shared between sites
Change Out Engineer/Geologist/Env. Scientist (2)	0.5	ea	@	$3,000	ea	$1,479			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	800	hours	@	$100	/hour	$80,000			Assumes work plan effort shared with multiple sites and stand alone cleanup report combined with decom report for each site
Contingency (15%)						$27,595			

Alternative 3 - Monitored Natural Attenuation (Soil) Total: $298,439

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST		TOTAL COST PER YEAR		DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER CY*
Mobilization/Demobilization Costs	5	$46,000		$46,000		0.713	$32,797	
Mobilization/Demobilization Costs	10	$46,000		$46,000		0.508	$23,384	-
Mobilization/Demobilization Costs	15	$46,000		$46,000		0.362	$16,673	
Mobilization/Demobilization Costs	20	$46,000		$46,000		0.258	$11,887	-
Mobilization/Demobilization Costs	25	$46,000		$46,000		0.184	$8,475	-
Mobilization/Demobilization Costs	30	$46,000		$46,000		0.131	$6,026	-
O&M Cost	0	$0		$0		1.000	$0	$0
Future Capital Costs (Every 5 Years)	5	$40,876		$40,876		0.713	$29,144	$1
Future Capital Costs (Every 5 Years)	10	$40,876		$40,876		0.508	$20,779	$1
Future Capital Costs (Every 5 Years)	15	$40,876		$40,876		0.362	$14,815	$1
Future Capital Costs (Every 5 Years)	20	$40,876		$40,876		0.258	$10,563	$1
Future Capital Costs (Every 5 Years)	25	$40,876		$40,876		0.184	$7,531	$0.4
Future Capital Costs (One time)	30	$211,562		$211,562		0.131	$27,792	$1
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)							**$110,626**	**$6**

* Average cost per cubic yard is for treating a site having an estimated volume of 20,000 cubic yards of impacted soil.

TABLE C.3A - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 3 - MONITORED NATURAL ATTENUATION (SOIL)

Alternative 3 - Monitored Natural Attenuation (Soil)

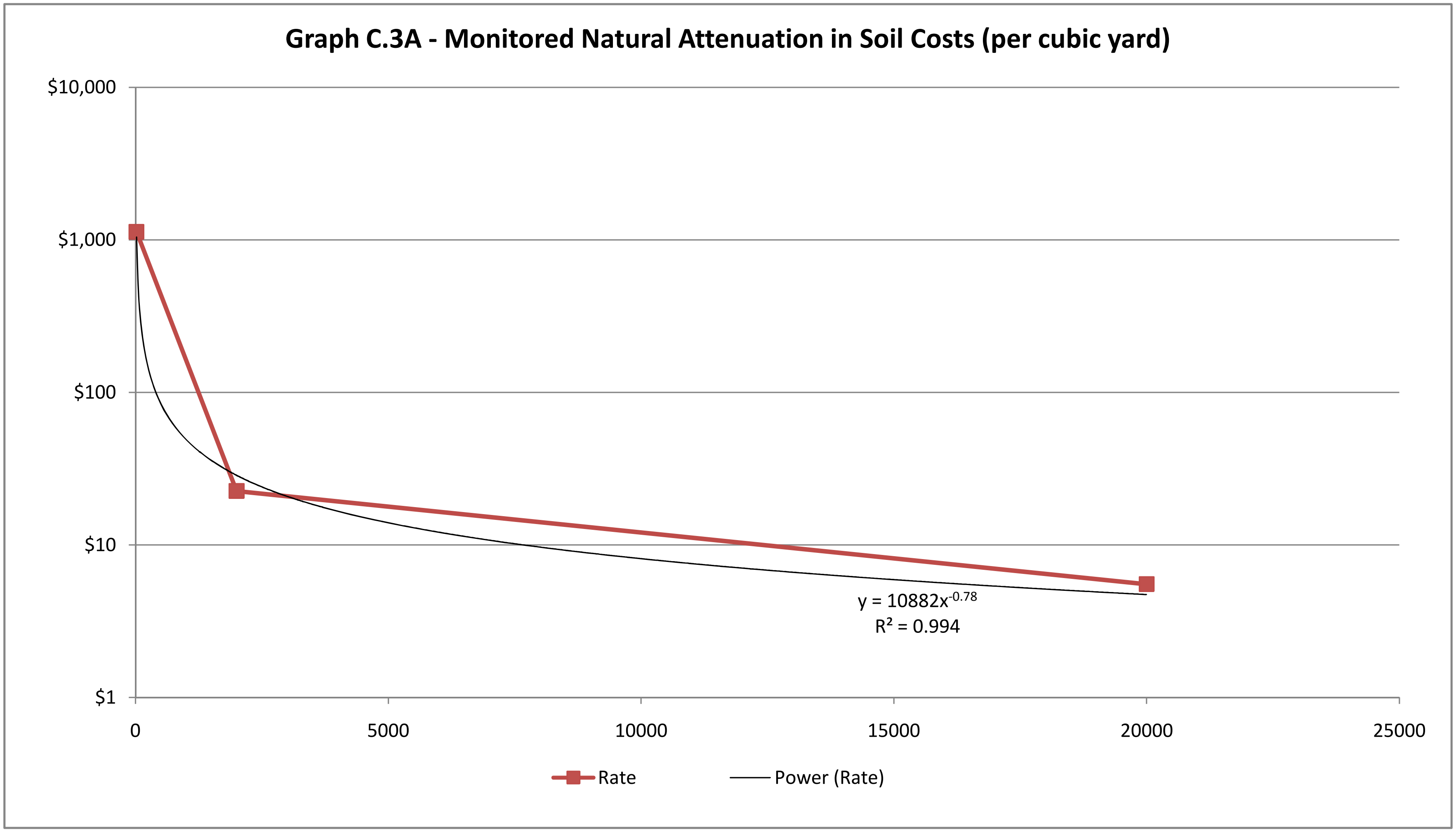


TABLE C.3B - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 3 - MONITORED NATURAL ATTENUATION (GROUNDWATER)

Alternative 3B - Monitored Natural Attenuation (Groundwater)

AOC C6

Item	Qty	Unit		Rate	Per	Cost	Subtotal	COSTS	Notes
Mobilization/Demobilization Costs								**$46,000**	
Equipment and Personnel Mobilization/Demobilization Effort							$46,000		
Well Equipment and Personnel									
Tubex Drill Rig Mob/Demob	1	lump sum	@	$32,500	ea	$32,500			Assumes mobilization/demobilization costs for Year 1 (installation) and Year 30 (system decommissioning) - Present Value Analysis Table shows costs
Driller (1), Helper (1) and Laborer	1	ea	@	$4,500	ea	$4,500			
Environmental Consultant									
Engineer/Geologist/Env. Scientist (2)	1	ea	@	$3,000	ea	$3,000			
Contingency (15%)						$6,000			
Capital Costs								**$60,103**	
Additional Monitoring Well Installation Effort							$60,103		10 monitoring wells needed. C6 has 3 monitoring wells. Need 7 monitoring wells to 20 feet.
(Assumes 40,000 square foot groundwater plume. Assumes 3 monitoring wells for first 5,000 square foot and 1 monitoring well for each additional 5,000 square foot area are needed. Three monitoring wells already are present.)									
Well Installation									
Tubex Drill Rig (100 ft well/day)	1.4	days	@	$4,500	/day	$6,300			7 wells to 20 feet
Well Piping Materials and Shipping	154.0	lin ft	@	$25	/lf	$3,850			7 wells to 20 feet plus 2 feet stickup
Per Diem (3)	1.4	days	@	$420	/day	$588			Same days as drill crew
Change Out Driller (1), Helper (1) and Laborer	0.1	ea	@	$4,500	ea	$300			Change out drill crew every 21 days
Laboratory Analytical Sample Analysis									
GRO, DRO, VOCs, SVOCs	14	samples	@	$435	ea	$6,090			One sample per boring and 1 sample per monitoring well
Environmental Consultant									
Project Management	10.8	hours	@	$140	/hour	$1,512			2 hours per work day
Monitoring and Sampling (2 person)	5.4	days	@	$1,800	/day	$9,720			Same days as drill crew plus 4 days to develop wells, sample and treat water
Miscellaneous Equipment	5.4	days	@	$200	/day	$1,080			
Per Diem (2) and Vehicle	5.4	days	@	$380	/day	$2,052			
Change Out Engineer/Geologist/Env. Scientist (2)	0.3	ea	@	$3,000	ea	$771			
Work Plan and Reporting	200	hours	@	$100	/hour	$20,000			Assumes part of larger work plan and report effort for all sites included in Tables 6.0-2 and 6.0-3
Contingency (15%)						$7,840			
Annual O&M Costs								**$24,071**	
Monitoring							$24,071		
Laboratory Analytical Sample Analysis									
GRO, RRO, VOCs, SVOCs - water	12.0	samples	@	$435	ea	$5,220			Assume 10 monitoring wells plus 20% QC each year
Environmental Consultant									
Project Management	10.0	hours	@	$134	/hour	$1,340			2 hours per work day
Filtration Equipment	1.0	event	@	$100	/event	$100			
Monitoring and Sampling (1 person)	5.0	days	@	$900	/day	$4,500			0.5 day per well per year
Per Diem (1) and Vehicle	5.0	days	@	$240	/day	$1,200			Assumes shared between sites
Travel to Site (1 person)	0.14	ea	@	$1,500	ea	$214			Assumes travel shared between 7 sites eligible for MNA
Change Out Engineer/Geologist/Env. Scientist (1)	0.2	ea	@	$1,500	ea	$357			Change out crew every 21 days (assumes work at multiple sites)
Reporting	80	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites included in Tables 6.0-2 and 6.0-3
Contingency (15%)						$3,140			
Future Capital Costs (One Time in Year 30)								**$38,458**	
Decommissioning Efforts							$38,458		
Well Decommissioning									
Tubex Drill Rig (100 feet/day)	2	days	@	$4,500	/day	$9,000			10 wells to 20 feet
Per Diem (3)	2	days	@	$420	/day	$840			
Change Out Driller (1), Helper (1) and Laborer	0.10	ea	@	$4,500	ea	$429			
Environmental Consultant									
Project Management	4	hours	@	$134	/hour	$536			2 hours per work day
Decommissioning Monitoring	2	days	@	$900	/day	$1,800			Same days as drill crew
Per Diem (1) and Vehicle	2	days	@	$240	/day	$480			
Travel to Site (1 person)	0.14	ea	@	$1,500	ea	$214			Assumes travel shared between 7 sites eligible for MNA
Change Out Engineer/Geologist/Env. Scientist (1)	0.1	ea	@	$1,500	ea	$143			Change out crew every 21 days (assumes work at multiple sites)
Reporting	200	hours	@	$100	/hour	$20,000			Assumes stand alone cleanup report for each site
Contingency (15%)						$5,016			
Alternative 3B - Monitored Natural Attenuation (Groundwater) at C6 Total:								**$168,632**	

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST		TOTAL COST PER YEAR		DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER SQUARE FOOT*
Mobilization/Demobilization Costs	1	$46,000		$46,000		0.935	$42,991	-
Mobilization/Demobilization Costs	30	$46,000		$46,000		0.131	$6,043	-
Capital Cost	1	$60,103		$60,103		0.935	$56,171	$1
O&M Cost (Annually for 30 years)	1-30	$722,134		$24,071		12.409	$298,699	$7
Future Capital Costs (One time)	30	$38,458		$38,458		0.131	$5,052	$0.1
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)							**$408,955**	$9

* Average cost per square feet is for treating AOC C6 having a groundwater plume with an areal extent of 40,000 square feet.

TABLE C.3B - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 3 - MONITORED NATURAL ATTENUATION (GROUNDWATER)

Alternative 3B - Monitored Natural Attenuation (Groundwater)

AOC D AST7									**COSTS**	
Mobilization/Demobilization Costs									**$46,000**	
Equipment and Personnel Mobilization/Demobilization Effort								$46,000		
Well Equipment and Personnel										
Tubex Drill Rig Mob/Demob	1	lump sum	@	$32,500	ea	$32,500				Assumes mobilization/demobilization costs for Year 1 (installation) and Year 30 (system decommissioning) - Present Value Analysis Table shows costs
Driller (1), Helper (1) and Laborer	1	ea	@	$4,500	ea	$4,500				
Environmental Consultant										
Engineer/Geologist/Env. Scientist (2)	1	ea	@	$3,000	ea	$3,000				
Contingency (15%)						$6,000				
Capital Costs									**$123,223**	
Additional Monitoring Well Installation Effort								$123,223		6 monitoring wells needed. D-AST7 has 1 monitoring well. Need 5 monitoring wells to 58 feet.
(Assumes 16,000 square foot groundwater plume. Assumes 3 monitoring wells for first 5,000 square foot and 1 monitoring well for each additional 5,000 square foot area are needed. One monitoring well already are present)										
Well Installation										
Tubex Drill Rig (50 ft well/day)	5.8	days	@	$4,500	/day	$26,100				5 wells to 58 feet
Well Piping Materials and Shipping	300.0	lin ft	@	$25	/lf	$7,500				5 wells to 58 feet plus 2 feet stickup
Per Diem (3)	5.8	days	@	$420	/day	$2,436				Same days as drill crew
Change Out Driller (1), Helper (1) and Laborer	0.3	ea	@	$4,500	ea	$1,243				Change out drill crew every 21 days
Laboratory Analytical Sample Analysis										
GRO, DRO, VOCs, SVOCs	10	samples	@	$435	ea	$4,350				One sample per boring and 1 sample per monitoring well
Environmental Consultant										
Project Management	11.6	hours	@	$140	/hour	$1,624				2 hours per work day
Monitoring and Sampling (2 person)	17.4	days	@	$1,800	/day	$31,320				Same days as drill crew plus 3 days to develop wells, sample and treat water
Miscellaneous Equipment	17.4	days	@	$200	/day	$3,480				
Per Diem (2) and Vehicle	17.4	days	@	$380	/day	$6,612				
Change Out Engineer/Geologist/Env. Scientist (2)	0.8	ea	@	$3,000	ea	$2,486				
Work Plan and Reporting	200	hours	@	$100	/hour	$20,000				Assumes part of larger work plan and report effort for all sites included in Tables 6.0-2 and 6.0-3
Contingency (15%)						$16,073				
Annual O&M Costs									**$18,267**	
Monitoring								$18,267		
Laboratory Analytical Sample Analysis										
Annual Lab Sampling (1 event)	7.2	samples	@	$435	ea	$3,132				6 wells; 1 sample per well each year plus 20% QC
Environmental Consultant										
Project Management	6.0	hours	@	$134	/hour	$804				2 hours per work day
Filtration Equipment	1.0	event	@	$100	/event	$100				
Monitoring and Sampling (1 person)	3.0	days	@	$900	/day	$2,700				0.5 day per well per year
Per Diem (1) and Vehicle	3.0	days	@	$240	/day	$720				Assumes shared between sites
Travel to Site (1 person)	0.14	ea	@	$1,500	ea	$214				Assumes travel shared between 7 sites eligible for MNA
Change Out Engineer/Geologist/Env. Scientist (1)	0.1	ea	@	$1,500	ea	$214				Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80.0	hours	@	$100	/hour	$8,000				Assumes part of larger work plan and report effort for all sites included in Tables 6.0-2 and 6.0-3
Contingency (15%)						$2,383				
Future Capital Costs (One Time in Year 30)									**$51,154**	
Decommissioning Efforts								$51,154		
Well Decommissioning										
Tubex Drill Rig (100 feet/day)	3.5	days	@	$4,500	/day	$15,660				6 wells @ 58 feet
Per Diem (3)	3.5	days	@	$420	/day	$1,462				
Change Out Driller (1), Helper (1) and Laborer	0.17	ea	@	$4,500	ea	$746				
Environmental Consultant										
Project Management	7.0	hours	@	$134	/hour	$933				2 hours per work day
Decommissioning Monitoring	3.5	days	@	$900	/day	$3,132				Same days as drill crew
Per Diem (1) and Vehicle	3.5	days	@	$240	/day	$835				
Change Out Engineer/Geologist/Env. Scientist (1)	0.14	ea	@	$1,500	ea	$214				Assumes travel shared between 7 sites eligible for MNA
Travel to Site (1 person)	1.0	ea	@	$1,500	ea	$1,500				Change out crew every 21 days (assumes work at multiple sites)
Reporting	200	hours	@	$100	/hour	$20,000				Assumes stand alone cleanup report for each site
Contingency (15%)						$6,672				
Alternative 3B - Monitored Natural Attenuation (Groundwater) D AST 7 Total:									**$238,644**	

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER SQUARE FOOT*
Mobilization/Demobilization Costs	1	$46,000	$46,000	0.935	$42,991	-
Mobilization/Demobilization Costs	30	$46,000	$46,000	0.131	$6,043	-
Capital Cost	1	$123,223	$123,223	0.935	$115,162	$7
O&M Cost (Annually for 30 years)	1-30	$548,018	$18,267	12.409	$226,678	$14
Future Capital Costs (One time)	30	$51,154	$51,154	0.131	$6,720	$0.4
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)					**$397,594**	$22

*** Average cost per square feet is for treating AOC DAST7 having a groundwater plume with an areal extent of 16,000 square feet.**

TABLE C.3B - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 3 - MONITORED NATURAL ATTENUATION (GROUNDWATER)

Alternative 3B - Monitored Natural Attenuation (Groundwater)

AOC L1

Item	Qty	Unit		Unit Cost	Per	Extended	Subtotal	COSTS	Notes
Mobilization/Demobilization Costs								**$46,000**	
Equipment and Personnel Mobilization/Demobilization Effort							$46,000		
Well Equipment and Personnel									
Tubex Drill Rig Mob/Demob	1	lump sum	@	$32,500	ea	$32,500			Assumes mobilization/demobilization costs for Year 1 (installation) and Year 30 (system decommissioning) - Present Value Analysis Table shows costs
Driller (1), Helper (1) and Laborer	1	ea	@	$4,500	ea	$4,500			
Environmental Consultant									
Engineer/Geologist/Env. Scientist (2)	1	ea	@	$3,000	ea	$3,000			
Contingency (15%)						$6,000			
Capital Costs								**$17,380**	
Additional Monitoring Well Installation Effort							$17,380		
(Assume 630 square foot contaminant plume, two wells present, site needs 1 new well to 16 feet deep)									
Well Installation									
Tubex Drill Rig (100 ft well/day)	0.2	days	@	$4,500	/day	$720			1 well to 16 feet
Well Piping Materials and Shipping	18.0	lin ft	@	$25	/lf	$450			1 well to 16 feet plus 2 feet stickup
Per Diem (3)	0.2	days	@	$420	/day	$67			Same days as drill crew
Change Out Driller (1), Helper (1) and Laborer	0.01	ea	@	$4,500	ea	$34			Change out drill crew every 21 days
Laboratory Analytical Sample Analysis									
GRO, DRO, VOCs, SVOCs	2	samples	@	$435	ea	$870			One sample per boring and 1 sample per monitoring well
Environmental Consultant									
Project Management	0.3	hours	@	$140	/hour	$45			2 hours per work day
Monitoring and Sampling (2 person)	1.2	days	@	$1,800	/day	$2,088			Same days as drill crew plus 1 day to develop wells, sample and treat water
Miscellaneous Equipment	1.2	days	@	$200	/day	$232			
Per Diem (2) and Vehicle	1.2	days	@	$380	/day	$441			
Change Out Engineer/Geologist/Env. Scientist (2)	0.1	ea	@	$3,000	ea	$166			
Work Plan and Reporting	100	hours	@	$100	/hour	$10,000			Assumes part of larger work plan and report effort for all sites included in Tables 6.0-2 and 6.0-3
Contingency (15%)						$2,267			
Annual O&M Costs								**$9,314**	
Monitoring							$9,314		
Laboratory Analytical Sample Analysis									
Annual Lab Sampling (1 event)	3.6	samples	@	$435	ea	$1,566			3 wells; 1 sample per well each year plus 20% QC
Environmental Consultant									
Project Management	3.0	hours	@	$134	/hour	$402			2 hours per work day
Filtration Equipment	1.0	event	@	$100	/event	$100			
Monitoring and Sampling (1 person)	1.5	days	@	$900	/day	$1,350			0.5 day per well per year
Per Diem (1) and Vehicle	1.5	days	@	$240	/day	$360			Assumes shared between sites
Travel to Site (1 person)	0.14	ea	@	$1,500	ea	$214			Assumes travel shared between 7 sites eligible for MNA
Change Out Engineer/Geologist/Env. Scientist (1)	0.1	ea	@	$1,500	ea	$107			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	40	hours	@	$100	/hour	$4,000			Assumes part of larger work plan and report effort for all sites included in Tables 6.0-2 and 6.0-3
Contingency (15%)						$1,215			
Future Capital Costs (One Time in Year 30)								**$16,876**	
Decommissioning Efforts							$16,876		
Well Decommissioning									
Tubex Drill Rig (100 feet/day)	0.5	days	@	$4,500	/day	$2,160			3 wells @ 16 feet
Per Diem (3)	0.5	days	@	$420	/day	$202			
Change Out Driller (1), Helper (1) and Laborer	0.02	ea	@	$4,500	ea	$103			
Environmental Consultant									
Project Management	1.0	hours	@	$134	/hour	$129			2 hours per work day
Decommissioning Monitoring	0.5	days	@	$900	/day	$432			Same days as drill crew
Per Diem (1) and Vehicle	0.5	days	@	$240	/day	$115			
Travel to Site (1 person)	1.0	ea	@	$1,500	ea	$1,500			Assumes travel shared between 7 sites eligible for MNA
Change Out Engineer/Geologist/Env. Scientist (1)	0.02	ea	@	$1,500	ea	$34			Change out crew every 21 days (assumes work at multiple sites)
Reporting	100	hours	@	$100	/hour	$10,000			Assumes stand alone cleanup report for each site
Contingency (15%)						$2,201			

Alternative 3B - Monitored Natural Attenuation (Groundwater) L1 Total: $89,570

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER SQUARE FOOT*
Mobilization/Demobilization Costs	1	$46,000	$46,000	0.935	$42,991	-
Mobilization/Demobilization Costs	30	$46,000	$46,000	0.131	$6,043	-
Capital Cost	1	$17,380	$17,380	0.935	$16,243	$26
O&M Cost (Annually for 30 years)	1-30	$279,430	$9,314	12.409	$115,582	$183
Future Capital Costs (One time)	30	$16,876	$16,876	0.131	$2,217	$3.5
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)					**$183,075**	$213

* Average cost per square feet is for treating AOC L1 having a groundwater plume with an areal extent of 630 square feet.

TABLE C.3B - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 3 - MONITORED NATURAL ATTENUATION (GROUNDWATER)

Alternative 3B - Monitored Natural Attenuation (Groundwater)

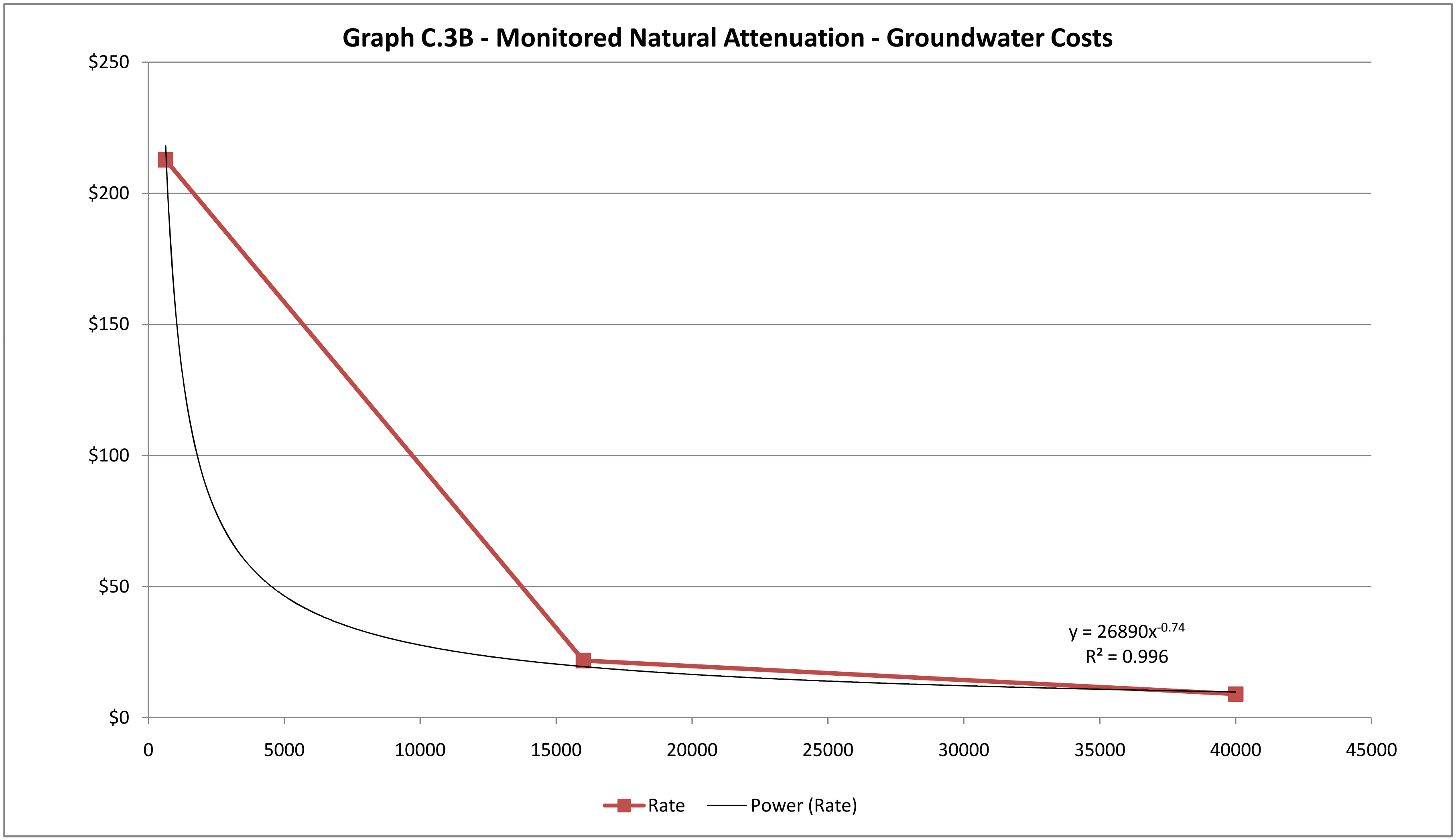


TABLE C.3C - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 3 - MONITORED NATURAL ATTENUATION (SURFACE WATER)

Item	Quantity	Unit		Rate	Per	Amount	Subtotal	COSTS	Notes
Alternative 3C - Monitored Natural Attenuation (Surface Water)									
Mobilization/Demobilization Costs								**$0**	Assumes no mobilization/demobilization costs
Capital Costs								**$0**	Assumes no capital costs
Annual O&M Costs								**$2,632**	
Monitoring							$2,632		
Laboratory Analytical Sample Analysis									1 sample per site each year plus 20% QC for dioxins, PCBs, and/or metals
Annual Lab Sampling (1 event)	1.2	samples	@	$435	ea	$522			
Environmental Consultant									
Project Management	0.5	hours	@	$134	/hour	$67			
Monitoring and Sampling (1 person)	0.25	days	@	$900	/day	$225			0.25 day per site per year
Per Diem (1) and Vehicle	0.25	days	@	$240	/day	$60			
Travel to Site (1 person)	0.14	ea	@	$1,500	ea	$214			Assumes travel shared between 7 water sites eligible for MNA
Work Plan and Reporting	12	hours	@	$100	/hour	$1,200			Assumes part of larger work plan/report effort for all sites included in Tables 6.0-2 and 6.0-3.
Contingency (15%)						$343			
Annual O&M Costs								**$0**	
							Alternative 3C - Monitored Natural Attenuation (Surface Water) Total:	**$2,632**	

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST		TOTAL COST PER YEAR		DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER SITE*
Mobilization/Demobilization Costs	1	$0		$0		0.935	$0	$0
Capital Cost	1	$0		$0		0.935	$0	$0
O&M Cost (Annually for 30 years)	1-30	$78,946		$2,632		12.409	$32,655	$32,655
Future Capital Costs (One time)	30	$0		$0		0.131	$0	$0
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)							**$32,655**	**$32,655**

* Average cost per site is for monitoring a site having a "hotspot" of surface water impact.

TABLE C.4 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 4 - FENTON'S REAGENT OXIDATION

Alternative 4 - Fenton's Reagent Oxidation

	2,000 Cubic Yards								
								COSTS	
Mobilization/Demobilization Costs								**$46,805**	
Equipment and Personnel Mobilization/Demobilization Effort							$46,805		
Chemical Oxidation Well Equipment and Personnel									
Tubex Drill Rig Mob/Demob	1.0	lump sum	@	$32,500	ea	$32,500			
Driller (1), Helper (1) and Laborer	1.0	ea	@	$4,500	ea	$4,500			Assumes mobilization/demobilization efforts for Year 1 (treatability study), Year 1 (installation and treatment), and Year 2 (confirmation of cleanup) for this technology for 2,000 cy - Present Value Analysis Table shows costs
Chemical Oxidation Manifold, Equipment and Personnel									
Excavator/Backhoe - Local	1.0	lump sum	@	$500	ea	$500			
Operator (1) & Laborers (1) - Local	1.0	ea	@	$200	ea	$200			
Environmental Consultant									
Engineer/Geologist/Env. Scientist (2)	1.0	ea	@	$3,000	ea	$3,000			
Contingency (15%)						$6,105			
Capital Costs								**$245,679**	
(Assumes 2,000 cubic yards of impacted soil extending to depth of 11 feet over 5,000 square foot area)									See Case Study Page D-33 to D-36 in Technical and Regulatory Guidance for In Situ Chemical Oxidation of Contaminated Soil and Groundwater and Regenesis study and quotes using RegenOx.
Fenton's Reagent Oxidation Treatability Study							$33,503		
(Assumes install 1 injection well to 11 feet. Radius of influence of injection well equals 10 feet.)									
Well Installation									
Tubex Drill Rig (50 ft well/day)	0.2	days	@	$4,500	/day	$990			1 injection well to 11 feet
Well Piping Materials (Stainless) and Shipping	13.0	lin ft	@	$55	/lf	$715			1 @ 11 feet with 2 feet stickup
Per Diem (3)	0.2	days	@	$420	/day	$92			Assumes shared with multiple sites
Change Out Driller (1), Helper (1) and Laborer	0.01	ea	@	$4,500	ea	$47			Change out crew every 21 days (assumes work at multiple sites)
Confirmation Borings									
Tubex Drill Rig (100 feet/day)	0.2	days	@	$4,500	/day	$990			2 borings to 11 feet
Per Diem (3)	0.2	days	@	$420	/day	$92			Assumes shared with multiple sites
Change Out Driller (1), Helper (1) and Laborer	0.01	ea	@	$4,500	ea	$47			Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis									
N:P:K, Het/Oil Bacteria, Grainsize	2.0	samples	@	$200	each	$400			One sample per boring
GRO, DRO, VOCs, SVOCs	2.0	samples	@	$435	each	$870			One sample per boring
Environmental Consultant									
Project Management	0.4	hours	@	$140	/hour	$62			2 hours per work day
Monitoring and Sampling (2 person)	2.4	days	@	$1,800	/day	$4,392			1 time to monitor installation, 2 days to conduct treatability test, and
Miscellaneous Equipment	2.4	days	@	$1,500	/day	$3,660			1 time for confirmation borings.
RegenOx Mix ($50 per cubic yard impacted soil)	150	cy	@	$50	/cy	$7,500			RegenOx Mix ($50 per cubic yard impacted soil) to reduce 6,000
Per Diem (2) and Vehicle	2.4	days	@	$380	/day	$927			mg/kg DRO to 230 mg/kg. 1 well per 150 cy.
Change Out Engineer/Geologist/Env. Scientist (2)	0.1	ea	@	$3,000	ea	$349			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$4,370			included in Tables 6.0-2 and 6.0-3
Chemical Oxidation System Installation Effort							$212,175		
(Assumes 16 injection wells to 11 feet needed. Radius of influence of injection well equals 10 feet.)									16 injection wells needed. 1 injection well installed for treatability
Well Installation									study. Need additional 15 injection wells to 11 feet.
Tubex Drill Rig (50 ft well/day)	3.3	days	@	$4,500	/day	$14,850			
Well Piping Materials (Stainless) and Shipping	195.0	lin ft	@	$55	/lf	$10,725			15 @ 11 feet with 2 feet stickup
Per Diem (3)	3.3	days	@	$420	/day	$1,386			Assumes shared with multiple sites
Change Out Driller (1), Helper (1) and Laborer	0.2	ea	@	$4,500	ea	$707			Change out crew every 21 days (assumes work at multiple sites)
Manifold Piping and Equipment Installation									
Clearing and Grubbing (10,000 square feet/day)	0.5	days	@	$5,000	/day	$2,500			Remove vegetation from 5,000 square feet site
Manifold Piping Materials (SS) and Shipping	100.0	lin ft	@	$55	/lf	$5,500			Piping to furthest injection well
Batch Tank (Stainless Steel) and Valves	1.0	site	@	$25,000	/site	$25,000			Including fittings
Electricity Hook-Up	1.0	site	@	$25,000	/site	$25,000			Use existing electricity or bring generator
Chain-Link Fence for Treatment Area	300.0	lin ft	@	$132	/lf	$39,600			75 feet x 75 feet site
Per Diem (3) and Vehicle (1)	3.0	days	@	$520	/day	$1,560			Assume 100 feet per day and 3 days for blower/shed setup
Change Out Operator (1) & Laborers (1) - Local	0.1	ea	@	$100	ea	$14			Change out crew every 21 days (assumes work at multiple sites)
Environmental Consultant									
Project Management	12.6	hours	@	$140	/hour	$1,764			2 hours per work day
Excavation Monitoring and Sampling (2 person)	6.3	days	@	$1,800	/day	$11,340			Same hours as drill and excavation crew
Miscellaneous Equipment	6.3	days	@	$200	/day	$1,260			
Per Diem (2) and Vehicle	6.3	days	@	$380	/day	$2,394			
Change Out Engineer/Geologist/Env. Scientist (2)	0.3	ea	@	$3,000	ea	$900			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	400.0	hours	@	$100	/hour	$40,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$27,675			included in Tables 6.0-2 and 6.0-3
O&M Costs								**$134,077**	
Treatment Efforts							$134,077		
Chemical Oxidation									
Chemical Oxidation Application	6.0	days	@	$800	/day	$4,800			3 events at 2 days each
RegenOx Mix ($50 per cubic yard impacted soil)	1850	cy	@	$50	/cy	$92,500			RegenOx Mix ($50 per cubic yard impacted soil) to reduce 6,000
Per Diem (1) and Vehicle	6.0	days	@	$240	/day	$1,440			mg/kg DRO to 230 mg/kg. 1 well per 150 cy.
Environmental Consultant									
Project Management	12.0	hours	@	$140	/hour	$1,680			2 hours per work day
Treatment Monitoring	6.0	days	@	$900	/day	$5,400			Assumes 3 events at 2 days per event
Per Diem (1) and Vehicle	6.0	days	@	$240	/day	$1,440			Assumes shared between sites
Travel to Site (1 person)	0.6	ea	@	$1,500	ea	$900			Assumes travel shared between 10 other sites.
Change Out Engineer/Geologist/Env. Scientist (1)	0.3	ea	@	$1,500	ea	$429			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$17,488			included in Tables 6.0-2 and 6.0-3

TABLE C.4 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 4 - FENTON'S REAGENT OXIDATION

Alternative 4 - Fenton's Reagent Oxidation

	2,000 Cubic Yards							COSTS	
Future Capital Costs (One Time at End of Treatment)								**$83,826**	
Confirmation of Cleanup							$61,790		
Confirmation Borings									
Tubex Drill Rig (100 feet/day)	1.1	days	@	$4,500	/day	$4,950			10 borings to 11 feet deep
Per Diem (3)	1.1	days	@	$420	/day	$462			
Change Out Driller (1), Helper (1) and Laborer	0.1	ea	@	$4,500	ea	$236			Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis									1 sample per 200 cubic yards to 2,000 cy and then 1 sample per 500 cubic yards plus 20% QC; Minimum 4 samples
Confirmation Samples (GRO, DRO, VOCs, SVOCs)	12.0	samples	@	$435	each	$5,220			
Environmental Consultant									
Project Management	2.2	hours	@	$140	/hour	$308			2 hours per work day
Monitoring and Sampling (2 person)	1.1	days	@	$1,800	/day	$1,980			Same hours as drill crew
Per Diem (2) and Vehicle	1.1	days	@	$380	/day	$418			
Change Out Engineer/Geologist/Env. Scientist (2)	0.1	ea	@	$3,000	ea	$157			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	400	hours	@	$100	/hour	$40,000			Assumes work plan effort shared with multiple sites and stand alone cleanup report combined with decom report for each site
Contingency (15%)						$8,060			
Decommissioning Efforts							$22,035		
Well Decommissioning									
Remove Chain-Link Fence (150 feet/day)	2.0	days	@	$1,750	/day	$3,500			580 Backhoe with Operator and 2 Laborers
Tubex Drill Rig (100 feet/day)	1.8	days	@	$4,500	/day	$7,920			16 wells to 11 feet
Per Diem (3)	1.8	days	@	$420	/day	$739			
Change Out Driller (1), Helper (1) and Laborer	0.1	ea	@	$4,500	ea	$377			Change out crew every 21 days (assumes work at multiple sites)
Environmental Consultant									
Project Management	3.5	hours	@	$140	/hour	$493			2 hours per work day
Decommissioning Monitoring	1.8	days	@	$900	/day	$1,584			Same hours as drill crew
Per Diem (1) and Vehicle	1.8	days	@	$240	/day	$422			
Change Out Engineer/Geologist/Env. Scientist (1)	0.1	ea	@	$1,500	ea	$126			Change out crew every 21 days (assumes work at multiple sites)
Reporting	40	hours	@	$100	/hour	$4,000			Assumes decommissioning portion included in stand alone cleanup report
Contingency (15%)						$2,874			
							Alternative 4 - Fenton's Reagent Oxidation Total:	**$510,387**	

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER CY*
Mobilization/Demobilization Costs	1	$46,805	$46,805	0.935	$43,743	-
Mobilization/Demobilization Costs	1	$46,805	$46,805	0.935	$43,743	-
Mobilization/Demobilization Costs	2	$46,805	$46,805	0.873	$40,881	-
Capital Cost	1	$245,679	$245,679	0.935	$229,607	$115
O&M Cost (Year 1)	1	$134,077	$134,077	0.935	$125,305	$63
Future Capital Cost (one time)	2	$83,826	$83,826	0.873	$73,217	$37
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)					**$428,129**	**$214**

* Average cost per cubic yard is for treating a site having an estimated volume of 2000 cubic yards of impacted soil.

TABLE C.4 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 4 - FENTON'S REAGENT OXIDATION

Alternative 4 - Fenton's Reagent Oxidation

Item	Quantity	Unit		Unit Cost	Per	Amount	Subtotal	COSTS	Notes
20 Cubic Yards									
Mobilization/Demobilization Costs								**$3,680**	
Equipment and Personnel Mobilization/Demobilization Effort							$3,680		
Chemical Oxidation Manifold, Equipment and Personnel									Assumes mobilization/demobilization efforts for Year 1 (treatability
Laborers (2) - Local	1.0	ea	@	$200	ea	$200			study), Year 1 (installation and treatment), and Year 2 (confirmation
Environmental Consultant									of cleanup) for this technology for 20 cy - Present Value Analysis
Engineer/Geologist/Env. Scientist (2)	1.0	ea	@	$3,000	ea	$3,000			Table shows costs
Contingency (15%)						$480			
Capital Costs								**$34,702**	
(Assumes 20 cubic yards of impacted soil extending to depth of 2 feet over 270 square foot area and									Case Study Page D-33 to D-36 in Technical and Regulatory
surface application of ChemOx solution)									Guidance for In Situ Chemical Oxidation of Contaminated Soil and
Fenton's Reagent Oxidation Treatability Study							$12,029		Groundwater and Regenesis study and quotes using RegenOx.
(Assumes surface application of ChemOx solution over 100 square foot area.)									
Surface Application									
Clearing and Grubbing (10,000 square feet/day)	0.03	days	@	$5,000	/day	$135			Remove vegetation from 270 square feet site
Laborers (2) - Local	1.0	days	@	$880	/day	$880			
Laboratory Analytical Sample Analysis									
N:P:K, Het/Oil Bacteria, Grainsize	2.0	samples	@	$200	each	$400			One sample per hand boring
GRO, DRO, VOCs, SVOCs	2.0	samples	@	$435	each	$870			One sample per hand boring
Environmental Consultant									
Project Management	2.0	hours	@	$140	/hour	$280			2 hours per work day
Monitoring and Sampling (2 person)	1.0	days	@	$1,800	/day	$1,800			Application, treatability test and 2 hand borings
Miscellaneous Equipment	1.0	days	@	$1,500	/day	$1,500			Monitoring, tanks, pumps, etc.
RegenOx Mix ($50 per cubic yard impacted soil)	7	cy	@	$50	/cy	$370			RegenOx Mix ($50 per cubic yard impacted soil) to reduce 6,000
Per Diem (2) and Vehicle	1.0	days	@	$380	/day	$380			mg/kg DRO to 230 mg/kg.
Change Out Engineer/Geologist/Env. Scientist (2)	0.05	ea	@	$3,000	ea	$143			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	40.0	hours	@	$100	/hour	$4,000			included in Tables 6.0-2 and 6.0-3
Contingency (15%)						$1,271			
Chemical Oxidation System Treatment Effort							$22,672		
(Assumes surface application of ChemOx solution over remaining 170 square foot area.)									
Surface Application									
Laborers (2) - Local	1.0	days	@	$880	/day	$880			
Environmental Consultant									
Project Management	2.0	hours	@	$140	/hour	$280			2 hours per work day
Monitoring and Sampling (2 person)	1.0	days	@	$1,800	/day	$1,800			Application
Miscellaneous Equipment	1.0	days	@	$1,500	/day	$1,500			Monitoring, tanks, pumps, etc.
RegenOx Mix ($50 per cubic yard impacted soil)	13	cy	@	$50	/cy	$630			RegenOx Mix ($50 per cubic yard impacted soil) to reduce 6,000
Per Diem (2) and Vehicle	1.0	days	@	$380	/day	$380			mg/kg DRO to 230 mg/kg.
Change Out Engineer/Geologist/Env. Scientist (2)	0.05	ea	@	$3,000	ea	$143			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	100.0	hours	@	$100	/hour	$10,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$7,060			included in Tables 6.0-2 and 6.0-3
O&M Costs								**$0**	
Future Capital Costs (One Time at End of Treatment)								**$14,737**	
Confirmation of Cleanup							$14,737		
Laboratory Analytical Sample Analysis									1 sample per 200 cubic yards to 2,000 cy and then 1 sample per 500
Confirmation Samples (GRO, DRO, VOCs, SVOCs)	4.0	samples	@	$435	each	$1,740			cubic yards plus 20% QC; Minimum 4 samples
Environmental Consultant									
Project Management	1.0	hours	@	$140	/hour	$140			2 hours per work day
Monitoring and Sampling (2 person)	0.5	days	@	$1,800	/day	$900			Hand borings
Per Diem (2) and Vehicle	0.5	days	@	$380	/day	$190			
Change Out Engineer/Geologist/Env. Scientist (2)	0.0	ea	@	$3,000	ea	$71			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	100	hours	@	$100	/hour	$10,000			Assumes work plan effort shared with multiple sites and stand alone
Contingency (15%)						$1,695			cleanup report combined with decom report for each site
Decommissioning Efforts							$0		
							Alternative 4 - Fenton's Reagent Oxidation Total:	**$53,118**	

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER CY*
Mobilization/Demobilization Costs	1	$3,680	$3,680	0.935	$3,439	-
Mobilization/Demobilization Costs	1	$3,680	$3,680	0.935	$3,439	-
Mobilization/Demobilization Costs	2	$3,680	$3,680	0.873	$3,214	-
Capital Cost	1	$34,702	$34,702	1.000	$34,702	$1,735
O&M Cost	1	$0	$0	1.000	$0	$0
Future Capital Cost (one time)	2	$14,737	$14,737	1.000	$14,737	$737
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)					**$49,438**	**$2,472**

* Average cost per cubic yard is for treating a site having an estimated volume of 20 cubic yards of impacted soil.

TABLE C.4 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 4 - FENTON'S REAGENT OXIDATION

Alternative 4 - Fenton's Reagent Oxidation

Item	Quantity	Unit		Rate	Per	Amount	Subtotal	Costs	Notes
	20,000 Cubic Yards							**COSTS**	
Mobilization/Demobilization Costs								**$46,805**	
Equipment and Personnel Mobilization/Demobilization Effort							$46,805		
Chemical Oxidation Well Equipment and Personnel									
Tubex Drill Rig Mob/Demob	1.0	lump sum	@	$32,500	ea	$32,500			Assumes mobilization/demobilization efforts for Year 1 (treatability study), Year 1 (installation and treatment), and Year 2 (confirmation of cleanup) for this technology for 20,000 cy - Present Value Analysis Table shows costs
Driller (1), Helper (1) and Laborer	1.0	ea	@	$4,500	ea	$4,500			
Chemical Oxidation Manifold, Equipment and Personnel									
Excavator/Backhoe - Local	1.0	lump sum	@	$500	ea	$500			
Operator (1) & Laborers (1) - Local	1.0	ea	@	$200	ea	$200			
Environmental Consultant									
Engineer/Geologist/Env. Scientist (2)	1.0	ea	@	$3,000	ea	$3,000			
Contingency (15%)						$6,105			
Capital Costs								**$724,208**	
(Assumes 20,000 cubic yards of impacted soil extending to depth of 45 feet over 12,000 square foot area)									See Case Study Page D-33 to D-36 in Technical and Regulatory Guidance for In Situ Chemical Oxidation of Contaminated Soil and Groundwater and Regenesis study and quotes using RegenOx.
Fenton's Reagent Oxidation Treatability Study							$75,418		
(Assumes install 1 injection well to 45 feet. Radius of influence of injection well equals 10 feet.)									
Well Installation									
Tubex Drill Rig (50 ft well/day)	0.9	days	@	$4,500	/day	$4,050			1 injection well to 45 feet
Well Piping Materials (Stainless) and Shipping	47.0	lin ft	@	$55	/lf	$2,585			1 @ 45 feet with 2 feet stickup
Per Diem (3)	0.9	days	@	$420	/day	$378			Assumes shared with multiple sites
Change Out Driller (1), Helper (1) and Laborer	0.04	ea	@	$4,500	ea	$193			Change out crew every 21 days (assumes work at multiple sites)
Confirmation Borings									
Tubex Drill Rig (100 feet/day)	0.9	days	@	$4,500	/day	$4,050			2 borings to 45 feet
Per Diem (3)	0.9	days	@	$420	/day	$378			Assumes shared with multiple sites
Change Out Driller (1), Helper (1) and Laborer	0.04	ea	@	$4,500	ea	$193			Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis									
N:P:K, Het/Oil Bacteria, Grainsize	5.0	samples	@	$200	each	$1,000			Two samples per boring
GRO, DRO, VOCs, SVOCs	5.0	samples	@	$435	each	$2,175			Two samples per boring
Environmental Consultant									
Project Management	1.8	hours	@	$140	/hour	$252			2 hours per work day
Monitoring and Sampling (2 person)	3.8	days	@	$1,800	/day	$6,840			1 time to monitor installation, 2 days to conduct treatability test, and
Miscellaneous Equipment	3.8	days	@	$1,500	/day	$5,700			1 time for confirmation borings.
RegenOx Mix ($50 per cubic yard impacted soil)	556	cy	@	$50	/cy	$27,800			RegenOx Mix ($50 per cubic yard impacted soil) to reduce 6,000
Per Diem (2) and Vehicle	3.8	days	@	$380	/day	$1,444			mg/kg DRO to 230 mg/kg. 1 well per 556 cy.
Change Out Engineer/Geologist/Env. Scientist (2)	0.2	ea	@	$3,000	ea	$543			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$9,837			included in Tables 6.0-2 and 6.0-3
Chemical Oxidation System Installation Effort							$648,791		
(Assumes install 36 injection wells to depth of 45 feet. Radius of influence of injection well equals 10 feet.)									36 injection wells needed. 1 injection well installed for treatability study. Need additional 35 injection wells to 45 feet.
Well Installation									
Tubex Drill Rig (50 ft well/day)	31.5	days	@	$4,500	/day	$141,750			35 injection wells @ 45 feet
Well Piping Materials (Stainless) and Shipping	1645.0	lin ft	@	$55	/lf	$90,475			35 @ 47 feet each
Per Diem (3)	31.5	days	@	$420	/day	$13,230			Assumes shared with multiple sites
Change Out Driller (1), Helper (1) and Laborer	1.5	ea	@	$4,500	ea	$6,750			Change out crew every 21 days (assumes work at multiple sites)
Manifold Piping and Equipment Installation									
Clearing and Grubbing (10,000 square feet/day)	1.20	days	@	$5,000	/day	$6,000			Remove vegetation from 12,000 square feet site
Manifold Piping Materials (SS) and Shipping	175.0	lin ft	@	$55	/lf	$9,625			Piping to furthest injection well
Batch Tank (Stainless Steel) and Valves	1.0	site	@	$25,000	/site	$25,000			Including fittings
Electricity	1.0	site	@	$25,000	/site	$25,000			Use existing electricity or bring generator
Chain-Link Fence for Treatment Area	440.0	lin ft	@	$132	/lf	$58,080			110 feet x 110 feet site
Per Diem (3) and Vehicle (1)	6.0	days	@	$520	/day	$3,120			Assumes 6 days to set up
Change Out Operator (1) & Laborers (1) - Local	0.3	ea	@	$100	ea	$29			Change out crew every 21 days (assumes work at multiple sites)
Environmental Consultant									
Project Management	75.0	hours	@	$140	/hour	$10,500			2 hours per work day
Excavation Monitoring and Sampling (2 person)	37.5	days	@	$1,800	/day	$67,500			Same hours as drill and excavation crew
Miscellaneous Equipment	37.5	days	@	$200	/day	$7,500			
Per Diem (2) and Vehicle	37.5	days	@	$380	/day	$14,250			
Change Out Engineer/Geologist/Env. Scientist (2)	1.8	ea	@	$3,000	ea	$5,357			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	800	hours	@	$100	/hour	$80,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$84,625			included in Tables 6.0-2 and 6.0-3
O&M Costs								**$1,164,234**	
Treatment Efforts							$1,164,234		
Chemical Oxidation									
Chemical Oxidation Application	12.0	days	@	$800	/day	$9,600			3 events at 4 days each
RegenOx Mix ($50 per cubic yard impacted soil)	19444	cy	@	$50	/cy	$972,200			RegenOx Mix ($50 per cubic yard impacted soil) to reduce 6,000
Per Diem (1) and Vehicle	12.0	days	@	$240	/day	$2,880			mg/kg DRO to 230 mg/kg. 1 well per 556 cy.
Environmental Consultant									
Project Management	24.0	hours	@	$140	/hour	$3,360			2 hours per work day
Treatment Monitoring	12.0	days	@	$900	/day	$10,800			Assumes 3 events at 4 days per event
Per Diem (1) and Vehicle	12.0	days	@	$240	/day	$2,880			Assumes shared between sites
Travel to Site (1 person)	1.2	ea	@	$1,500	ea	$1,800			Assumes travel shared between 10 other sites.
Change Out Engineer/Geologist/Env. Scientist (1)	0.6	ea	@	$1,500	ea	$857			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$151,857			included in Tables 6.0-2 and 6.0-3

TABLE C.4 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 4 - FENTON'S REAGENT OXIDATION

Alternative 4 - Fenton's Reagent Oxidation

Item	Qty	Unit		Rate	Per	Amount	Subtotal	Costs	Notes
	20,000 Cubic Yards							**COSTS**	
Future Capital Costs (One Time at End of Treatment)								**$365,665**	
Confirmation of Cleanup							$231,725		
Confirmation Borings									
Tubex Drill Rig (100 feet/day)	12.6	days	@	$4,500	/day	$56,700			28 borings to 45 feet deep and 2 samples per boring
Per Diem (3)	12.6	days	@	$420	/day	$5,292			
Change Out Driller (1), Helper (1) and Laborer	0.6	ea	@	$4,500	ea	$2,700			Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis									1 sample per 200 cubic yards to 2,000 cy and then 1 sample per 500 cubic yards plus 20% QC; Minimum 4 samples
Confirmation Samples (GRO, DRO, VOCs, SVOCs)	55.2	samples	@	$435	each	$24,012			
Environmental Consultant									
Project Management	25.2	hours	@	$140	/hour	$3,528			2 hours per work day
Monitoring and Sampling (2 person)	12.6	days	@	$1,800	/day	$22,680			Same hours as drill crew
Per Diem (2) and Vehicle	12.6	days	@	$380	/day	$4,788			
Change Out Engineer/Geologist/Env. Scientist (2)	0.6	ea	@	$3,000	ea	$1,800			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	800	hours	@	$100	/hour	$80,000			Assumes work plan effort shared with multiple sites and stand alone cleanup report combined with decom report for each site
Contingency (15%)						$30,225			
Decommissioning Efforts							$133,940		
Well Decommissioning									
Remove Chain-Link Fence (150 feet/day)	2.9	days	@	$1,750	/day	$5,133			580 Backhoe with Operator and 2 Laborers
Tubex Drill Rig (100 feet/day)	16.2	days	@	$4,500	/day	$72,900			36 wells to 45 feet
Per Diem (3)	16.2	days	@	$420	/day	$6,804			
Change Out Driller (1), Helper (1) and Laborer	0.8	ea	@	$4,500	ea	$3,471			Change out crew every 21 days (assumes work at multiple sites)
Environmental Consultant									
Project Management	32.4	hours	@	$140	/hour	$4,536			2 hours per work day
Decommissioning Monitoring	16.2	days	@	$900	/day	$14,580			Same hours as drill crew
Per Diem (1) and Vehicle	16.2	days	@	$240	/day	$3,888			
Change Out Engineer/Geologist/Env. Scientist (1)	0.8	ea	@	$1,500	ea	$1,157			Change out crew every 21 days (assumes work at multiple sites)
Reporting	40.0	hours	@	$100	/hour	$4,000			Assumes decommissioning portion included in stand alone cleanup report
Contingency (15%)						$17,470			
							Alternative 4 - Fenton's Reagent Oxidation Total:	**$2,300,912**	

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST		TOTAL COST PER YEAR		DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER CY*
Mobilization/Demobilization Costs	1	$46,805		$46,805		0.935	$43,743	-
Mobilization/Demobilization Costs	1	$46,805		$46,805		0.935	$43,743	-
Mobilization/Demobilization Costs	2	$46,805		$46,805		0.873	$40,881	-
Capital Cost	1	$724,208		$724,208		0.935	$676,830	$34
O&M Costs	1	$1,164,234		$1,164,234		0.935	$1,088,069	$54
Future Capital Cost (one time)	2	$365,665		$365,665		0.873	$319,386	$16
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)							**$2,084,285**	**$104**

* Average cost per cubic yard is for treating a site having an estimated volume of 20,000 cubic yards of impacted soil.

TABLE C.4 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 4 - FENTON'S REAGENT OXIDATION

Alternative 4 - Fenton's Reagent Oxidation

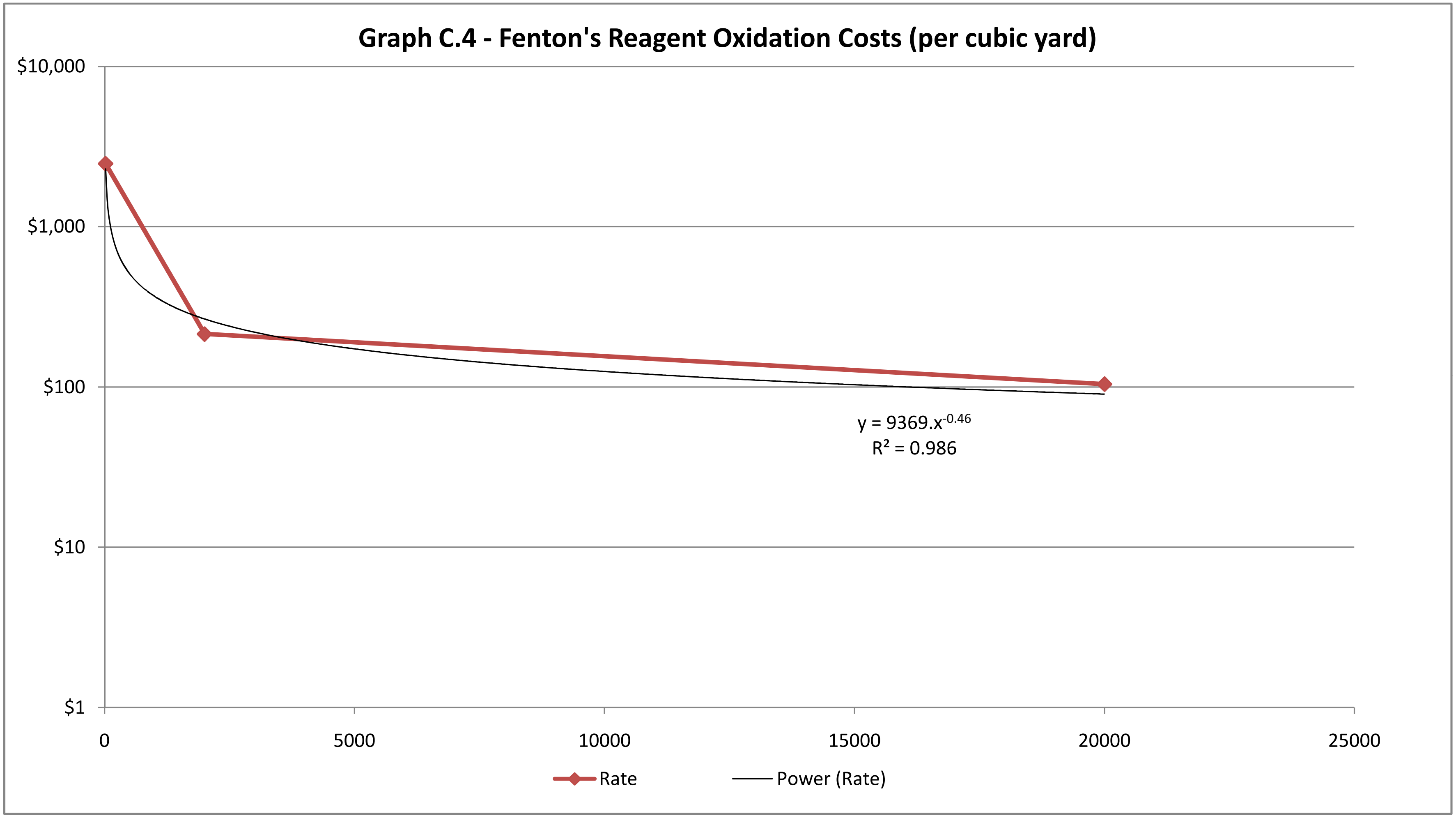


TABLE C.5 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 5 - SOIL HEATING

Alternative 5 - Soil Heating (Thermal Conductive Heating)

Description	2,000 Cubic Yards							COSTS	
Mobilization/Demobilization Costs (Treatability Study, Confirmation Borings, and Decommissioning)								**$46,000**	
Equipment and Personnel Mobilization/Demobilization Effort							$46,000		
Soil Heating Well Equipment and Personnel									
Tubex Drill Rig Mob/Demob	1.0	lump sum	@	$32,500	ea	$32,500			Assumes mobilization/demobilization efforts for Year 1 (treatability study), Year 1 (confirmation of cleanup), and Year 2 (Decommissioning) for this technology for 2,000 cy - Present Value Analysis Table shows costs
Driller (1), Helper (1) and Laborer	1.0	ea	@	$4,500	ea	$4,500			
Environmental Consultant									
Engineer/Geologist/Env. Scientist (2)	1.0	ea	@	$3,000	ea	$3,000			
Contingency (15%)						$6,000			
Mobilization/Demobilization Costs (Installation and Treatment)								**$131,618**	
Equipment and Personnel Mobilization/Demobilization Effort							$131,618		
Soil Heating Well Equipment and Personnel									
Tubex Drill Rig Mob/Demob	1.0	lump sum	@	$32,500	ea	$32,500			
Driller (1), Helper (1) and Laborer	1.0	ea	@	$4,500	ea	$4,500			Assumes mobilization/demobilization efforts for Year 1 (installation and treatment) for this technology for 2,000 cy - Present Value Analysis Table shows costs
Soil Heating Manifold, Equipment and Personnel									
Excavator/Backhoe - Local	1.0	lump sum	@	$500	ea	$500			
Operator (1) & Laborers (1) - Local	1.0	ea	@	$200	ea	$200			
TerraTherm Equipment and Personnel									
Mob/Decon/Demob Labor (3)	1	lump sum	@	$8,250	ea	$8,250			
150 kw Electrical Generator	1	lump sum	@	$7,500	ea	$7,500			150 kw generator from Caterpillar
Equipment Shipping	1	lump sum	@	$55,000	ea	$55,000			TerraTherm Electrical Heater
Operator (1) & Laborers (1)	1	trip	@	$3,000	ea	$3,000			
Environmental Consultant									
Engineer/Geologist/Env. Scientist (2)	1.0	ea	@	$3,000	ea	$3,000			
Contingency (15%)						$17,168			
Capital Costs								**$489,892**	
(Assumes 2,000 cubic yards of impacted soil extending to depth of 11 feet over 5,000 square foot area)									
Soil Heat Treatability Study							$35,216		Assumes injection well and monitoring points for the Biovent alternative are sufficient for conducting a VES radius of influence test.
(Assumes install 1 VES well and 2 monitoring points to depth of 11 feet will be needed to establish VES radius of influence.)									
Well Installation									
Tubex Drill Rig (50 ft well/day)	0.7	days	@	$4,500	/day	$2,970			1 VES well and 2 monitoring points to 11 feet each
Well Piping Materials (Stainless) and Shipping	39	lin ft	@	$55	/lf	$2,145			3 @ 11 feet each plus 2 feet stickup
Per Diem (3)	0.7	days	@	$420	/day	$277			Assumes shared with multiple sites
Change Out Driller (1), Helper (1) and Laborer	0.03	ea	@	$4,500	ea	$141			Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis									
N:P:K, Het/Oil Bacteria, Grainsize	3.0	samples	@	$200	each	$600			One sample per boring
GRO, DRO, VOCs, SVOCs	3.0	samples	@	$435	each	$1,305			One sample per boring
Environmental Consultant									
Project Management	1.3	hours	@	$140	/hour	$185			2 hours per work day
Monitoring and Sampling (2 person)	2.0	days	@	$1,800	/day	$3,564			Thrice as long as drill crew; 1 time to monitor, 1 time to set up, and 1 time to conduct treatability test
Blower Test Equipment	1.0	day	@	$500	/day	$500			Assumes 1 portable system for treatability studies at multiple sites
Miscellaneous Equipment	2.0	days	@	$5,000	/day	$9,900			
Per Diem (2) and Vehicle	2.0	days	@	$380	/day	$752			Assumes shared with multiple sites
Change Out Engineer/Geologist/Env. Scientist (2)	0.1	ea	@	$3,000	ea	$283			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites included in Tables 6.0-2 and 6.0-3
Contingency (15%)						$4,593			
Soil Heating System Installation Effort							$454,676		64 probes and 4 VES wells needed. 1 VES well will be installed for treatability study. Need 64 probes and 3 VES wells to 11 feet.
(Assumes 2,000 cubic yards of impacted soil extending to depth of 11 feet over 5,000 square foot area)									
Subsurface Installation									
Tubex Drill Rig (50 ft well/day)	18.7	days	@	$4,500	/day	$84,150			64 probes, 9 thermistors, 9 transducers, and 3 VES wells to 11 feet.
Galvanized Pipe Materials	832	ft	@	$15.00	/ft	$12,480			63 @ 13 feet each
Well Piping Materials (Stainless) and Shipping	33.0	lin ft	@	$55.00	/ft	$1,815			3 VES @ 11 feet each (1 previously installed)
Thermistor and Transducers Materials and Shipping	198	ft	@	$25	/ft	$4,950			18 @ 11 feet each
Per Diem (5)	18.7	days	@	$700	/day	$13,090			Assumes shared with multiple sites
Change Out Driller (1), Helper (1) and Laborer	0.9	ea	@	$4,500	ea	$4,007			Change out crew every 21 days (assumes work at multiple sites)
Surface Installation									
Clearing and Grubbing (10,000 square feet/day)	0.5	days	@	$5,000	/day	$2,500			Remove vegetation from 5,000 square feet site
Manifold Piping Materials (SS) and Shipping	300	lin ft	@	$55	/lf	$16,500			Piping to individual VES wells
Excavate Trenches 3 feet wide by 4 feet deep	150	lin ft	@	$18	/lf	$2,700			Common Trenches for VES manifold piping
Manifold Piping Materials (Galvanized) and Shipping	592	ft	@	$15.00	/ft	$8,880			62 feet @ 8 rows plus 72 feet @ 1 column plus 20 feet @ 1 row = 592 feet
Shed, Knockout Drum, Meters etc.	1.0	sites	@	$25,000	/site	$25,000			
Thermal Blanket at Surface	5000	sq ft	@	$4	/site	$20,000			Ceramic Fiber Blanket
Heat Exchanger, Oil/Water Seperator, GAC	1.0	sites	@	$20,000	/site	$20,000			Process steam and water produced during treatment
Chain-Link Fence around Treatment Area	300	lin ft	@	$132	/lf	$39,600			75 feet x 75 feet site
Per Diem (3) and Vehicle (1)	8.5	days	@	$520	/day	$4,420			Assume 100 feet per day and 7 days for blower/shed setup
Change Out Operator (1) & Laborers (1) - Local	0.4	ea	@	$100	ea	$40			Change out crew every 21 days (assumes work at multiple sites)
TerraTherm									
Operator (1) & Laborers (1)	7.0	days	@	$1,600	/day	$11,200			Assume TerraTherm needs 5 days to setup Electrical Heater
Per Diem (3) and Vehicle (1)	7.0	days	@	$620	/day	$4,340			
Change Out Operator (1) & Laborers (2)	0.3	ea	@	$4,500	ea	$1,500			Change out crew every 21 days (assumes work at multiple sites)
Environmental Consultant									
Project Management	68.4	hours	@	$140	/hour	$9,576			2 hours per work day
Installation Monitoring and Sampling (2 person)	27.2	days	@	$1,800	/day	$48,960			Same hours as drill and excavation crew
Per Diem (2) and Vehicle	27.2	days	@	$380	/day	$10,336			Assumes shared with multiple sites
Miscellaneous Equipment	27.2	days	@	$200	/day	$5,440			
Change Out Engineer/Geologist/Env. Scientist (2)	1.3	ea	@	$3,000	ea	$3,886			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	400	hours	@	$100	/hour	$40,000			Assumes part of larger work plan and report effort for all sites included in Tables 6.0-2 and 6.0-3
Contingency (15%)						$59,306			

TABLE C.5 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 5 - SOIL HEATING

Alternative 5 - Soil Heating (Thermal Conductive Heating)

	2,000 Cubic Yards							COSTS	
O&M Costs (Year 1)								**$317,773**	
Treatment Efforts							$317,773		
Soil Heating									
Operate Soil Heating System	60.0	days	@	$800	/day	$48,000			TerraTherm operates electricity for 180 days at $3,300 per day for
Soil Heating and VES Electricity	2000	cy	@	$99	/cy	$198,000			6,000 cy ($99/cy). Assume 60 days at $99/cy.
Treatment Knockout Drum Water	60.0	days	@	$50	/day	$3,000			Same hours as treatment crew
Per Diem (1) and Vehicle	60.0	days	@	$240	/day	$14,400			
Environmental Consultant									
Project Management	6.0	hours	@	$140	/hour	$840			2 hours per work day
Treatment Monitoring	3.0	days	@	$900	/day	$2,700			One day per month
Per Diem (1) and Vehicle	3.0	days	@	$240	/day	$720			Assumes shared with multiple sites
Travel to Site (1 person)	0.3	ea	@	$1,500	ea	$450			Assumes travel shared between 10 other sites.
Change Out Engineer/Geologist/Env. Scientist (1)	0.1	ea	@	$1,500	ea	$214			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$41,449			included in Tables 6.0-2 and 6.0-3
Future Capital Costs (One Time at End of Treatment)								**$142,497**	
Confirmation of Cleanup							$61,790		
Confirmation Borings									
Tubex Drill Rig (100 feet/day)	1.1	days	@	$4,500	/day	$4,950			10 borings to 11 feet deep
Per Diem (3)	1.1	days	@	$420	/day	$462			Assumes shared with multiple sites
Change Out Driller (1), Helper (1) and Laborer	0.1	ea	@	$4,500	ea	$236			Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis									1 sample per 200 cubic yards to 2,000 cy and then 1 sample per 500
Confirmation Samples (GRO, DRO, VOCs, SVOCs)	12.0	samples	@	$435	each	$5,220			cubic yards plus 20% QC; Minimum 4 samples
Environmental Consultant									
Project Management	2.2	hours	@	$140	/hour	$308			2 hours per work day
Monitoring and Sampling (2 person)	1.1	days	@	$1,800	/day	$1,980			Same hours as drill crew
Per Diem (2) and Vehicle	1.1	days	@	$380	/day	$418			Assumes shared with multiple sites
Change Out Engineer/Geologist/Env. Scientist (2)	0.1	ea	@	$3,000	ea	$157			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	400	hours	@	$100	/hour	$40,000			Assumes work plan effort shared with multiple sites and stand alone
Contingency (15%)						$8,060			cleanup report combined with decom report for each site
Decommissioning Efforts							$80,706		
Well Decommissioning									
Remove Chain-Link Fence (150 feet/day)	2.0	days	@	$1,750	/day	$3,500			580 Backhoe with Operator and 2 Laborers
Tubex Drill Rig (100 feet/day)	9.5	days	@	$4,500	/day	$42,570			64 probes, 9 thermistors, 9 transducers, and 4 VES wells to 11 feet
Per Diem (3)	9.5	days	@	$420	/day	$3,973			Assumes shared with multiple sites
Change Out Driller (1), Helper (1) and Laborer	0.5	ea	@	$4,500	ea	$2,027			Change out crew every 21 days (assumes work at multiple sites)
Environmental Consultant									
Project Management	18.9	hours	@	$140	/hour	$2,649			2 hours per work day
Decommissioning Monitoring	9.5	days	@	$900	/day	$8,514			Same hours as drill crew
Per Diem (1) and Vehicle	9.5	days	@	$240	/day	$2,270			Assumes shared with multiple sites
Change Out Engineer/Geologist/Env. Scientist (1)	0.5	ea	@	$1,500	ea	$676			Change out crew every 21 days (assumes work at multiple sites)
Reporting	40	hours	@	$100	/hour	$4,000			Assumes decommissioning portion included in stand alone cleanup
Contingency (15%)						$10,527			report
							Alternative 5 - Soil Heating Total:	**$1,127,779**	

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST		TOTAL COST PER YEAR		DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER CY*
Mobilization/Demobilization Costs	1	$46,000		$46,000		0.935	$42,991	-
Mobilization/Demobilization Costs	1	$131,618		$131,618		0.935	$123,007	-
Mobilization/Demobilization Costs	2	$46,000		$46,000		0.873	$40,178	-
Capital Cost	1	$489,892		$489,892		0.935	$457,843	$229
O&M Cost (Year 1)	1	$317,773		$317,773		0.935	$296,984	$148
Future Capital Cost (one time)	2	$142,497		$142,497		0.873	$124,462	$62
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)							**$879,289**	$440

* Average cost per cubic yard is for treating a site having an estimated volume of 2000 cubic yards of impacted soil.

TABLE C.5 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 5 - SOIL HEATING

Alternative 5 - Soil Heating (Thermal Conductive Heating)

Item	Qty	Unit		Rate	Per	Amount	Subtotal	COSTS	Notes
	20 Cubic Yards								
Mobilization/Demobilization Costs (Treatability Study, Confirmation Borings, and Decommissioning)								**$4,255**	
Equipment and Personnel Mobilization/Demobilization Effort							$4,255		Assumes mobilization/demobilization efforts for Year 1 (treatability study), Year 1 (confirmation of cleanup), and Year 2 (Decommissioning) for this technology for 20 cy - Present Value Analysis Table shows costs
Excavating Equipment and Personnel									
Excavator/Backhoe - Local	1.0	lump sum	@	$500	ea	$500			
Operator (1) & Laborers (1) - Local	1.0	ea	@	$200	ea	$200			
Environmental Consultant									
Engineer/Geologist/Env. Scientist (2)	1.0	ea	@	$3,000	ea	$3,000			
Contingency (15%)						$555			
Mobilization/Demobilization Costs (Installation and Treatment)								**$83,893**	
Equipment and Personnel Mobilization/Demobilization Effort							$83,893		
Soil Heating Manifold, Equipment and Personnel									Assumes mobilization/demobilization efforts for Year 1 (installation and treatment) for this technology for 20 cy - Present Value Analysis Table shows costs
Excavator/Backhoe - Local	1.0	lump sum	@	$500	ea	$500			
Operator (1) & Laborers (1) - Local	1.0	ea	@	$200	ea	$200			
TerraTherm Equipment and Personnel									
Mob/Decon/Demob Labor (3)	1	lump sum	@	$8,250	ea	$8,250			
500 kw Electrical Generator	1	lump sum	@	$3,000	ea	$3,000			60 kw generator from Caterpillar
Equipment Shipping	1	lump sum	@	$55,000	ea	$55,000			TerraTherm Electrical Heater
Operator (1) & Laborers (1)	1	trip	@	$3,000	ea	$3,000			
Environmental Consultant									
Engineer/Geologist/Env. Scientist (2)	1.0	ea	@	$3,000	ea	$3,000			
Contingency (15%)						$10,943			
Capital Costs								**$40,908**	
(Assumes 20 cubic yards of impacted soil extending to depth of 2 feet over 270 square foot area)									
Soil Heat Treatability Study							$11,793		Assumes VES line and monitoring points can be installed with backhoe for conducting a VES radius of influence test.
(Assumes a 20-foot VES line and two monitoring points to depth of 1 foot will be needed to establish VES radius of influence.)									
VES Line Installation									
Excavator/Backhoe - Local (150 feet/day)	0.2	days	@	$1,750	/day	$350			1 ves line at 20 feet and 2 monitoring points at 5 feet
Manifold Piping Materials (SS) and Shipping	30.0	lin ft	@	$55.00	/ft	$1,650			1 ves line to 20 feet and 2 monitoring points to 5 feet
Laboratory Analytical Sample Analysis									
N:P:K, Het/Oil Bacteria, Grainsize	3.0	samples	@	$200	each	$600			
GRO, DRO, VOCs, SVOCs	3.0	samples	@	$435	each	$1,305			
Environmental Consultant									
Project Management	0.4	hours	@	$140	/hour	$56			2 hours per work day
Monitoring and Sampling (2 person)	0.6	days	@	$1,800	/day	$1,080			Thrice as long as crew; 1 time to monitor, 1 time to set up, and 1 time to conduct treatability test
Blower Test Equipment	0.6	days	@	$500	/day	$300			
Miscellaneous Equipment	0.6	days	@	$1,000	/day	$600			
Per Diem (2) and Vehicle	0.6	days	@	$380	/day	$228			Assumes shared with multiple sites
Change Out Engineer/Geologist/Env. Scientist (2)	0.0	ea	@	$3,000	ea	$86			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	40	hours	@	$100	/hour	$4,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$1,538			included in Tables 6.0-2 and 6.0-3
Soil Heating System Installation Effort							$29,115		3 heat probe lines and 1 VES line needed. 1 VES line will be installed for treatability study. Need 3 heat probe lines.
Surface Installation									
(Assumes install 3 15-foot heat probes and 30 feet manifold piping to 1 foot depth)									
Clearing and Grubbing (10,000 square feet/day)	0.03	days	@	$5,000	/day	$135			Remove vegetation from 270 square feet site
Excavate Trenches 3 feet wide by 4 feet deep	55.0	lin ft	@	$18	/lf	$990			Common Trenches for manifold piping
Manifold Piping Materials (Galvanized) and Shipping	75.0	ft	@	$15.00	/ft	$1,125			3 heat lines at 15 feet and 30 feet manifold piping
Blower/Shed/Meters etc.	0.1	sites	@	$25,000	/site	$3,125			Assume shared with 8 other surface soil contaminated sites
Thermal Blanket	270.0	sq ft	@	$4	/site	$1,080			Ceramic Fiber Blanket
Heat Exchanger, Oil/Water Seperator, GAC	0.1	sites	@	$20,000	/site	$2,500			Assume shared with 8 other surface soil contaminated sites
Per Diem (1)	1.4	days	@	$140	/day	$191			Assume 100 feet per day and 1 day for blower/shed setup
Change Out Operator (1) & Laborers (1) - Local	0.07	ea	@	$100	ea	$7			Change out crew every 21 days (assumes work at multiple sites)
TerraTherm									
Operator (1) & Laborers (1)	1.00	days	@	$1,600	/day	$1,600			Assume TerraTherm needs 1 day to hookup Electrical Heater
Per Diem (3) and Vehicle (1)	1.0	days	@	$520	/day	$520			Assumes shared with multiple sites
Change Out Operator (1) & Laborers (2)	0.05	ea	@	$4,500	ea	$214			Change out crew every 21 days (assumes work at multiple sites)
Environmental Consultant									
Project Management	2.7	hours	@	$140	/hour	$383			2 hours per work day
Installation Monitoring and Sampling (2 person)	1.4	days	@	$1,800	/day	$2,460			Same hours as excavation crew
Per Diem (2) and Vehicle	1.4	days	@	$380	/day	$519			
Miscellaneous Equipment	1.4	days	@	$200	/day	$273			
Change Out Engineer/Geologist/Env. Scientist (2)	0.1	ea	@	$3,000	ea	$195			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	100	hours	@	$100	/hour	$10,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$3,798			included in Tables 6.0-2 and 6.0-3
O&M Costs								**$7,718**	TerraTherm operates electricity for 180 days at $3,300 per day for 6,000 cy ($99/cy). Assume 1 day at $99/cy.
Treatment Efforts							$7,718		
Soil Heating									
Operate Soil Heating System	1.0	days	@	$800	/day	$800			Operate for 1 day after installation
Soil Heating and VES Electricity	20	cy	@	$99	/cy	$1,980			TerraTherm operates electricity for 180 days at $3,300 per day for 6,000 cy
Treatment Knockout Drum Water	1.0	days	@	$50	/day	$50			Same hours as treatment crew
Per Diem (1) and Vehicle	1.0	days	@	$240	/day	$240			
Environmental Consultant									
Project Management	2.0	hours	@	$140	/hour	$280			2 hours per work day
Treatment Monitoring	1.0	days	@	$900	/day	$900			One day per month
Per Diem (1) and Vehicle	1.0	days	@	$240	/day	$240			One day per month
Travel to Site (1 person)	0.10	ea	@	$1,500	ea	$150			Assumes travel shared between 10 other sites.
Change Out Engineer/Geologist/Env. Scientist (1)	0.05	ea	@	$1,500	ea	$71			Change out crew every 21 days (assumes work at multiple sites)
Reporting	20	hours	@	$100	/hour	$2,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$1,007			included in Tables 6.0-2 and 6.0-3

TABLE C.5 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 5 - SOIL HEATING

Alternative 5 - Soil Heating (Thermal Conductive Heating)

	20 Cubic Yards							COSTS	
Future Capital Costs (One Time at End of Treatment)								**$11,013**	
Confirmation of Cleanup							$6,850		
Confirmation Test Pits									
Excavator/Backhoe - Local (150 feet/day)	0.1	days	@	$1,750	/day	$93			4 test pits to 2 feet
Laboratory Analytical Sample Analysis									1 sample per 200 cubic yards to 2,000 cy and then 1 sample per 500 cubic yards plus 20% QC; Minimum 4 samples
Confirmation Samples (GRO, DRO, VOCs, SVOCs)	4.0	samples	@	$435	each	$1,740			
Environmental Consultant									
Project Management	0.1	hours	@	$140	/hour	$15			2 hours per work day
Monitoring and Sampling (2 person)	0.1	days	@	$1,800	/day	$96			Same hours as excavation crew
Per Diem (2) and Vehicle	0.1	days	@	$380	/day	$20			
Change Out Engineer/Geologist/Env. Scientist (1)	0.00	ea	@	$1,500	ea	$4			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	40	hours	@	$100	/hour	$4,000			Assumes work plan effort shared with multiple sites and stand alone cleanup report combined with decom report for each site
Contingency (15%)						$881			
Decommissioning Efforts							$4,164		
System Decommissioning									
Remove Piping (150 feet/day)	0.5	days	@	$1,750	/day	$875			
Environmental Consultant									
Project Management	1.0	hours	@	$140	/hour	$140			2 hours per work day
Decommissioning Monitoring	0.5	days	@	$900	/day	$450			Same hours as drill crew
Per Diem (1) and Vehicle	0.5	days	@	$240	/day	$120			
Change Out Engineer/Geologist/Env. Scientist (1)	0.02	ea	@	$1,500	ea	$36			Change out crew every 21 days (assumes work at multiple sites)
Reporting	20	hours	@	$100	/hour	$2,000			Assumes work plan effort shared with multiple sites and stand alone cleanup report combined with decom report for each site
Contingency (15%)						$543			
							Alternative 5 - Soil Heating Total:	**$147,787**	

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST		TOTAL COST PER YEAR		DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER CY*
Mobilization/Demobilization Costs	1	$4,255		$4,255		0.935	$3,977	-
Mobilization/Demobilization Costs	1	$83,893		$83,893		0.935	$78,404	-
Mobilization/Demobilization Costs	2	$4,255		$4,255		0.873	$3,716	-
Capital Cost	1	$40,908		$40,908		0.935	$38,232	$1,912
O&M Cost (Year 1)	1	$7,718		$7,718		0.935	$7,213	$361
Future Capital Cost (one time)	2	$11,013		$11,013		0.873	$9,620	$481
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)							**$55,065**	$2,753

* Average cost per cubic yard is for treating a site having an estimated volume of 20 cubic yards of impacted soil.

TABLE C.5 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 5 - SOIL HEATING

Alternative 5 - Soil Heating (Thermal Conductive Heating)

Item	Qty	Unit		Unit Cost	Per	Amount	Subtotal	COSTS	Notes
20,000 Cubic Yards									
Mobilization/Demobilization Costs (Treatability Study, Confirmation Borings, and Decommissioning)								**$46,000**	
Equipment and Personnel Mobilization/Demobilization Effort							$46,000		
Soil Heating Well Equipment and Personnel									
Tubex Drill Rig Mob/Demob	1.0	lump sum	@	$32,500	ea	$32,500			
Driller (1), Helper (1) and Laborer	1.0	ea	@	$4,500	ea	$4,500			Assumes mobilization/demobilization efforts for Year 1 (treatability study), Year 1 (confirmation of cleanup), and Year 2 (Decommissioning) for this technology for 20,000 cy - Present Value Analysis Table shows costs
Environmental Consultant									
Engineer/Geologist/Env. Scientist (2)	1.0	ea	@	$3,000	ea	$3,000			
Contingency (15%)						$6,000			
Mobilization/Demobilization Costs (Installation and Treatment)								**$209,243**	
Equipment and Personnel Mobilization/Demobilization Effort							$209,243		
Soil Heating Well Equipment and Personnel									
Tubex Drill Rig Mob/Demob	1.0	lump sum	@	$32,500	ea	$32,500			
Driller (1), Helper (1) and Laborer	1.0	ea	@	$4,500	ea	$4,500			Assumes mobilization/demobilization efforts for Year 1 (installation and treatment) for this technology for 20,000 cy - Present Value Analysis Table shows costs
Soil Heating Manifold, Equipment and Personnel									
Excavator/Backhoe - Local	1.0	lump sum	@	$500	ea	$500			
Operator (1) & Laborers (1) - Local	1.0	ea	@	$200	ea	$200			
TerraTherm Equipment and Personnel									
Mob/Decon/Demob Labor (3)	1	lump sum	@	$8,250	ea	$8,250			
1500 kw Electrical Generator	1	lump sum	@	$75,000	ea	$75,000			1500 kw generator from Caterpillar
Equipment Shipping	1	lump sum	@	$55,000	ea	$55,000			TerraTherm Electrical Heater
Operator (1) & Laborers (1)	1	trip	@	$3,000	ea	$3,000			
Environmental Consultant									
Engineer/Geologist/Env. Scientist (2)	1.0	ea	@	$3,000	ea	$3,000			
Contingency (15%)						$27,293			
Capital Costs								**$2,380,047**	
(Assumes 20,000 cubic yards of impacted soil extending to depth of 45 feet over 12,000 square foot area)									
Soil Heat Treatability Study							$108,099		Assumes injection well and monitoring points for the Biovent alternative are sufficient for conducting a VES radius of influence test.
(Assumes install 1 VES well and 2 monitoring points to depth of 45 feet will be needed to establish VES radius of influence.)									
Well Installation									
Tubex Drill Rig (50 ft well/day)	2.7	days	@	$4,500	/day	$12,150			1 VES well and 2 monitoring points to 45 feet each
Well Piping Materials (Stainless) and Shipping	141	lin ft	@	$55	/lf	$7,755			3 @ 45 feet each plus 2 feet stickup
Per Diem (3)	2.7	days	@	$420	/day	$1,134			Assumes shared with multiple sites
Change Out Driller (1), Helper (1) and Laborer	0.13	ea	@	$4,500	ea	$579			Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis									
N:P:K, Het/Oil Bacteria, Grainsize	6.0	samples	@	$200	each	$1,200			Two samples per boring
GRO, DRO, VOCs, SVOCs	6.0	samples	@	$435	each	$2,610			Two samples per boring
Environmental Consultant									
Project Management	5.4	hours	@	$140	/hour	$756			2 hours per work day
Monitoring and Sampling (2 person)	8.1	days	@	$1,800	/day	$14,580			Thrice as long as drill crew; 1 time to monitor, 1 time to set up, and 1 time to conduct treatability test
Blower Test Equipment	1.0	day	@	$500	/day	$500			Assumes 1 portable system for treatability studies at multiple sites
Miscellaneous Equipment	8.1	days	@	$5,000	/day	$40,500			
Per Diem (2) and Vehicle	8.1	days	@	$380	/day	$3,078			Assumes shared with multiple sites
Change Out Engineer/Geologist/Env. Scientist (2)	0.4	ea	@	$3,000	ea	$1,157			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$14,100			included in Tables 6.0-2 and 6.0-3
Soil Heating System Installation Effort							$2,271,949		
(Assumes 20,000 cubic yards of impacted soil extending to depth of 45 feet over 12,000 square foot area. Assume Radius of Influence for Heat Probe = 10 feet and ROI for VES Well = 25 feet.)									144 probes, 20 thermistors, 20 transducers, and 8 VES wells to 45 feet . 1 VES well will be installed for treatability study. Need 144 probes and 7 VES wells to 45 feet.
Subsurface Installation									
Tubex Drill Rig (50 ft well/day)	171.9	days	@	$4,500	/day	$773,550			144 probes, 20 thermistors, 20 transducers, and 7 VES wells to 45 feet
Galvanized Pipe Materials	6768.0	ft	@	$15.00	/ft	$101,520			143 @ 47 feet each
Well Piping Materials (Stainless) and Shipping	315.0	lin ft	@	$55.00	/ft	$17,325			8 VES @ 45 feet each
Thermistor and Transducers Materials and Shipping	1800.0	ft	@	$25	/ft	$45,000			20 thermisters, 20, transducers @ 45 feet each
Per Diem (5)	171.9	days	@	$700	/day	$120,330			Assumes shared with multiple sites
Change Out Driller (1), Helper (1) and Laborer	8.2	ea	@	$4,500	ea	$36,836			Change out crew every 21 days (assumes work at multiple sites)
Surface Installation									
Clearing and Grubbing (10,000 square feet/day)	1.20	days	@	$5,000	/day	$6,000			Remove vegetation from 12,000 square feet site
Manifold Piping Materials (SS) and Shipping	796.0	lin ft	@	$55	/lf	$43,780			Piping to individual VES wells
Excavate Trenches 3 feet wide by 4 feet deep	480.0	lin ft	@	$18	/lf	$8,640			Common Trenches for VES manifold piping
Manifold Piping Materials (Galvanized) and Shipping	1430.0	ft	@	$15.00	/ft	$21,450			110 feet @ 12 rows plus 100 feet @ 1 column plus 10 feet @ 1 row = 1430
Shed, Knockout Drum, Meters etc.	1.0	sites	@	$25,000	/site	$25,000			
Thermal Blanket at Surface	12000.0	sq ft	@	$4	/site	$48,000			Ceramic Fiber Blanket
Heat Exchanger, Oil/Water Seperator, GAC	1.0	sites	@	$20,000	/site	$20,000			Process steam and water produced during treatment
Chain-Link Fence around Treatment Area	440.0	lin ft	@	$132	/lf	$58,080			110 feet x 110 feet site
Per Diem (3) and Vehicle (1)	11.8	days	@	$520	/day	$6,136			Assume 100 feet per day and 7 days for blower/shed setup
Change Out Operator (1) & Laborers (1) - Local	0.6	ea	@	$100	ea	$56			Change out crew every 21 days (assumes work at multiple sites)
TerraTherm									
Operator (1) & Laborers (1)	21.0	days	@	$1,600	/day	$33,600			Assume TerraTherm needs 21 days to setup Electrical Heater
Per Diem (3) and Vehicle (1)	21.0	days	@	$520	/day	$10,920			
Change Out Operator (1) & Laborers (2)	1.0	ea	@	$4,500	ea	$4,500			Change out crew every 21 days (assumes work at multiple sites)
Environmental Consultant									
Project Management	367.4	hours	@	$140	/hour	$51,436			2 hours per work day
Installation Monitoring and Sampling (2 person)	183.7	days	@	$1,800	/day	$330,660			Same hours as drill and excavation crew
Per Diem (2) and Vehicle	183.7	days	@	$380	/day	$69,806			Assumes shared with multiple sites
Miscellaneous Equipment	183.7	days	@	$200	/day	$36,740			
Change Out Engineer/Geologist/Env. Scientist (2)	8.7	ea	@	$3,000	ea	$26,243			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	800.0	hours	@	$100	/hour	$80,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$296,341			included in Tables 6.0-2 and 6.0-3

TABLE C.5 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 5 - SOIL HEATING

Alternative 5 - Soil Heating (Thermal Conductive Heating)

Item	Qty	Unit		Rate	Per	Amount	Subtotal	COSTS	Notes
	20,000 Cubic Yards								
O&M Costs (Year 1)								**$3,155,078**	
Treatment Efforts							$3,155,078		
Soil Heating									
Operate Soil Heating System	600.0	days	@	$800	/day	$480,000			TerraTherm operates electricity for 180 days at $3,300 per day for
Soil Heating and VES Electricity	20000	cy	@	$99	/cy	$1,980,000			6,000 cy ($99/cy). Assume 600 days at $99/cy.
Treatment Knockout Drum Water	600.0	days	@	$50	/day	$30,000			Same hours as treatment crew
Per Diem (1) and Vehicle	600.0	days	@	$240	/day	$144,000			
Environmental Consultant									
Project Management	36.0	hours	@	$140	/hour	$5,040			2 hours per work day
Treatment Monitoring	18.0	days	@	$900	/day	$16,200			One day per month
Per Diem (1) and Vehicle	18.0	days	@	$240	/day	$4,320			Assumes shared with multiple sites
Travel to Site (1 person)	1.8	ea	@	$1,500	ea	$2,700			Assumes travel shared between 10 other sites.
Change Out Engineer/Geologist/Env. Scientist (1)	0.9	ea	@	$1,500	ea	$1,286			Change out crew every 21 days (assumes work at multiple sites)
Reporting	800	hours	@	$100	/hour	$80,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$411,532			included in Tables 6.0-2 and 6.0-3
Future Capital Costs (One Time at End of Treatment)								**$920,224**	Assume installation and treatment takes 1 year
Confirmation of Cleanup							$230,690		
Confirmation Borings									
Tubex Drill Rig (100 feet/day)	12.6	days	@	$4,500	/day	$56,700			28 borings to 45 feet deep 2 samples per boring
Per Diem (3)	12.6	days	@	$420	/day	$5,292			
Change Out Driller (1), Helper (1) and Laborer	0.6	ea	@	$4,500	ea	$2,700			Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis									1 sample per 200 cubic yards to 2,000 cy and then 1 sample per 500
Confirmation Samples (GRO, DRO, VOCs, SVOCs)	55.2	samples	@	$435	each	$24,012			cubic yards plus 20% QC; Minimum 4 samples
Environmental Consultant									
Project Management	25.2	hours	@	$140	/hour	$3,528			2 hours per work day
Monitoring and Sampling (2 person)	12.6	days	@	$1,800	/day	$22,680			Same hours as drill crew
Per Diem (2) and Vehicle	12.6	days	@	$380	/day	$4,788			$140/person + $100 vehicle
Change Out Engineer/Geologist/Env. Scientist (1)	0.6	ea	@	$1,500	ea	$900			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	800	hours	@	$100	/hour	$80,000			Assumes work plan effort shared with multiple sites and stand alone
Contingency (15%)						$30,090			cleanup report combined with decom report for each site
Decommissioning Efforts							$689,534		
Well Decommissioning									
Remove Chain-Link Fence (150 feet/day)	2.9	days	@	$1,750	/day	$5,133			580 Backhoe with Operator and 2 Laborers
Tubex Drill Rig (100 feet/day)	86.4	days	@	$4,500	/day	$388,800			144 probes, 20 thermistors, 20 transducers, and 8 VES wells to 45
Per Diem (3)	86.4	days	@	$420	/day	$36,288			feet
Change Out Driller (1), Helper (1) and Laborer	4.1	ea	@	$4,500	ea	$18,514			Change out crew every 21 days (assumes work at multiple sites)
Environmental Consultant									
Project Management	172.8	hours	@	$140	/hour	$24,192			2 hours per work day
Decommissioning Monitoring	86.4	days	@	$900	/day	$77,760			Same hours as drill crew
Per Diem (1) and Vehicle	86.4	days	@	$240	/day	$20,736			$140/person + $100 vehicle
Change Out Engineer/Geologist/Env. Scientist (1)	4.1	ea	@	$1,500	ea	$6,171			Change out crew every 21 days (assumes work at multiple sites)
Reporting	220.0	hours	@	$100	/hour	$22,000			Assumes work plan effort shared with multiple sites and stand alone
Contingency (15%)						$89,939			cleanup report combined with decom report for each site
							Alternative 5 - Soil Heating Total:	**$6,710,592**	

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST		TOTAL COST PER YEAR		DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER CY*
Mobilization/Demobilization Costs	1	$46,000		$46,000		0.935	$42,991	-
Mobilization/Demobilization Costs	1	$209,243		$209,243		0.935	$195,554	-
Mobilization/Demobilization Costs	2	$46,000		$46,000		0.873	$40,178	-
Capital Cost	1	$2,380,047		$2,380,047		0.935	$2,224,343	$111
O&M Cost (Year 1)	1	$3,155,078		$3,155,078		0.935	$2,948,671	$147
Future Capital Cost (One time)	2	$920,224		$920,224		0.873	$803,760	$40
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)							**$5,976,774**	$299

* Average cost per cubic yard is for treating a site having an estimated volume of 20,000 cubic yards of impacted soil.

TABLE C.5 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 5 - SOIL HEATING

Alternative 5 - Soil Heating (Thermal Conductive Heating)

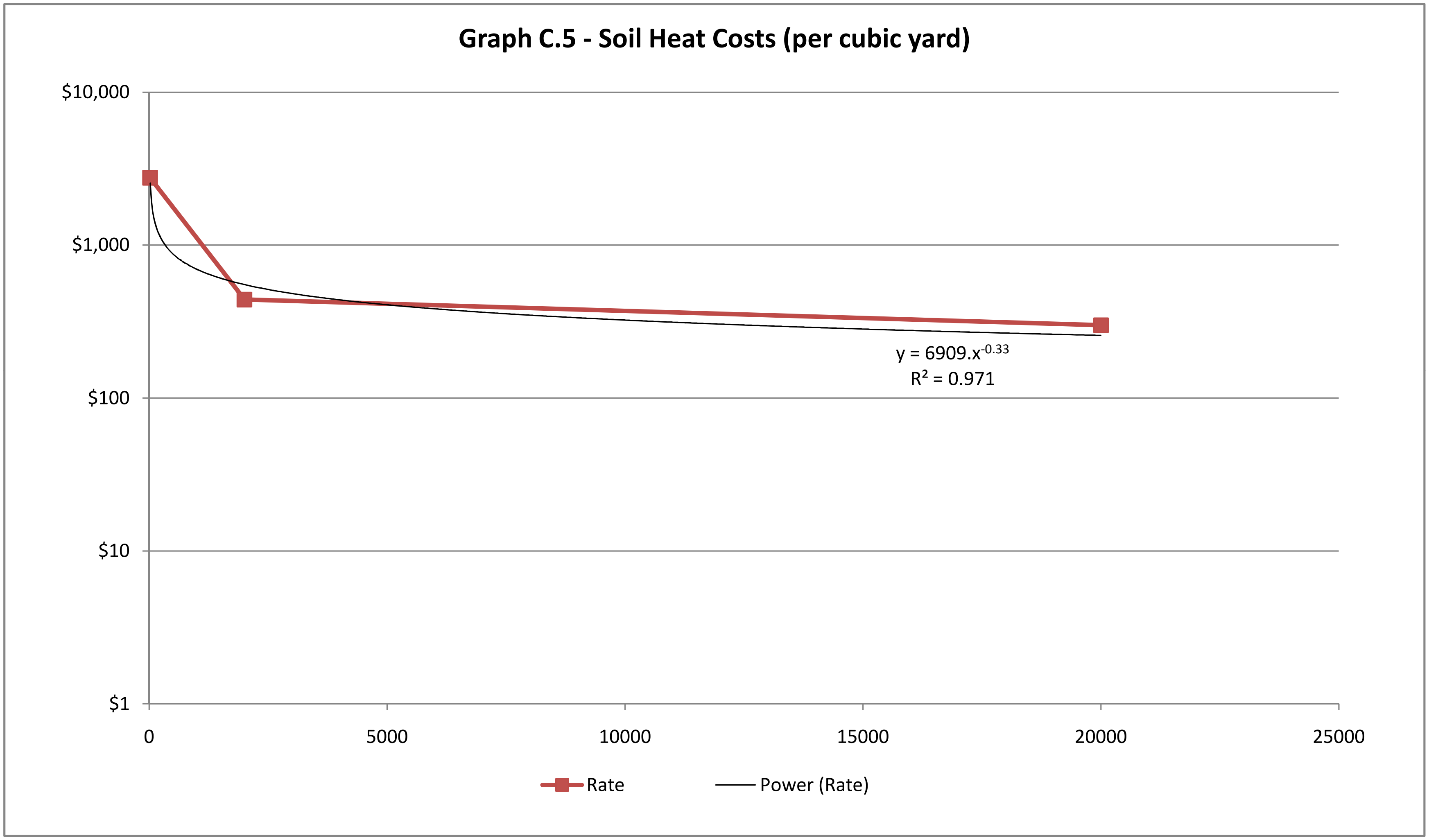


TABLE C.6 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 6 - BIOVENTING

Alternative 6 - Bioventing

Item	Qty	Unit		Rate	Per	Amount	Subtotal	COSTS	Notes
2,000 Cubic Yards									
Mobilization/Demobilization Costs								**$46,805**	
Equipment and Personnel Mobilization/Demobilization Effort							$46,805		
Biovent Well Equipment and Personnel									
Tubex Drill Rig Mob/Demob	1.0	lump sum	@	$32,500	ea	$32,500			Assumes mobilization/demobilization efforts for Year 1 (treatability study), Year 1 (system installation), Year 5 (screening for cleanup), and Year 10 (confirmation of cleanup) for this technology for 2,000 cy - Present Value Analysis Table shows costs
Driller (1), Helper (1) and Laborer	1.0	ea	@	$4,500	ea	$4,500			
Biovent Manifold, Equipment and Personnel									
Excavator/Backhoe - Local	1.0	lump sum	@	$500	ea	$500			
Operator (1) & Laborers (1) - Local	1.0	ea	@	$200	ea	$200			
Environmental Consultant									
Engineer/Geologist/Env. Scientist (2)	1.0	ea	@	$3,000	ea	$3,000			
Contingency (15%)						$6,105			
Capital Costs								**$186,786**	
(Assumes 2,000 cubic yards of impacted soil extending to depth of 11 feet over 5,000 square foot area)									
Biovent Treatability Study							$33,632		
(Assumes install 1 injection well and 2 monitoring points to depth of 11 feet)									
Well Installation									
Tubex Drill Rig (50 ft well/day)	0.7	days	@	$4,500	/day	$2,970			1 injection well and 2 monitoring points to 11 feet each
Well Piping Materials and Shipping	39	lin ft	@	$25	/lf	$975			3 @ 11 feet each plus 2 feet stickup
Per Diem (3)	0.7	days	@	$420	/day	$277			Assumes shared with multiple sites
Change Out Driller (1), Helper (1) and Laborer	0.03	ea	@	$4,500	ea	$141			Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis									
N:P:K, Het/Oil Bacteria, Grainsize	3.0	samples	@	$200	each	$600			One sample per boring
GRO, DRO, VOCs, SVOCs	3.0	samples	@	$435	each	$1,305			One sample per boring
Environmental Consultant									
Project Management	1.3	hours	@	$140	/hour	$185			2 hours per work day
Monitoring and Sampling (2 person)	4.0	days	@	$1,800	/day	$7,200			1 day to monitor drilling, 1 day to set up, and 2 days to conduct treatability test
Blower Test Equipment	1.0	day	@	$500	/day	$500			Assumes 1 portable system for treatability studies at multiple sites
Miscellaneous Equipment	1.0	ea	@	$5,000	ea	$5,000			Flow, pressure, carbon dioxide, and oxygen meters, and data loggers
Per Diem (2) and Vehicle	4.0	days	@	$380	/day	$1,520			
Change Out Engineer/Geologist/Env. Scientist (2)	0.2	ea	@	$3,000	ea	$571			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites included in Tables 6.0-2 and 6.0-3
Contingency (15%)						$4,387			
Bioventing System Installation Effort							$153,154		
(Assumes 2,000 cubic yards of impacted soil extending to depth of 11 feet over 5,000 square foot area)									
Well Installation									
Tubex Drill Rig (2 wells/day)	1.5	days	@	$4,500	/day	$6,750			3 injection wells (in addition to the 1 well installed during the treatibility study)
Well Piping Materials and Shipping	33	lin ft	@	$25	/lf	$825			
Per Diem (3)	1.5	days	@	$420	/day	$630			Assumes shared with multiple sites
Change Out Driller (1), Helper (1) and Laborer	0.07	ea	@	$4,500	ea	$321			Change out crew every 21 days (assumes work at multiple sites)
Manifold Piping and Equipment Installation									
Clearing and Grubbing (10,000 square feet/day)	0.5	days	@	$5,000	/day	$2,500			Remove vegetation from 5,000 square feet site
Manifold Piping Materials and Shipping	260	lin ft	@	$25	/lf	$6,500			Piping to 4 individual injection wells
Excavate Trenches 3 feet wide by 4 feet deep	170	lin ft	@	$18	/lf	$3,060			Common trenches for manifold piping
Blower/Shed/Meters etc.	1.0	shed	@	$25,000	/site	$25,000			
Chain-Link Fence for Treatment Area	35	lin ft	@	$132	/lf	$4,620			65 square foot area, 35 linear feet - assumes 100 ft of fence per day
Per Diem (3) and Vehicle (1)	12	days	@	$520	/day	$6,058			Assume 100 feet per day (excavate trench, place pipe, and backfill) and 1 week for blower/shed setup and testing
Change Out Operator (1) & Laborers (1) - Local	0.6	ea	@	$100	ea	$55			Change out crew every 21 days (assumes work at multiple sites)
Environmental Consultant									
Project Management	26	hours	@	$140	/hour	$3,682			2 hours per work day
Excavation Monitoring and Sampling (2 person)	13.2	days	@	$1,800	/day	$23,670			Same hours as drill and excavation crew
Miscellaneous Equipment	13.2	days	@	$200	/day	$2,630			
Per Diem (2) and Vehicle	13.2	days	@	$380	/day	$4,997			
Change Out Engineer/Geologist/Env. Scientist (2)	0.6	ea	@	$3,000	ea	$1,879			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	400	hours	@	$100	/hour	$40,000			Assumes part of larger work plan and report effort for all sites included in Tables 6.0-2 and 6.0-3
Contingency (15%)						$19,977			
O&M Costs								**$35,737**	**Assumes O&M Costs are shared between multiple sites**
Biovent Treatment Efforts							$35,737		
Bioventing									
Treatment System Maintenance Labor (12 Months)	12	days	@	$800	/day	$9,600			Assumes 2 events per month, 0.5 day per event
Treatment Electricity (12 months @ 1 hp)	1.73	hp-months	@	$538	/hp-mo	$931			Assumes pulse operation for 2 (12 hour) days per week or 52 days = 1.73 mo
Environmental Consultant									
Project Management	12	hours	@	$134	/hour	$1,608			2 hours per work day
Treatment Monitoring and Sampling (1 person)	6	days	@	$900	/day	$5,400			Assumes 1 event per month, 0.5 day per event
Per Diem (1) and Vehicle	12	days	@	$240	/day	$2,880			Assumes shared between sites
Travel to Site (1 person)	1.2	ea	@	$1,500	ea	$1,800			Assumes travel shared between 10 other sites.
Change Out Engineer/Geologist/Env. Scientist (1)	0.6	ea	@	$1,500	ea	$857			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites included in Tables 6.0-2 and 6.0-3
Contingency (15%)						$4,661			

TABLE C.6 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 6 - BIOVENTING

Alternative 6 - Bioventing

Item	Quantity	Unit		Rate	Per	Amount	Subtotal	COSTS	Notes
	2,000 Cubic Yards								
Future Capital Costs (Every 5 Years)								**$18,255**	
Screening for Cleanup							$18,255		
Screening Borings									
Tubex Drill Rig (100 feet/day)	0.4	days	@	$1,600	/day	$704			4 borings per event to 11 feet, 1 sample per boring
Per Diem (3)	0.4	days	@	$420	/day	$185			
Driller (1), Helper (1) and Laborer	1	ea	@	$4,500	ea	$4,500			
Change Out Driller (1), Helper (1) and Laborer	0.02	ea	@	$4,500	ea	$94			Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis									
Screening Samples (GRO, DRO, VOCs, SVOCs)	4.0	samples	@	$435	each	$1,740			Assumes 30% of total sample number required for cleanup conf
Environmental Consultant									
Project Management	0.9	hours	@	$134	/hour	$118			2 hours per work day
Monitoring and Sampling (1 person)	0.4	days	@	$900	/day	$396			Same hours as drill crew
Per Diem (1) and Vehicle	0.4	days	@	$240	/day	$106			
Change Out Engineer/Geologist/Env. Scientist (1)	0.02	ea	@	$1,500	ea	$31			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$2,381			included in Tables 6.0-2 and 6.0-3
Future Capital Costs (One Time at End of Treatment)								**$72,100**	
Confirmation of Cleanup							$61,956		
Confirmation Borings									
Tubex Drill Rig (100 feet/day)	1.1	days	@	$4,500	/day	$4,950			10 borings to 11 feet deep
Per Diem (3)	1.1	days	@	$420	/day	$462			
Change Out Driller (1), Helper (1) and Laborer	0.1	ea	@	$4,500	ea	$236			Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis									1 sample per 200 cubic yards to 2,000 cy and then 1 sample per
Confirmation Samples (GRO, DRO, VOCs, SVOCs)	12.0	samples	@	$435	each	$5,220			500 cubic yards plus 20% QC; Minimum 4 samples
Environmental Consultant									
Project Management	2.2	hours	@	$134	/hour	$295			2 hours per work day
Monitoring and Sampling (2 person)	1.1	days	@	$1,800	/day	$1,980			Same hours as drill crew
Per Diem (2) and Vehicle	1.1	days	@	$380	/day	$418			
Change Out Engineer/Geologist/Env. Scientist (2)	0.1	ea	@	$3,000	ea	$314			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	400	hours	@	$100	/hour	$40,000			Assumes work plan effort shared with multiple sites and stand
Contingency (15%)						$8,081			alone cleanup report combined with decom report for each site
Decommissioning Efforts							$10,144		
Well Decommissioning									
Remove Chain-Link Fence (150 feet/day)	0.2	days	@	$1,750	/day	$408			580 Backhoe with Operator and 2 Laborers
Tubex Drill Rig (100 feet/day)	0.7	days	@	$4,500	/day	$2,970			4 wells and 2 monitoring points to 11 feet
Per Diem (3)	0.7	days	@	$420	/day	$277			
Change Out Driller (1), Helper (1) and Laborer	0.03	ea	@	$4,500	ea	$141			Change out crew every 21 days (assumes work at multiple sites)
Environmental Consultant									
Project Management	1.3	hours	@	$134	/hour	$177			2 hours per work day
Decommissioning Monitoring	0.7	days	@	$900	/day	$594			Same hours as drill crew
Per Diem (1) and Vehicle	0.7	days	@	$240	/day	$158			
Change Out Engineer/Geologist/Env. Scientist (1)	0.1	ea	@	$1,500	ea	$94			Change out crew every 21 days (assumes work at multiple sites)
Reporting	40.0	hours	@	$100	/hour	$4,000			Assumes decommissioning portion included in stand alone cleanup
Contingency (15%)						$1,323			report
							Alternative 6 - Bioventing Total:	**$359,683**	

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST		TOTAL COST PER YEAR		DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER CY*
Mobilization/Demobilization Costs	1	$46,805		$46,805		0.935	$43,743	-
Mobilization/Demobilization Costs	1	$46,805		$46,805		0.935	$43,743	
Mobilization/Demobilization Costs	5	$46,805		$46,805		0.713	$33,371	
Mobilization/Demobilization Costs	10	$46,805		$46,805		0.508	$23,793	-
Capital Cost	1	$186,786		$186,786		0.935	$174,566	$87
O&M Cost (Year 1)	1	$35,737		$35,737		0.935	$33,399	$17
O&M Cost (Year 2)	2	$35,737		$35,737		0.873	$31,214	$16
O&M Cost (Year 3)	3	$35,737		$35,737		0.816	$29,172	$15
O&M Cost (Year 4)	4	$35,737		$35,737		0.763	$27,264	$14
O&M Cost (Year 5)	5	$35,737		$35,737		0.713	$25,480	$13
O&M Cost (Year 6)	6	$35,737		$35,737		0.666	$23,813	$12
O&M Cost (Year 7)	7	$35,737		$35,737		0.623	$22,255	$11
O&M Cost (Year 8)	8	$35,737		$35,737		0.582	$20,799	$10
O&M Cost (Year 9)	9	$35,737		$35,737		0.544	$19,439	$10
Future Capital Costs (Every 5 Years)	5	$18,255		$18,255		0.713	$13,016	$7
Future Capital Cost (one time)	10	$72,100		$72,100		0.508	$36,652	$18
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)							**$457,070**	$229

* Average cost per cubic yard is for treating a site having an estimated volume of 2000 cubic yards of impacted soil.

TABLE C.6 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 6 - BIOVENTING

Alternative 6 - Bioventing

	20 Cubic Yards								
								COSTS	
Mobilization/Demobilization Costs								**$4,255**	
Equipment and Personnel Mobilization/Demobilization Effort							$4,255		
Biovent Manifold, Equipment and Personnel									Assumes mobilization/demobilization efforts for Year 1
Excavator/Backhoe - Local	1.0	lump sum	@	$500	ea	$500			(treatability study), Year 5 (screening for cleanup), and Year 10
Operator (1) & Laborers (1) - Local	1.0	ea	@	$200	ea	$200			(confirmation of cleanup) for this technology for 20 cy - Present
Environmental Consultant									Value Analysis Table shows costs
Engineer/Geologist/Env. Scientist (2)	1.0	ea	@	$3,000	ea	$3,000			
Contingency (15%)						$555			
Capital Costs								**$29,133**	
(Assumes 20 cubic yards of impacted soil extending from a depth of 2 feet to 4 feet over 235 square foot area)									
Biovent Treatability Study							$29,133		
(Assumes install 15 feet of horizontal injection piping to depth of 3 feet)									
Biovent Manifold, Equipment and Personnel									
Excavator/Backhoe - Local (150 feet/day)	0.1	days	@	$1,750	/day	$175			1 horizontal line 15 feet long
Manifold Piping Materials and Shipping	15.0	lin ft	@	$25.00	/ft	$375			1 @ 15 feet each
Chain-Link Fence for Treatment Area	22.0	lin ft	@	$132	/lf	$2,904			28 sf footprint
20-mil Petroleum Resistant Liners	250	sq ft	@	$0.45	/sf	$113			liner to cover contaminated area to reduce short circuiting at ground
Laboratory Analytical Sample Analysis									surface due to shallow installation depth
N:P:K, Het/Oil Bacteria, Grainsize	2.0	samples	@	$200	each	$400			Assumes 2 samples collected along trench during horizontal pipe
GRO, DRO, VOCs, SVOCs	2.0	samples	@	$435	each	$870			installation
Environmental Consultant									
Project Management	0.2	hours	@	$140	/hour	$28			2 hours per work day
									0.5 day to monitor test pits, 0.5 day to set up, and 2 days to conduct
Monitoring and Sampling (2 person)	3.0	days	@	$1,800	/day	$5,400			treatability test
Blower Test Equipment	1.0	days	@	$500	/day	$500			Assumes 1 portable system for treatability studies at multiple sites
Miscellaneous Equipment	1.0	ea	@	$5,000	ea	$5,000			Flow, pressure, carbon dioxide, and oxygen meters, and data loggers
Per Diem (2) and Vehicle	3.0	days	@	$380	/day	$1,140			Assumes shared between multiple sites
Change Out Engineer/Geologist/Env. Scientist (2)	0.1	ea	@	$3,000	ea	$429			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$3,800			included in Tables 6.0-2 and 6.0-3
Bioventing System Installation Effort							$0		
(Assumes lines installed under pilot test are sufficient for treatment of 20 cy impacted soil)									
O&M Costs								**$35,202**	**Assumes O&M Costs are shared between multiple sites**
Biovent Treatment Efforts							$35,202		
Bioventing									
Treatment System Maintenance Labor (12 Months)	12	days	@	$800	/day	$9,600			Assumes 2 events per month, 0.5 day per event
Treatment Electricity (12 months @ 0.5 hp)	0.87	hp-months	@	$538	/hp-mo	$465			Assumes pulse operation for 2 (12 hour) days per week or 52 days
Environmental Consultant									= 1.73 mo
Project Management	12	hours	@	$134	/hour	$1,608			2 hours per work day
Treatment Monitoring and Sampling (1 person)	6	days	@	$900	/day	$5,400			Assumes 1 event per month, 0.5 day per event
Travel to Site (1 person)	1.2	ea	@	$1,500	ea	$1,800			Assumes travel shared between 10 other sites.
Per Diem (1) and Vehicle	12	days	@	$240	/day	$2,880			Assumes shared between sites
Change Out Engineer/Geologist/Env. Scientist (1)	0.6	ea	@	$1,500	ea	$857			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$4,592			included in Tables 6.0-2 and 6.0-3
Future Capital Costs (Year 5)								**$10,342**	
Screening for Cleanup							$10,342		
Test Pits									
Backhoe & Operator - Local (100 feet/day)	0.04	days	@	$1,600	/day	$64			1 Test Pit per event to 4 feet - assumes multiple sites
Laboratory Analytical Sample Analysis									
Screening Samples (GRO, DRO, VOCs, SVOCs)	2.0	samples	@	$435	each	$870			Assumes 30% of total sample number required for cleanup
Environmental Consultant									confirmation (minimum of 2 samples)
Project Management	0.1	hours	@	$134	/hour	$11			2 hours per work day
Monitoring and Sampling (1 person)	0.04	days	@	$900	/day	$36			Same hours as backhoe crew
Per Diem (1) and Vehicle	0.04	days	@	$240	/day	$10			Assumes shared between sites
Change Out Engineer/Geologist/Env. Scientist (1)	0.002	ea	@	$1,500	ea	$3			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$1,349			included in Tables 6.0-2 and 6.0-3
Future Capital Costs (One Time at End of Treatment)								**$16,029**	
Confirmation of Cleanup							$12,842		
Test Pits									
Backhoe & Operator - Local (100 feet/day)	0.04	days	@	$1,600	/day	$64			1 Test Pit per event to 4 feet - assumes multiple sites
Laboratory Analytical Sample Analysis									
Screening Samples (GRO, DRO, VOCs, SVOCs)	2.4	samples	@	$435	each	$1,044			2 samples per 250 sf, 1 for each additional 250 sf, plus 20% QC
Environmental Consultant									(minimum of 2 samples) - QC shared with multiple sites
Project Management	0.1	hours	@	$134	/hour	$11			2 hours per work day
Monitoring and Sampling (1 person)	0.04	days	@	$900	/day	$36			Same hours as backhoe crew
Per Diem (1) and Vehicle	0.04	days	@	$240	/day	$10			Assumes shared between sites
Change Out Engineer/Geologist/Env. Scientist (1)	0.002	ea	@	$1,500	ea	$3			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	100	hours	@	$100	/hour	$10,000			Assumes work plan effort shared with multiple sites and stand
Contingency (15%)						$1,675			alone cleanup report combined with decom report for each site
Decommissioning Efforts							$3,186		
Treatment Line Decommissioning									
Remove Chain-Link Fence (150 feet/day)	0.1	days	@	$1,750	/day	$257			580 Backhoe with Operator and 2 Laborers
Backhoe & Operator - Local (100 feet/day)	0.2	days	@	$1,600	/day	$240			15 feet of horizontal piping
Per Diem (3)	0.2	days	@	$420	/day	$63			
Environmental Consultant									
Project Management	0.3	hours	@	$134	/hour	$40			2 hours per work day
Decommissioning Monitoring	0.2	days	@	$900	/day	$135			Same hours as drill crew
Per Diem (1) and Vehicle	0.2	days	@	$240	/day	$36			
Reporting	20	hours	@	$100	/hour	$2,000			Assumes decommissioning portion included in stand alone cleanup
Contingency (15%)						$416			report
							Alternative 6 - Bioventing Total:	**$94,961**	

TABLE C.6 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 6 - BIOVENTING

Alternative 6 - Bioventing

20 Cubic Yards

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST		TOTAL COST PER YEAR		DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER CY*
Mobilization/Demobilization Costs	1	$4,255		$4,255		0.935	$3,977	-
Mobilization/Demobilization Costs	5	$4,255		$4,255		0.713	$3,034	
Mobilization/Demobilization Costs	10	$4,255		$4,255		0.508	$2,163	-
Capital Cost	1	$29,133		$29,133		0.935	$27,227	$1,361
O&M Cost (Year 1)	1	$35,202		$35,202		0.935	$32,899	$1,645
O&M Cost (Year 2)	2	$35,202		$35,202		0.873	$30,747	$1,537
O&M Cost (Year 3)	3	$35,202		$35,202		0.816	$28,735	$1,437
O&M Cost (Year 4)	4	$35,202		$35,202		0.763	$26,856	$1,343
O&M Cost (Year 5)	5	$35,202		$35,202		0.713	$25,099	$1,255
O&M Cost (Year 6)	6	$35,202		$35,202		0.666	$23,457	$1,173
O&M Cost (Year 7)	7	$35,202		$35,202		0.623	$21,922	$1,096
O&M Cost (Year 8)	8	$35,202		$35,202		0.582	$20,488	$1,024
O&M Cost (Year 9)	9	$35,202		$35,202		0.544	$19,148	$957
Future Capital Cost (Year 5)	5	$10,342		$10,342		0.713	$7,374	$369
Future Capital Cost (one time)	10	$16,029		$16,029		0.508	$8,148	$407
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)							**$272,099**	$13,605

* Average cost per cubic yard is for treating a site having an estimated volume of 20 cubic yards of impacted soil.

TABLE C.6 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 6 - BIOVENTING

Alternative 6 - Bioventing

	20,000 Cubic Yards								
								COSTS	
Mobilization/Demobilization Costs								**$46,805**	
Equipment and Personnel Mobilization/Demobilization Effort							$46,805		
Biovent Well Equipment and Personnel									
Tubex Drill Rig Mob/Demob	1.0	lump sum	@	$32,500	ea	$32,500			Assumes mobilization/demobilization efforts for Year 1
Driller (1), Helper (1) and Laborer	1.0	ea	@	$4,500	ea	$4,500			(treatability study), Year 2 (system installation), Year 5 (screening
Biovent Manifold, Equipment and Personnel									for cleanup), and Year 10 (confirmation of cleanup) for this
Excavator/Backhoe - Local	1.0	lump sum	@	$500	ea	$500			technology for 20,000 cy - Present Value Analysis Table shows
Operator (1) & Laborers (1) - Local	1.0	ea	@	$200	ea	$200			costs
Environmental Consultant									
Engineer/Geologist/Env. Scientist (2)	1.0	ea	@	$3,000	ea	$3,000			
Contingency (15%)						$6,105			
Capital Costs								**$348,548**	
(Assumes 20,000 cubic yards of impacted soil extending to depth of 45 feet over 12,000 square foot area)									
Biovent Treatability Study							$60,046		
(Assumes install 3 AIS wells to depth of 45 feet)									
Well Installation									
Tubex Drill Rig (50 ft well/day)	2.7	days	@	$4,500	/day	$12,150			1 injection well and 2 monitoring points to 45 feet each
Well Piping Materials and Shipping	135	lin ft	@	$25	/lf	$3,375			3 @ 45 feet each
Per Diem (3)	2.7	days	@	$420	/day	$1,134			Assumes shared with multiple sites
Change Out Driller (1), Helper (1) and Laborer	0.13	ea	@	$4,500	ea	$579			Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis									
N:P:K, Het/Oil Bacteria, Grainsize	3.0	samples	@	$200	each	$600			1 sample per boring
GRO, DRO, VOCs, SVOCs	3.0	samples	@	$435	each	$1,305			1 sample per boring
Environmental Consultant									
Project Management	5.4	hours	@	$140	/hour	$756			2 hours per work day
Monitoring and Sampling (2 person)	8.1	days	@	$1,800	/day	$14,580			Thrice as long as drill crew; 1 time to monitor, 1 time to set up, and 1 time to conduct treatability test
Blower Test Equipment	1.0	day	@	$500	/day	$500			Assumes 1 portable system for treatability studies at multiple sites
Miscellaneous Equipment	1.0	ea	@	$5,000	ea	$5,000			Flow, pressure, carbon dioxide, and oxygen meters, and data loggers
Per Diem (2) and Vehicle	8.1	days	@	$380	/day	$3,078			
Change Out Engineer/Geologist/Env. Scientist (2)	0.4	ea	@	$3,000	ea	$1,157			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$7,832			included in Tables 6.0-2 and 6.0-3
Bioventing System Installation Effort							$288,503		
(Assumes 20,000 cubic yards of impacted soil extending to depth of 45 feet over 12,000 square foot area)									
Well Installation									
Tubex Drill Rig (2 wells/day)	4.0	days	@	$4,500	/day	$18,000			8 injection wells to 45 feet
Well Piping Materials and Shipping	360	lin ft	@	$25	/lf	$9,000			8 @ 45 feet each
Per Diem (3)	4.0	days	@	$420	/day	$1,680			
Change Out Driller (1), Helper (1) and Laborer	0.2	ea	@	$4,500	ea	$857			Change out crew every 21 days (assumes work at multiple sites)
Manifold Piping and Equipment Installation									
Clearing and Grubbing (10,000 square feet/day)	1.20	days	@	$5,000	/day	$6,000			Remove vegetation from 12,000 square feet site
Manifold Piping Materials and Shipping	850.0	lin ft	@	$25	/lf	$21,250			Piping to individual injection well
Excavate Trenches 3 feet wide by 4 feet deep	400.0	lin ft	@	$18	/lf	$7,200			Common Trenches for manifold piping
Blower/Shed/Meters etc.	1.0	site	@	$25,000	/site	$25,000			
Chain-Link Fence for Treatment Area	35	lin ft	@	$132	/lf	$4,620			65 square foot area, 35 linear feet - assumes 100 ft of fence per day
Per Diem (3) and Vehicle (1)	20	days	@	$520	/day	$10,322			Assume 100 feet per day (excavate trench, place pipe, and backfill) and 1 week for blower/shed setup and testing
Change Out Operator (1) & Laborers (1) - Local	0.9	ea	@	$100	ea	$95			Change out crew every 21 days (assumes work at multiple sites)
Environmental Consultant									
Project Management	47.7	hours	@	$140	/hour	$6,678			2 hours per work day
Excavation Monitoring and Sampling (2 person)	23.9	days	@	$1,800	/day	$42,930			Same hours as drill and excavation crew
Miscellaneous Equipment	23.9	days	@	$200	/day	$4,770			Assumes shared between multiple sites
Per Diem (2) and Vehicle	23.9	days	@	$380	/day	$9,063			Assumes shared between multiple sites
Change Out Engineer/Geologist/Env. Scientist (2)	1.1	ea	@	$3,000	ea	$3,407			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	800	hours	@	$100	/hour	$80,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$37,631			included in Tables 6.0-2 and 6.0-3
O&M Costs								**$36,272**	**Assumes O&M Costs are shared between multiple sites**
Biovent Treatment Efforts							$36,272		
Bioventing									
Treatment System Maintenance Labor (12 Months)	12	days	@	$800	/day	$9,600			Assumes 2 events per month, 0.5 day per event
Treatment Electricity (12 months @ 1.5 hp)	2.60	hp-months	@	$538	/hp-mo	$1,396			Assumes pulse operation for 2 (12 hour) days per week or 52 days = 1.73 mo
Environmental Consultant									
Project Management	12	hours	@	$134	/hour	$1,608			2 hours per work day
Treatment Monitoring and Sampling (1 person)	6	days	@	$900	/day	$5,400			Assumes 1 event per month, 0.5 day per event
Per Diem (1) and Vehicle	12	days	@	$240	/day	$2,880			Assumes shared between sites
Travel to Site (1 person)	1.2	ea	@	$1,500	ea	$1,800			Assumes travel shared between 10 other sites.
Change Out Engineer/Geologist/Env. Scientist (1)	0.6	ea	@	$1,500	ea	$857			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$4,731			included in Tables 6.0-2 and 6.0-3

TABLE C.6 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 6 - BIOVENTING

Alternative 6 - Bioventing

20,000 Cubic Yards

Item	Qty	Unit		Rate	Per	Cost	Subtotal	COSTS	Notes
Future Capital Costs (Year 5)								**$41,066**	
Screening for Cleanup							$41,066		
Screening Borings									
Tubex Drill Rig (100 feet/day)	4.1	days	@	$1,600	/day	$6,480			9 borings per event to 45 feet, 2 samples per boring
Per Diem (3)	4.1	days	@	$420	/day	$1,701			
Driller (1), Helper (1) and Laborer	1	ea	@	$4,500	ea	$4,500			
Change Out Driller (1), Helper (1) and Laborer	0.2	ea	@	$4,500	ea	$868			Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis									
Screening Samples (GRO, DRO, VOCs, SVOCs)	18.7	samples	@	$435	each	$8,120			Assumes 30% of total sample number required for cleanup conf
Environmental Consultant									
Project Management	8.1	hours	@	$140	/hour	$1,134			2 hours per work day
Monitoring and Sampling (1 person)	4.1	days	@	$900	/day	$3,645			Same hours as backhoe crew
Per Diem (1) and Vehicle	4.1	days	@	$240	/day	$972			Assumes shared between sites
Change Out Engineer/Geologist/Env. Scientist (1)	0.2	ea	@	$1,500	ea	$289			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites included in Tables 6.0-2 and 6.0-3
Contingency (15%)						$5,356			
Future Capital Costs (One Time at End of Treatment)								**$272,376**	
Confirmation of Cleanup							$231,551		
Confirmation Borings									
Tubex Drill Rig (100 feet/day)	12.6	days	@	$4,500	/day	$56,700			23 borings to 45 feet deep 2 samples per boring
Per Diem (3)	12.6	days	@	$420	/day	$5,292			
Change Out Driller (1), Helper (1) and Laborer	0.6	ea	@	$4,500	ea	$2,700			Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis									
Confirmation Samples (GRO, DRO, VOCs, SVOCs)	55.2	samples	@	$435	each	$24,012			1 sample per 200 cubic yards to 2,000 cy and then 1 sample per 500 cubic yards plus 20% QC; Minimum 4 samples
Environmental Consultant									
Project Management	25.2	hours	@	$134	/hour	$3,377			2 hours per work day
Monitoring and Sampling (2 person)	12.6	days	@	$1,800	/day	$22,680			Same hours as drill crew
Per Diem (2) and Vehicle	12.6	days	@	$380	/day	$4,788			Assumes shared between sites
Change Out Engineer/Geologist/Env. Scientist (2)	0.6	ea	@	$3,000	ea	$1,800			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	800	hours	@	$100	/hour	$80,000			Assumes work plan effort shared with multiple sites and stand alone cleanup report combined with decom report for each site
Contingency (15%)						$30,202			
Decommissioning Efforts							$40,825		
Well Decommissioning									
Remove Chain-Link Fence (150 feet/day)	0.2	days	@	$1,750	/day	$408			580 Backhoe with Operator and 2 Laborers
Tubex Drill Rig (100 feet/day)	5.0	days	@	$4,500	/day	$22,275			9 wells and 2 monitoring points to 45 feet
Per Diem (3)	5.0	days	@	$420	/day	$2,079			
Change Out Driller (1), Helper (1) and Laborer	0.2	ea	@	$4,500	ea	$1,061			Change out crew every 21 days (assumes work at multiple sites)
Environmental Consultant									
Project Management	9.9	hours	@	$134	/hour	$1,327			2 hours per work day
Decommissioning Monitoring	5.0	days	@	$900	/day	$4,455			Same hours as drill crew
Per Diem (1) and Vehicle	5.0	days	@	$240	/day	$1,188			
Change Out Engineer/Geologist/Env. Scientist (1)	0.5	ea	@	$1,500	ea	$707			Change out crew every 21 days (assumes work at multiple sites)
Reporting	20	hours	@	$100	/hour	$2,000			Assumes decommissioning portion included in stand alone cleanup report
Contingency (15%)						$5,325			
							Alternative 6 - Bioventing Total:	**$745,067**	

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER CY*
Mobilization/Demobilization Costs	1	$46,805	$46,805	0.935	$43,743	-
Mobilization/Demobilization Costs	1	$46,805	$46,805	0.935	$43,743	-
Mobilization/Demobilization Costs	5	$46,805	$46,805	0.713	$33,371	-
Mobilization/Demobilization Costs	10	$46,805	$46,805	0.508	$23,793	-
Capital Cost	1	$348,548	$348,548	0.935	$325,746	$16
O&M Cost (Year 1)	1	$36,272	$36,272	0.935	$33,899	$2
O&M Cost (Year 2)	2	$36,272	$36,272	0.873	$31,682	$2
O&M Cost (Year 3)	3	$36,272	$36,272	0.816	$29,609	$1
O&M Cost (Year 4)	4	$36,272	$36,272	0.763	$27,672	$1
O&M Cost (Year 5)	5	$36,272	$36,272	0.713	$25,862	$1
O&M Cost (Year 6)	6	$36,272	$36,272	0.666	$24,170	$1
O&M Cost (Year 7)	7	$36,272	$36,272	0.623	$22,589	$1
O&M Cost (Year 8)	8	$36,272	$36,272	0.582	$21,111	$1
O&M Cost (Year 9)	9	$36,272	$36,272	0.544	$19,730	$1
Future Capital Cost (Year 5)	5	$41,066	$41,066	0.713	$29,279	$1
Future Capital Cost (one time)	10	$272,376	$272,376	0.508	$138,462	$7
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)					**$729,811**	$36

* Average cost per cubic yard is for treating a site having an estimated volume of 20,000 cubic yards of impacted soil.

TABLE C.6 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 6 - BIOVENTING

Alternative 6 - Bioventing

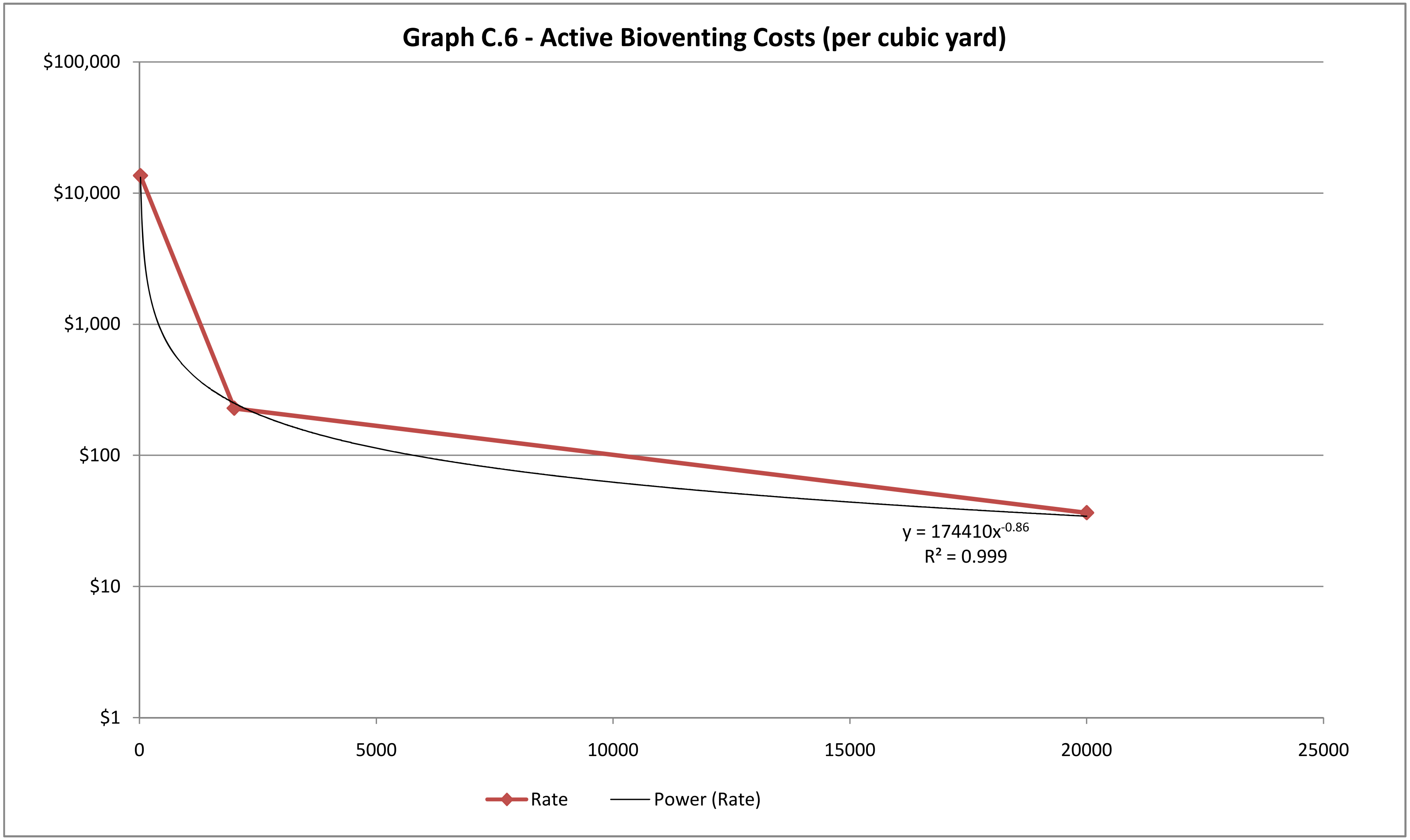


TABLE C.7 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 7 - PASSIVE BIOVENTING

Alternative 7 - Passive Bioventing

Item	Qty	Unit	@	Rate	Per	Amount	Subtotal	Costs	Notes
	2,000 Cubic Yards								
								COSTS	
Mobilization/Demobilization Costs								**$46,805**	
Equipment and Personnel Mobilization/Demobilization Effort							$46,805		
Passive Biovent Well Equipment and Personnel									
Tubex Drill Rig Mob/Demob	1.0	lump sum	@	$32,500	ea	$32,500			Assumes mobilization/demobilization efforts for Year 1 (treatability
Driller (1), Helper (1) and Laborer	1.0	ea	@	$4,500	ea	$4,500			study), Year 1 (system installation), Year 5 (screening for cleanup),
Passive Biovent Manifold, Equipment and Personnel									Year 10 (screening for cleanup), Year 15 (screening for cleanup),
Excavator/Backhoe - Local	1.0	lump sum	@	$500	ea	$500			and Year 20 (confirmation of cleanup) for this technology for 2,000
Operator (1) & Laborers (1) - Local	1.0	ea	@	$200	ea	$200			cy - Present Value Analysis Table shows costs
Environmental Consultant									
Engineer/Geologist/Env. Scientist (2)	1.0	ea	@	$3,000	ea	$3,000			
Contingency (15%)						$6,105			
Capital Costs								**$203,617**	
(Assumes 2,000 cubic yards of impacted soil extending to depth of 11 feet over 5,000 square foot area)									
Passive Biovent Treatability Study							$39,885		
(Assumes install 1 vent well and 3 monitoring points to depth of 11 feet)									
Well Installation									
Tubex Drill Rig (50 ft well/day)	0.9	days	@	$4,500	/day	$3,960			1 vent well and 3 monitoring points to 11 feet each
Well Piping Materials and Shipping	52	lin ft	@	$25	/lf	$1,300			4 @ 11 feet each plus 2 feet stickup
One-Way Passive Valves (2-inch)	1.0	ea	@	$163	ea	$163			1 vent well
Per Diem (3)	0.9	days	@	$420	/day	$370			Assumes shared with multiple sites
Change Out Driller (1), Helper (1) and Laborer	0.04	ea	@	$4,500	ea	$189			Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis									
N:P:K, Het/Oil Bacteria, Grainsize	4.0	samples	@	$200	each	$800			One sample per boring
VOCs Vapors with GORE Modules	4.0	samples	@	$250	each	$1,000			One sample per boring
GRO, DRO, VOCs, SVOCs	4.0	samples	@	$435	each	$1,740			One sample per boring
Environmental Consultant									
Project Management	8.0	hours	@	$140	/hour	$1,120			2 hours per work day
Monitoring and Sampling (2 person)	4.0	days	@	$1,800	/day	$7,200			1 day to monitor drilling, 1 day to set up, and 2 days to conduct treatability test
Passive Biovent Equipment	1.0	ea	@	$5,000	ea	$5,000			Flow, pressure, carbon dioxide, and oxygen meters, and data loggers
Miscellaneous Equipment	8.0	days	@	$200	/day	$1,600			
Per Diem (2) and Vehicle	4.0	days	@	$380	/day	$1,520			Assumes shared between sites
Travel to Site (1 person)	0.10	ea	@	$1,500	ea	$150			Assumes travel shared between 10 other sites.
Change Out Engineer/Geologist/Env. Scientist (2)	0.2	ea	@	$3,000	ea	$571			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$5,202			included in Tables 6.0-2 and 6.0-3
Passive Bioventing System Installation Effort							$163,732		
(Assumes 2,000 cubic yards of impacted soil extending to depth of 11 feet over 5,000 square foot area.									25 vent wells required for 5,000 sf site; 1 installed w/feasibility study
Radius of influence of injection well equals 10 feet.)									
Well Installation									
Tubex Drill Rig (2 wells/day)	5.3	days	@	$4,500	/day	$23,760			24 vent wells to 11 feet
Well Piping Materials and Shipping (2-inch)	312.0	lin ft	@	$25	/lf	$7,800			24 vent wells to 13 feet
One-Way Passive Valves (2-inch)	24.0	ea	@	$163	ea	$3,912			24 vent wells
Per Diem (3)	5.3	days	@	$420	/day	$2,218			
Change Out Driller (1), Helper (1) and Laborer	0.3	ea	@	$4,500	ea	$1,131			Change out crew every 21 days (assumes work at multiple sites)
Equipment Installation									
Clearing and Grubbing (10,000 square feet/day)	0.5	days	@	$5,000	/day	$2,500			Remove vegetation from 5,000 square feet site
Chain-Link Fence for Treatment Area	300.0	lin ft	@	$132	/lf	$39,600			75 feet x 75 feet site
Per Diem (3) and Vehicle (1)	2.0	days	@	$520	/day	$1,040			Assume 2 days for setup
Change Out Operator (1) & Laborers (1) - Local	0.1	ea	@	$100	ea	$10			Change out crew every 21 days (assumes work at multiple sites)
Environmental Consultant									
Project Management	14.6	hours	@	$140	/hour	$2,038			2 hours per work day
Monitoring and Sampling (2 person)	7.3	days	@	$1,800	/day	$13,104			Same hours as drill and excavation crew
Miscellaneous Equipment	7.3	days	@	$200	/day	$1,456			
Per Diem (2) and Vehicle	7.3	days	@	$380	/day	$2,766			
Change Out Engineer/Geologist/Env. Scientist (2)	0.3	ea	@	$3,000	ea	$1,040			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	400	hours	@	$100	/hour	$40,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$21,356			included in Tables 6.0-2 and 6.0-3
O&M Costs								**$0**	
Future Capital Costs (Every 5 Years)								**$12,765**	
Screening for Cleanup							$12,765		
Test Pits									
Backhoe & Operator - Local (100 feet/day)	0.4	days	@	$1,600	/day	$704			4 Test Pits per event to 11 feet
Laboratory Analytical Sample Analysis									
Screening Samples (GRO, DRO, VOCs, SVOCs)	4.0	samples	@	$435	each	$1,740			Assumes 30% of total sample number required for cleanup conf
Environmental Consultant									
Project Management	1	hours	@	$140	/hour	$123			2 hours per work day
Monitoring and Sampling (1 person)	0.4	days	@	$900	/day	$396			Same hours as backhoe crew
Per Diem (1) and Vehicle	0.4	days	@	$240	/day	$106			Assumes shared between sites
Change Out Engineer/Geologist/Env. Scientist (1)	0.0	ea	@	$1,500	ea	$31			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$1,665			included in Tables 6.0-2 and 6.0-3

TABLE C.7 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 7 - PASSIVE BIOVENTING

Alternative 7 - Passive Bioventing

	2,000 Cubic Yards									
									COSTS	
Future Capital Costs (One Time at End of Treatment)									**$93,721**	
Confirmation of Cleanup								$61,628		
Confirmation Borings										
Tubex Drill Rig (100 feet/day)	1.1	days	@	$4,500	/day	$4,950				10 borings to 11 feet deep
Per Diem (3)	1.1	days	@	$420	/day	$462				
Change Out Driller (1), Helper (1) and Laborer	0.1	ea	@	$4,500	ea	$236				Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis										1 sample per 200 cubic yards to 2,000 cy and then 1 sample per 500
Confirmation Samples (GRO, DRO, VOCs, SVOCs)	12.0	samples	@	$435	each	$5,220				cubic yards plus 20% QC; Minimum 4 samples
Environmental Consultant										
Project Management	2.2	hours	@	$140	/hour	$308				2 hours per work day
Monitoring and Sampling (2 person)	1.1	days	@	$1,800	/day	$1,980				Same hours as drill crew
Per Diem (2) and Vehicle	1.1	days	@	$380	/day	$418				
Change Out Engineer/Geologist/Env. Scientist (2)	0.1	ea	@	$300	ea	$16				Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	400	hours	@	$100	/hour	$40,000				Assumes work plan effort shared with multiple sites and stand alone
Contingency (15%)						$8,038				cleanup report combined with decom report for each site
Decommissioning Efforts								$32,093		
Well Decommissioning										
Remove Chain-Link Fence (150 feet/day)	2.0	days	@	$1,750	/day	$3,500				580 Backhoe with Operator and 2 Laborers
Tubex Drill Rig (100 feet/day)	3.1	days	@	$4,500	/day	$13,860				28 wells to 11 feet
Per Diem (3)	3.1	days	@	$420	/day	$1,294				
Change Out Driller (1), Helper (1) and Laborer	0.1	ea	@	$4,500	ea	$660				Change out crew every 21 days (assumes work at multiple sites)
Environmental Consultant										
Project Management	6.2	hours	@	$140	/hour	$862				2 hours per work day
Decommissioning Monitoring	3.1	days	@	$900	/day	$2,772				Same hours as drill crew
Per Diem (1) and Vehicle	3.1	days	@	$240	/day	$739				
Change Out Engineer/Geologist/Env. Scientist (1)	0.1	ea	@	$1,500	ea	$220				Change out crew every 21 days (assumes work at multiple sites)
Reporting	40.0	hours	@	$100	/hour	$4,000				Assumes work plan effort shared with multiple sites and stand alone
Contingency (15%)						$4,186				cleanup report combined with decom report for each site
							Alternative 7 - Passive Bioventing (2k CY) Total:		**$356,908**	

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER CY*
Mobilization/Demobilization Costs	1	$46,805	$46,805	0.935	$43,743	-
Mobilization/Demobilization Costs	1	$46,805	$46,805	0.935	$43,743	-
Mobilization/Demobilization Costs	5	$46,805	$46,805	0.713	$33,371	-
Mobilization/Demobilization Costs	10	$46,805	$46,805	0.508	$23,793	-
Mobilization/Demobilization Costs	15	$46,805	$46,805	0.362	$16,964	-
Mobilization/Demobilization Costs	20	$46,805	$46,805	0.258	$12,095	-
Capital Cost	1	$203,617	$203,617	0.935	$190,296	$95
O&M Cost	1	$0	$0	0.935	$0	$0
Future Capital Costs (Every 5 Years)	5	$12,765	$12,765	0.713	$9,101	$5
Future Capital Costs (Every 5 Years)	10	$12,765	$12,765	0.508	$6,489	$3
Future Capital Costs (Every 5 Years)	15	$12,765	$12,765	0.362	$4,627	$2
Future Capital Cost (one time)	20	$12,765	$12,765	0.258	$3,299	$2
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)					**$213,812**	$107

* Average cost per cubic yard is for treating a site having an estimated volume of 2000 cubic yards of impacted soil.

TABLE C.7 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 7 - PASSIVE BIOVENTING

Alternative 7 - Passive Bioventing

	20 Cubic Yards								
								COSTS	
Mobilization/Demobilization Costs								**$4,255**	
Equipment and Personnel Mobilization/Demobilization Effort							$4,255		Assumes mobilization/demobilization efforts for Year 1 (treatability
Biovent Manifold, Equipment and Personnel									study), Year 1 (system installation), Year 5 (screening for cleanup),
Excavator/Backhoe - Local	1.0	lump sum	@	$500	ea	$500			Year 10 (screening for cleanup), Year 15 (screening for cleanup),
Operator (1) & Laborers (1) - Local	1.0	ea	@	$200	ea	$200			and Year 20 (confirmation of cleanup) for this technology for 20 cy -
Environmental Consultant									Present Value Analysis Table shows costs
Engineer/Geologist/Env. Scientist (2)	1.0	ea	@	$3,000	ea	$3,000			
Contingency (15%)						$555			
Capital Costs								**$33,674**	
(Assumes 20 cubic yards of impacted soil extending from a depth of 2 feet to 4 feet over 235 square foot area)									
Passive Biovent Treatability Study							$33,674		
(Assumes install 30 feet of horizontal passive vent piping to depth of 3 feet)									
Passive Biovent Manifold and Personnel									
Excavator/Backhoe - Local (150 feet/day)	0.2	days	@	$1,750	/day	$350			2 horizontal lines 15 feet long each = 30 feet
Manifold Piping Materials (SS) and Shipping	30.0	lin ft	@	$55.00	/ft	$1,650			2 @ 15 feet each
Chain-Link Fence for Treatment Area	36.0	lin ft	@	$132	/lf	$4,752			75 sf footprint
Laboratory Analytical Sample Analysis									
N:P:K, Het/Oil Bacteria, Grainsize	3.0	samples	@	$200	each	$600			
GRO, DRO, VOCs, SVOCs	3.0	samples	@	$435	each	$1,305			
Environmental Consultant									
Project Management	0.4	hours	@	$140	/hour	$56			2 hours per work day
Monitoring and Sampling (2 person)	3.0	days	@	$1,800	/day	$5,400			0.5 day to monitor test pits, 0.5 day to set up, and 2 days to conduct treatability test
Passive Biovent Equipment	1.0	ea	@	$5,000	ea	$5,000			Flow, pressure, carbon dioxide, and oxygen meters, and data loggers
Miscellaneous Equipment	3.0	days	@	$200	/day	$600			
Per Diem (2) and Vehicle	3.0	days	@	$380	/day	$1,140			Assumes shared between multiple sites
Change Out Engineer/Geologist/Env. Scientist (2)	0.1	ea	@	$3,000	ea	$429			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$4,392			included in Tables 6.0-2 and 6.0-3
Passive Bioventing System Installation Effort							$0		
(Assumes lines installed under pilot test are sufficient for treatment of 20 cy impacted soil)									
O&M Costs								**$0**	
Future Capital Costs (Year 5)								**$10,342**	
Screening for Cleanup							$10,342		
Test Pits									
Backhoe & Operator - Local (100 feet/day)	0.04	days	@	$1,600	/day	$64			1 Test Pit per event to 4 feet - assumes multiple sites
Laboratory Analytical Sample Analysis									
Screening Samples (GRO, DRO, VOCs, SVOCs)	2.0	samples	@	$435	each	$870			Assumes 30% of total sample number required for cleanup
Environmental Consultant									confirmation (minimum of 2 samples)
Project Management	0.1	hours	@	$134	/hour	$11			2 hours per work day
Monitoring and Sampling (1 person)	0.04	days	@	$900	/day	$36			Same hours as backhoe crew
Per Diem (1) and Vehicle	0.04	days	@	$240	/day	$10			Assumes shared between sites
Change Out Engineer/Geologist/Env. Scientist (1)	0.002	ea	@	$1,500	ea	$3			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80	hours	@	$100	/hour	$8,000			Change out crew every 21 days (assumes work at multiple sites)
Contingency (15%)						$1,349			included in Tables 6.0-2 and 6.0-3
Future Capital Costs (One Time at End of Treatment)								**$17,609**	
Confirmation of Cleanup							$13,639		
Confirmation Borings									
Backhoe & Operator - Local (100 feet/day)	0.1	days	@	$1,600	/day	$192			3 Test Pits per event to 4 feet
Per Diem (3)	0.1	days	@	$420	/day	$50			
Laboratory Analytical Sample Analysis									1 sample per 200 cubic yards to 2,000 cy and then 1 sample per 500
Confirmation Samples (GRO, DRO, VOCs, SVOCs)	3.0	samples	@	$435	each	$1,305			cubic yards plus 20% QC; Minimum 3 samples
Environmental Consultant									
Project Management	0.2	hours	@	$140	/hour	$34			2 hours per work day
Monitoring and Sampling (2 person)	0.1	days	@	$1,800	/day	$216			Same hours as drill crew
Per Diem (2) and Vehicle	0.1	days	@	$380	/day	$46			
Change Out Engineer/Geologist/Env. Scientist (2)	0.01	ea	@	$3,000	ea	$17			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	100	hours	@	$100	/hour	$10,000			Assumes work plan effort shared with multiple sites and stand alone
Contingency (15%)						$1,779			cleanup report combined with decom report for each site
Decommissioning Efforts							$3,970		
Passive Bioventing Lines									
Remove Chain-Link Fence (150 feet/day)	0.2	days	@	$1,750	/day	$420			580 Backhoe with Operator and 2 Laborers
Backhoe & Operator - Local (100 feet/day)	0.3	days	@	$1,600	/day	$480			30 feet of horizontal piping
Per Diem (3)	0.3	days	@	$420	/day	$126			
Environmental Consultant									
Project Management	0.6	hours	@	$140	/hour	$84			2 hours per work day
Decommissioning Monitoring	0.3	days	@	$900	/day	$270			Same hours as drill crew
Per Diem (1) and Vehicle	0.3	days	@	$240	/day	$72			
Reporting	20	hours	@	$100	/hour	$2,000			Assumes decommissioning portion included in stand alone cleanup
Contingency (15%)						$518			report
							Alternative 7 - Passive Bioventing (20 CY) Total:	**$65,879**	

TABLE C.7 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 7 - PASSIVE BIOVENTING

Alternative 7 - Passive Bioventing

20 Cubic Yards

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST		TOTAL COST PER YEAR		DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER CY*
Mobilization/Demobilization Costs	1	$4,255		$4,255		0.935	$3,977	-
Mobilization/Demobilization Costs	1	$4,255		$4,255		0.935	$3,977	-
Mobilization/Demobilization Costs	5	$4,255		$4,255		0.713	$3,034	-
Mobilization/Demobilization Costs	10	$4,255		$4,255		0.508	$2,163	-
Mobilization/Demobilization Costs	15	$4,255		$4,255		0.362	$1,542	-
Mobilization/Demobilization Costs	20	$4,255		$4,255		0.258	$1,100	-
Capital Cost	1	$33,674		$33,674		0.935	$31,471	$1,574
O&M Cost	1	$0		$0		0.935	$0	$0
Future Capital Costs (Every 5 Years)	5	$10,342		$10,342		0.713	$7,374	$369
Future Capital Costs (Every 5 Years)	10	$10,342		$10,342		0.508	$5,257	$263
Future Capital Costs (Every 5 Years)	15	$10,342		$10,342		0.362	$3,748	$187
Future Capital Cost (one time)	20	$17,609		$17,609		0.258	$4,550	$228
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)							**$52,401**	$2,620

* Average cost per cubic yard is for treating a site having an estimated volume of 20 cubic yards of impacted soil.

TABLE C.7 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 7 - PASSIVE BIOVENTING

Alternative 7 - Passive Bioventing

Item	Qty	Unit		Rate	Per	Amount	Subtotal	COSTS	Notes
	20,000 Cubic Yards								
Mobilization/Demobilization Costs								**$46,805**	
Equipment and Personnel Mobilization/Demobilization Effort							$46,805		Assumes mobilization/demobilization efforts for Year 1 (treatability study), Year 1 (system installation), Year 5 (screening for cleanup), Year 10 (screening for cleanup), Year 15 (screening for cleanup), and Year 20 (confirmation of cleanup) for this technology for 20,000 cy - Present Value Analysis Table shows costs
Passive Biovent Well Equipment and Personnel									
Tubex Drill Rig Mob/Demob	1.0	lump sum	@	$32,500	ea	$32,500			
Driller (1), Helper (1) and Laborer	1.0	ea	@	$4,500	ea	$4,500			
Passive Biovent Manifold, Equipment and Personnel									
Excavator/Backhoe - Local	1.0	lump sum	@	$500	ea	$500			
Operator (1) & Laborers (1) - Local	1.0	ea	@	$200	ea	$200			
Environmental Consultant									
Engineer/Geologist/Env. Scientist (2)	1.0	ea	@	$3,000	ea	$3,000			
Contingency (15%)						$6,105			
Capital Costs								**$713,697**	
(Assumes 20,000 cubic yards of impacted soil extending to depth of 45 feet over 12,000 square foot area)									
Passive Biovent Treatability Study							$68,605		
(Assumes 1 vent well and 3 monitoring points to 11 feet each)									
Well Installation									
Tubex Drill Rig (50 ft well/day)	3.6	days	@	$4,500	/day	$16,200			1 vent well and 3 monitoring points to 45 feet each
Well Piping Materials and Shipping	188	lin ft	@	$25	/lf	$4,700			4 @ 45 feet each plus 2 feet stickup
One-Way Passive Valves (2-inch)	1.0	ea	@	$163	ea	$163			1 vent well
Per Diem (3)	3.6	days	@	$420	/day	$1,512			Assumes shared with multiple sites
Change Out Driller (1), Helper (1) and Laborer	0.17	ea	@	$4,500	ea	$771			Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis									
N:P:K, Het/Oil Bacteria, Grainsize	4.0	samples	@	$200	each	$800			One sample per boring
VOCs Vapors with GORE Modules	4.0	samples	@	$250	each	$1,000			One sample per boring
GRO, DRO, VOCs, SVOCs	4.0	samples	@	$435	each	$1,740			One sample per boring
Environmental Consultant									
Project Management	14.0	hours	@	$140	/hour	$1,960			2 hours per work day
Monitoring and Sampling (2 person)	7.0	days	@	$1,800	/day	$12,600			4 days to monitor drilling, 1 day to set up, and 2 days to conduct treatability test
Passive Biovent Equipment	1.0	ea	@	$5,000	ea	$5,000			Flow, pressure, carbon dioxide, and oxygen meters, and data loggers
Miscellaneous Equipment	7.0	days	@	$200	/day	$1,400			
Per Diem (2) and Vehicle	7.0	days	@	$380	/day	$2,660			Assumes shared between sites
Travel to Site (1 person)	0.10	ea	@	$1,500	ea	$150			Assumes travel shared between 10 other sites.
Change Out Engineer/Geologist/Env. Scientist (2)	0.3	ea	@	$3,000	ea	$1,000			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$8,948			included in Tables 6.0-2 and 6.0-3
Passive Bioventing System Installation Effort							$645,092		
(Assumes 20,000 cubic yards of impacted soil extending to depth of 45 feet over 12,000 square foot area)									Need 49 vent wells and 1 was installed during treatability test.
Well Installation									
Tubex Drill Rig (50 ft well/day)	43.2	days	@	$4,500	/day	$194,400			48 vent wells to 45 feet bgs
Well Piping Materials and Shipping (2-inch)	2256.0	lin ft	@	$25	/lf	$56,400			48 vent wells at 47 feet
One-Way Passive Valves (2-inch)	48	ea	@	$163	ea	$7,824			48 vent wells
Per Diem (3)	43.2	days	@	$420	/day	$18,144			
Change Out Driller (1), Helper (1) and Laborer	2.1	ea	@	$4,500	ea	$9,257			Change out crew every 21 days (assumes work at multiple sites)
Equipment Installation									
Clearing and Grubbing (10,000 square feet/day)	1.20	days	@	$5,000	/day	$6,000			Remove vegetation from 12,000 square feet site
Chain-Link Fence for Treatment Area	440.0	lin ft	@	$132	/lf	$58,080			110 feet x 110 feet site
Per Diem (3) and Vehicle (1)	2.9	days	@	$520	/day	$1,525			
Change Out Operator (1) & Laborers (1) - Local	0.1	ea	@	$100	ea	$14			Change out crew every 21 days (assumes work at multiple sites)
Environmental Consultant									
Project Management	92.3	hours	@	$140	/hour	$12,917			2 hours per work day
Monitoring and Sampling (2 person)	46.1	days	@	$1,800	/day	$83,040			Same hours as drill and fence crew
Miscellaneous Equipment	46.1	days	@	$200	/day	$9,227			
Per Diem (2) and Vehicle	46.1	days	@	$380	/day	$17,531			
Change Out Engineer/Geologist/Env. Scientist (2)	2.2	ea	@	$3,000	ea	$6,590			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	800	hours	@	$100	/hour	$80,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$84,142			included in Tables 6.0-2 and 6.0-3
O&M Costs								**$0**	
Future Capital Costs (Every 5 Years)								**$41,066**	
Screening for Cleanup							$41,066		
Screening Borings									
Tubex Drill Rig (100 feet/day)	4.1	days	@	$1,600	/day	$6,480			9 borings per event to 45 feet, 2 samples per boring
Per Diem (3)	4.1	days	@	$420	/day	$1,701			
Driller (1), Helper (1) and Laborer	1	ea	@	$4,500	ea	$4,500			
Change Out Driller (1), Helper (1) and Laborer	0.2	ea	@	$4,500	ea	$868			Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis									
Screening Samples (GRO, DRO, VOCs, SVOCs)	18.7	samples	@	$435	each	$8,120			Assumes 30% of total sample number required for cleanup conf
Environmental Consultant									
Project Management	8.1	hours	@	$140	/hour	$1,134			2 hours per work day
Monitoring and Sampling (1 person)	4.1	days	@	$900	/day	$3,645			Same hours as drill crew
Per Diem (1) and Vehicle	4.1	days	@	$240	/day	$972			
Change Out Engineer/Geologist/Env. Scientist (1)	0.2	ea	@	$1,500	ea	$289			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$5,356			included in Tables 6.0-2 and 6.0-3

TABLE C.7 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 7 - PASSIVE BIOVENTING

Alternative 7 - Passive Bioventing

	20,000 Cubic Yards									
									COSTS	
Future Capital Costs (One Time at End of Treatment)									**$414,797**	Assume 20 years to achieve cleanup criteria
Confirmation of Cleanup								$231,725		
Confirmation Borings										
Tubex Drill Rig (100 feet/day)	12.6	days	@	$4,500	/day	$56,700				28 borings to 45 feet deep 2 samples per boring
Per Diem (3)	12.6	days	@	$420	/day	$5,292				
Change Out Driller (1), Helper (1) and Laborer	0.6	ea	@	$4,500	ea	$2,700				Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis										1 sample per 200 cubic yards to 2,000 cy and then 1 sample per 500
Confirmation Samples (GRO, DRO, VOCs, SVOCs)	55.2	samples	@	$435	each	$24,012				cubic yards plus 20% QC; Minimum 4 samples
Environmental Consultant										
Project Management	25.2	hours	@	$140	/hour	$3,528				2 hours per work day
Monitoring and Sampling (2 person)	12.6	days	@	$1,800	/day	$22,680				Same hours as drill crew
Per Diem (2) and Vehicle	12.6	days	@	$380	/day	$4,788				
Change Out Engineer/Geologist/Env. Scientist (2)	0.6	ea	@	$3,000	ea	$1,800				Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	800	hours	@	$100	/hour	$80,000				Assumes work plan effort shared with multiple sites and stand alone
Contingency (15%)						$30,225				cleanup report combined with decom report for each site
Decommissioning Efforts								$183,072		
Well Decommissioning										
Remove Chain-Link Fence (150 feet/day)	2.9	days	@	$1,750	/day	$5,133				
Tubex Drill Rig (100 feet/day)	23.0	days	@	$4,500	/day	$103,275				51 wells to 45 ft
Per Diem (3)	23.0	days	@	$420	/day	$9,639				
Change Out Driller (1), Helper (1) and Laborer	1.1	ea	@	$4,500	ea	$4,918				Change out crew every 21 days (assumes work at multiple sites)
Environmental Consultant										
Project Management	45.9	hours	@	$140	/hour	$6,426				2 hours per work day
Decommissioning Monitoring	23.0	days	@	$900	/day	$20,655				Same hours as drill crew
Per Diem (1) and Vehicle	23.0	days	@	$240	/day	$5,508				
Change Out Engineer/Geologist/Env. Scientist (1)	1.1	ea	@	$1,500	ea	$1,639				Change out crew every 21 days (assumes work at multiple sites)
Reporting	20.0	hours	@	$100	/hour	$2,000				Assumes work plan effort shared with multiple sites and stand alone
Contingency (15%)						$23,879				cleanup report combined with decom report for each site

Alternative 7 - Passive Bioventing (20k CY) Total: $1,216,365

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST		TOTAL COST PER YEAR		DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER CY*
Mobilization/Demobilization Costs	1	$46,805		$46,805		0.935	$43,743	-
Mobilization/Demobilization Costs	1	$46,805		$46,805		0.935	$43,743	-
Mobilization/Demobilization Costs	5	$46,805		$46,805		0.713	$33,371	-
Mobilization/Demobilization Costs	10	$46,805		$46,805		0.508	$23,793	-
Mobilization/Demobilization Costs	15	$46,805		$46,805		0.362	$16,964	-
Mobilization/Demobilization Costs	20	$46,805		$46,805		0.258	$12,095	-
Capital Cost	1	$713,697		$713,697		0.935	$667,006	$33
O&M Cost	1	$0		$0		0.935	$0	$0
Future Capital Costs (Every 5 Years)	5	$41,066		$41,066		0.713	$29,279	$1
Future Capital Costs (Every 5 Years)	10	$41,066		$41,066		0.508	$20,876	$1
Future Capital Costs (Every 5 Years)	15	$41,066		$41,066		0.362	$14,884	$1
Future Capital Cost (one time)	20	$414,797		$414,797		0.258	$107,192	$5
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)							**$925,461**	$42

* Average cost per cubic yard is for treating a site having an estimated volume of 20,000 cubic yards of impacted soil.

TABLE C.7 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 7 - PASSIVE BIOVENTING

Alternative 7 - Passive Bioventing

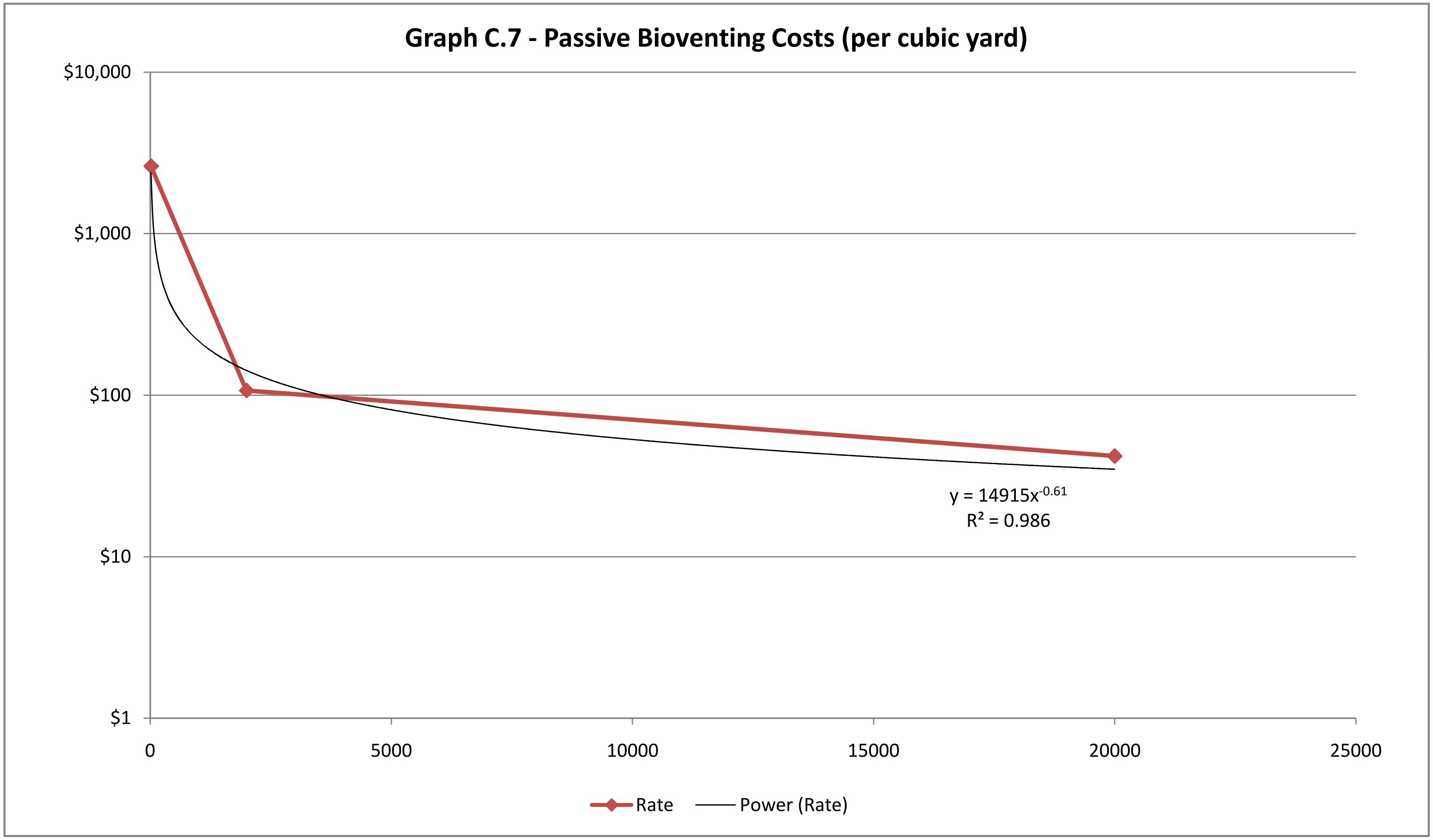


TABLE C.8 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 8 - BIOPILES

Alternative 8 - Biopiles

Item	Quantity	Unit		Unit Cost	Per	Amount	Subtotal	COSTS	Notes
	2,000 Cubic Yards								
Mobilization/Demobilization Costs								**$5,520**	
Equipment and Personnel Mobilization/Demobilization Effort							$5,520		
Excavation Equipment and Personnel									Assumes mobilization/demobilization efforts for Year 1 (treatability study), Year 1 (excavation and biopile construction), Year 5 (screening for cleanup), Year 5 (confirmation of cleanup and decommission biopile) for this technology for 2,000 cy - Present Value Analysis Table shows costs
Excavator/Backhoe - Local	1.0	lump sum	@	$500	ea	$500			
End Dump - Local	1.0	lump sum	@	$500	ea	$500			
Loader - Local	1.0	lump sum	@	$500	ea	$500			
Operator (2) & Laborers (1) - Local	1.0	lump sum	@	$300	ea	$300			
Environmental Consultant									
Engineer/Geologist/Env. Scientist (2)	1.0	ea	@	$3,000	ea	$3,000			
Contingency (15%)						$720			
Capital Costs								**$615,842**	
(Assumes 2,000 cubic yards of impacted soil extending to depth of 11 feet over 5,000 square foot area)									
Biovent Treatability Study							$15,146		
(Assumes install 15 feet of horizontal injection piping to depth of 3 feet to measure radius of influence for air injection.)									
Biovent Manifold, Equipment and Personnel									
Excavator/Backhoe - Local (150 feet/day)	0.1	days	@	$1,750	/day	$175			1 horizontal line 15 feet long
Manifold Piping Materials and Shipping	15.0	lin ft	@	$25.00	/ft	$375			1 @ 15 feet each
Laboratory Analytical Sample Analysis									
N:P:K, Het/Oil Bacteria, Grainsize	2.0	samples	@	$200	each	$400			Assumes 2 samples collected along trench during horizontal pipe installation
GRO, DRO, VOCs, SVOCs	2.0	samples	@	$435	each	$870			
Environmental Consultant									
Project Management	0.2	hours	@	$140	/hour	$28			2 hours per work day
Monitoring and Sampling (2 person)	1.0	days	@	$1,800	/day	$1,800			1 day to monitor installation, set up, and to conduct treatability test
Blower Test Equipment	1.0	days	@	$500	/day	$500			Assumes 1 portable system for treatability studies at multiple sites
Miscellaneous Equipment	1.0	days	@	$500	/day	$500			Flow, pressure, carbon dioxide, and oxygen meters, and data logge
Per Diem (2) and Vehicle	1.0	days	@	$380	/day	$380			Assumes shared between multiple sites
Change Out Engineer/Geologist/Env. Scientist (2)	0.0	ea	@	$3,000	ea	$143			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites included in Tables 6.0-2 and 6.0-3
Contingency (15%)						$1,976			
Excavation Effort							$219,691		
(Assumes 2,000 cubic yards of impacted soil extending to depth of 11 feet over 5,000 square foot area with 250 cubic yards of clean overburden)									
Excavation Equipment and Personnel									
Clearing and Grubbing (10,000 square feet/day)	0.5	days	@	$5,000	/day	$2,500			Remove vegetation from 5,000 square feet site
Excavate and Stockpile Non-Impacted Material	250.0	cy	@	$18	/cy	$4,500			
Excavate and Stockpile Impacted Material	2000.0	cy	@	$18	/cy	$36,000			
Backfill Excavation with Non-Impacted Material	250.0	cy	@	$10	/cy	$2,500			
Liners and Covers	46575	sq ft	@	$0.26	/sf	$12,110			Stockpiled soil is mounded, after 15% bulking factor, about 3 feet high on liner and covered
Chain-Link Fence Around Excavation Area	300.0	lin ft	@	$132	/lf	$39,600			75 feet x 75 feet site 5,000 sf site
Per Diem (3) and Vehicle	5.6	days	@	$520	/day	$2,925			
Change Out Operator (2) & Laborers (1)	0.3	ea	@	$4,500	ea	$1,205			Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis									
Confirmation Samples (GRO, DRO, VOCs, SVOCs)	78.0	samples	@	$435	each	$33,930			1 sample per 250 square feet of excavation plus 1 sample per 50 cubic yards excavated soil plus 20% QC
Environmental Consultant									
Project Management	11.3	hours	@	$140	/hour	$1,575			2 hours per work day
Monitoring and Sampling (2 person)	5.6	days	@	$1,800	/day	$10,125			Same hours as excavation crew
Miscellaneous Equipment	5.6	days	@	$200	/day	$1,125			
Per Diem (2) and Vehicle	5.6	days	@	$380	/day	$2,138			
Change Out Engineer/Geologist/Env. Scientist (2)	0.3	ea	@	$3,000	ea	$804			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	400	hours	@	$100	/hour	$40,000			Assumes work plan effort shared with multiple sites and stand alone cleanup report for each site
Contingency (15%)						$28,655			
Biopile Installation Efforts							$381,005		
Biopiles									
Clearing and Grubbing (10,000 square feet/day)	0.9	days	@	$5,000	/day	$4,314			Remove vegetation from 5,000 square feet site per 1333 cy
Chain-Link Fence for Treatment Area	517.6	lin ft	@	$132	/lf	$68,327			100 feet x 50 feet site per 1333 cy
Transport Impacted Material to Biopile	2300	cy	@	$10	/cy	$23,000			Includes bulking factor of 15%
Liners and Covers	17254	sq ft	@	$0.50	/sf	$8,627			Two 50 feet by 100 feet liners/covers for 1333 cy
Construct Biopiles at Site	2300	cy	@	$35	/cy	$80,500			Includes bulking factor of 15%
Manifold Piping Materials and Shipping	949	lin ft	@	$25	/lf	$23,725			1 vent line every 10 feet = 550 feet per 1333 cy Biopile
Blower/Shed/Meters etc.	1.7	site	@	$25,000	/site	$43,136			1 Blower/Shed/Meters etc. per 1333 cy biopile
Per Diem (3) and Vehicle (1)	17.8	days	@	$520	/day	$9,271			Assume 400 cy per day (place liners, berms, pipe, and backfill) and 1 week for blower/shed setup per 1333 cy
Change Out Operator (2) & Laborers (1)	0.8	ea	@	$4,500	ea	$3,820			Change out crew every 21 days (assumes work at multiple sites)
Environmental Consultant									
Project Management	35.7	hours	@	$140	/hour	$4,992			2 hours per work day
Monitoring and Sampling (1 person)	17.8	days	@	$900	/day	$16,045			Same hours as installation crew
Per Diem (1) and Vehicle	17.8	days	@	$240	/day	$4,279			
Change Out Engineer/Geologist/Env. Scientist (1)	0.8	ea	@	$1,500	ea	$1,273			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	400	hours	@	$100	/hour	$40,000			Assumes part of larger work plan and report effort for all sites included in Tables 6.0-2 and 6.0-3
Contingency (15%)						$49,696			
O&M Costs								**$49,941**	
Biopile Treatment Efforts							$49,941		
Biopile									
Treatment System Maintenance Labor (12 Months)	20.7	days	@	$800	/day	$16,564			Assumes 2 events per month, 0.5 day per event per 1333 cy biopile
Treatment Electricity (12 months @ 1 hp per 1333 cy)	2.98	hp-months	@	$538	/hp-mo	$1,606			Assumes pulse operation for 2 (12 hour) days per week or 52 days = 1.73 mo; 1 hp blower per 1333 cy biopile
Rental Property for Treatment Area	12.0	mos	@	$86.27	/mo	$1,035			$0.01 per square foot per month; 5,000 sq feet per 1333 cy
Laboratory Analytical Sample Analysis									
N:P:K, Het/Oil Bacteria	1.7	samples	@	$150	each	$259			Assumes 1 sample of leachate per event per 1333 cy biopile
Environmental Consultant									
Project Management	41.4	hours	@	$140	/hour	$5,797			2 hours per work day
Treatment Monitoring and Sampling (1 person)	6.0	days	@	$900	/day	$5,400			Assumes 1 event per month, 0.5 day per event
Per Diem (1) and Vehicle	12.0	days	@	$240	/day	$2,880			Assumes shared between sites
Travel to Site (1 person)	1.2	ea	@	$1,500	ea	$1,800			Assumes travel shared between 10 other sites.
Change Out Engineer/Geologist/Env. Scientist (1)	0.1	ea	@	$1,500	ea	$86			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites included in Tables 6.0-2 and 6.0-3
Contingency (15%)						$6,514			

TABLE C.8 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 8 - BIOPILES

Alternative 8 - Biopiles

	2,000 Cubic Yards							COSTS	
Future Capital Costs (Every 5 Years)								**$12,589**	
Screening for Cleanup							$12,589		
Test Pits									
Backhoe & Operator - Local (100 feet/day)	0.4	days	@	$1,600	/day	$634			4 Test Pits per event to 10 feet per 2000 cy
Laboratory Analytical Sample Analysis									
Screening Samples (GRO, DRO, VOCs, SVOCs)	4.0	samples	@	$435	each	$1,723			Assumes 33% of total sample number required for cleanup conf
Environmental Consultant									
Project Management	0.8	hours	@	$140	/hour	$111			2 hours per work day
Monitoring and Sampling (1 person)	0.4	days	@	$900	/day	$356			Same hours as backhoe crew
Per Diem (1) and Vehicle	0.4	days	@	$240	/day	$95			Assumes shared between sites
Change Out Engineer/Geologist/Env. Scientist (1)	0.02	ea	@	$1,500	ea	$28			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$1,642			included in Tables 6.0-2 and 6.0-3
Future Capital Costs (One Time at End of Treatment)								**$143,509**	
Confirmation of Cleanup							$60,322		
Confirmation Test Pits									
Backhoe & Operator - Local (100 feet/day)	1.0	days	@	$4,500	/day	$4,500			10 test pits to 10 feet deep
Laboratory Analytical Sample Analysis									1 sample per 200 cubic yards to 2,000 cy and then 1 sample per
Confirmation Samples (GRO, DRO, VOCs, SVOCs)	12.0	samples	@	$435	each	$5,220			500 cubic yards plus 20% QC; Minimum 4 samples
Environmental Consultant									
Project Management	2.0	hours	@	$134	/hour	$268			2 hours per work day
Monitoring and Sampling (2 person)	1.0	days	@	$1,800	/day	$1,800			Same hours as drill crew
Per Diem (2) and Vehicle	1.0	days	@	$380	/day	$380			
Change Out Engineer/Geologist/Env. Scientist (2)	0.1	ea	@	$3,000	ea	$286			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	400	hours	@	$100	/hour	$40,000			Assumes work plan effort shared with multiple sites and stand
Contingency (15%)						$7,868			alone cleanup report combined with decom report for each site
Decommissioning Efforts							$83,187		
Biopile Decommissioning									
Transport Clean Material to Excavation Site	2300	cy	@	$10	/cy	$23,000			
Backfill Excavation with Treated Material	2300	cy	@	$10	/cy	$23,000			
Remove Fence - Excavation Area (150 feet/day)	2.0	days	@	$1,750	/day	$3,500			580 Backhoe with Operator and 2 Laborers
Remove Fence - Treatment Area (150 feet/day)	3.5	days	@	$1,750	/day	$6,039			580 Backhoe with Operator and 2 Laborers
Per Diem (3) and Vehicle (1)	5.8	days	@	$520	/day	$2,990			
Change Out Operator (2) & Laborers (1)	0.3	ea	@	$4,500	ea	$1,232			Change out crew every 21 days (assumes work at multiple sites)
Environmental Consultant									
Project Management	11.5	hours	@	$140	/hour	$1,610			2 hours per work day
Decommissioning Monitoring	5.8	days	@	$900	/day	$5,175			Same hours as decommissioning crew
Per Diem (1) and Vehicle	5.8	days	@	$240	/day	$1,380			
Change Out Engineer/Geologist/Env. Scientist (1)	0.3	ea	@	$1,500	ea	$411			Change out crew every 21 days (assumes work at multiple sites)
Reporting	40	hours	@	$100	/hour	$4,000			Assumes decommissioning portion included in stand alone
Contingency (15%)						$10,851			cleanup report
							Alternative 8 - Biopiles Total:	**$827,402**	

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER CY*
Mobilization/Demobilization Costs	1	$5,520	$5,520	0.935	$5,159	-
Mobilization/Demobilization Costs	1	$5,520	$5,520	0.935	$5,159	-
Mobilization/Demobilization Costs	5	$5,520	$5,520	0.713	$3,936	-
Mobilization/Demobilization Costs	5	$5,520	$5,520	0.713	$3,936	-
Capital Cost	1	$615,842	$615,842	0.935	$575,554	$288
O&M Cost (Year 1)	1	$49,941	$49,941	0.935	$46,674	$23
O&M Cost (Year 2)	2	$49,941	$49,941	0.873	$43,621	$22
O&M Cost (Year 3)	3	$49,941	$49,941	0.816	$40,767	$20
O&M Cost (Year 4)	4	$49,941	$49,941	0.763	$38,100	$19
Future Capital Costs (Every 5 Years)	5	$12,589	$12,589	0.713	$8,976	$4
Future Capital Cost (one time)	5	$143,509	$143,509	0.713	$102,320	$51
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)					**$856,011**	$428

* Average cost per cubic yard is for treating a site having an estimated volume of 2000 cubic yards of impacted soil.

TABLE C.8 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 8 - BIOPILES

Alternative 8 - Biopiles

	20 Cubic Yards								
								COSTS	
Mobilization/Demobilization Costs								**$5,520**	
Equipment and Personnel Mobilization/Demobilization Effort							$5,520		
Excavation Equipment and Personnel									Assumes mobilization/demobilization efforts for Year 1 (treatability study), Year 1 (excavation and biopile construction), Year 5 (screening for cleanup), Year 5 (confirmation of cleanup and decommission biopile) for this technology for 20 cy - Present Value Analysis Table shows costs
Excavator/Backhoe - Local	1.0	lump sum	@	$500	ea	$500			
End Dump - Local	1.0	lump sum	@	$500	ea	$500			
Loader - Local	1.0	lump sum	@	$500	ea	$500			
Operator (2) & Laborers (1) - Local	1.0	lump sum	@	$300	ea	$300			
Environmental Consultant									
Engineer/Geologist/Env. Scientist (2)	1.0	ea	@	$3,000	ea	$3,000			
Contingency (15%)						$720			
Capital Costs								**$47,854**	
(Assumes 20 cubic yards of impacted soil extending to depth of 2 feet over 270 square foot area)									
Biovent Treatability Study							$15,146		
(Assumes install 15 feet of horizontal injection piping to depth of 3 feet to measure radius of influence for air injection.)									
Biovent Manifold, Equipment and Personnel									
Excavator/Backhoe - Local (150 feet/day)	0.1	days	@	$1,750	/day	$175			1 horizontal line 15 feet long
Manifold Piping Materials and Shipping	15.0	lin ft	@	$25.00	/ft	$375			1 @ 15 feet each
Laboratory Analytical Sample Analysis									
N:P:K, Het/Oil Bacteria, Grainsize	2.0	samples	@	$200	each	$400			Assumes 2 samples collected along trench during horizontal pipe installation
GRO, DRO, VOCs, SVOCs	2.0	samples	@	$435	each	$870			
Environmental Consultant									
Project Management	0.2	hours	@	$140	/hour	$28			2 hours per work day
Monitoring and Sampling (2 person)	1.0	days	@	$1,800	/day	$1,800			1 day to monitor installation, set up, and to conduct treatability test
Blower Test Equipment	1.0	days	@	$500	/day	$500			Assumes 1 portable system for treatability studies at multiple sites
Miscellaneous Equipment	1.0	days	@	$500	/day	$500			Flow, pressure, carbon dioxide, and oxygen meters, and data logge
Per Diem (2) and Vehicle	1.0	days	@	$380	/day	$380			Assumes shared between multiple sites
Change Out Engineer/Geologist/Env. Scientist (2)	0.0	ea	@	$3,000	ea	$143			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites included in Tables 6.0-2 and 6.0-3
Contingency (15%)						$1,976			
Excavation Effort							$17,857		
(Assumes 20 cubic yards of impacted soil extending to depth of 2 feet over 270 square foot area)									
Excavation Equipment and Personnel									
Clearing and Grubbing (10,000 square feet/day)	0.027	days	@	$5,000	/day	$135			Remove vegetation from 270 square feet site
Excavate and Stockpile Non-Impacted Material	0.0	cy	@	$18	/cy	$0			
Excavate and Stockpile Impacted Material	20.0	cy	@	$18	/cy	$360			
Backfill Excavation with Non-Impacted Material	0.0	cy	@	$10	/cy	$0			
Liners and Covers	414.0	sq ft	@	$0.26	/sf	$108			Stockpiled soil is mounded, after 15% bulking factor, about 3 feet high on liner and covered
Chain-Link Fence Around Excavation Area	16.2	lin ft	@	$132	/lf	$2,138			75 feet x 75 feet site for 5,000 sf site
Per Diem (3) and Vehicle	0.05	days	@	$520	/day	$26			
Change Out Operator (2) & Laborers (1)	0.002	ea	@	$4,500	ea	$11			Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis									
Confirmation Samples (GRO, DRO, VOCs, SVOCs)	6.0	samples	@	$435	each	$2,610			1 sample per 250 square feet of excavation plus 1 sample per 50 cubic yards excavated soil plus 20% QC; 3 samples minimum from excavation, 2 samples minimum from stockpile and 20% QC
Environmental Consultant									
Project Management	0.10	hours	@	$140	/hour	$14			2 hours per work day
Monitoring and Sampling (2 person)	0.05	days	@	$1,800	/day	$90			Same hours as excavation crew
Miscellaneous Equipment	0.05	days	@	$200	/day	$10			
Per Diem (2) and Vehicle	0.05	days	@	$380	/day	$19			
Change Out Engineer/Geologist/Env. Scientist (2)	0.002	ea	@	$3,000	ea	$7			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	100	hours	@	$100	/hour	$10,000			Assumes work plan effort shared with multiple sites and stand alone cleanup report for each site
Contingency (15%)						$2,329			
Biopile Installation Efforts							$14,850		
Biopiles									**Assumes soil from other sites used to construct large Biopile**
Clearing and Grubbing (10,000 square feet/day)	0.01	days	@	$5,000	/day	$43			Remove vegetation from 5,000 square feet site per 1333 cy
Chain-Link Fence for Treatment Area	5.2	lin ft	@	$132	/lf	$683			100 feet x 50 feet site per 1333 cy
Transport Impacted Material to Biopile	23.0	cy	@	$10	/cy	$230			Includes bulking factor of 15%
Liners and Covers	173	sq ft	@	$0.50	/sf	$86			Two 50 feet by 100 feet liners/covers for 1333 cy
Construct Biopiles at Site	23.0	cy	@	$35	/cy	$805			Includes bulking factor of 15%
Manifold Piping Materials and Shipping	9.5	lin ft	@	$25	/lf	$237			1 vent line every 10 feet = 550 feet per 1333 cy Biopile
Blower/Shed/Meters etc.	0.02	site	@	$25,000	/site	$431			1 Blower/Shed/Meters etc. per 1333 cy biopile
Per Diem (3) and Vehicle (1)	0.2	days	@	$520	/day	$93			Assume 400 cy per day (place liners, berms, pipe, and backfill) and 1 week for blower/shed setup per 1333 cy
Change Out Operator (2) & Laborers (1)	0.01	ea	@	$4,500	ea	$38			Change out crew every 21 days (assumes work at multiple sites)
Environmental Consultant									
Project Management	0.4	hours	@	$140	/hour	$50			2 hours per work day
Monitoring and Sampling (1 person)	0.2	days	@	$900	/day	$160			Same hours as installation crew
Per Diem (1) and Vehicle	0.2	days	@	$240	/day	$43			
Change Out Engineer/Geologist/Env. Scientist (1)	0.01	ea	@	$1,500	ea	$13			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	100	hours	@	$100	/hour	$10,000			Assumes part of larger work plan and report effort for all sites included in Tables 6.0-2 and 6.0-3
Contingency (15%)						$1,937			
O&M Costs								**$5,199**	
Biopile Treatment Efforts							$5,199		
Biopile									
Treatment System Maintenance Labor (12 Months)	0.2	days	@	$800	/day	$166			Assumes 2 events per month, 0.5 day per event per 1333 cy
Treatment Electricity (12 months @ 1 hp per 1333 cy)	0.03	hp-months	@	$538	/hp-mo	$16			Assumes pulse operation for 2 (12 hour) days per week or 52 days = 1.73 mo; 1 hp blower per 1333 cy biopile
Rental Property for Treatment Area	12.0	mos	@	$0.86	/mo	$10			$0.01 per square foot per month; 5,000 sq feet per 1333 cy
Laboratory Analytical Sample Analysis									
N:P:K, Het/Oil Bacteria	0.02	samples	@	$150	each	$3			Assumes 1 sample of leachate per event per 1333 cy biopile
Environmental Consultant									
Project Management	0.4	hours	@	$140	/hour	$58			2 hours per work day
Treatment Monitoring and Sampling (1 person)	0.2	days	@	$900	/day	$186			Assumes 1 event per month, 0.5 day per event
Per Diem (1) and Vehicle	0.2	days	@	$240	/day	$50			Assumes shared between sites
Travel to Site (1 person)	0.02	ea	@	$1,500	ea	$31			Assumes travel shared between 10 other sites.
Change Out Engineer/Geologist/Env. Scientist (1)	0.001	ea	@	$1,500	ea	$1			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	40	hours	@	$100	/hour	$4,000			Assumes part of larger work plan and report effort for all sites included in Tables 6.0-2 and 6.0-3
Contingency (15%)						$678			

TABLE C.8 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 8 - BIOPILES

Alternative 8 - Biopiles

									Notes
	20 Cubic Yards							**COSTS**	
Future Capital Costs (Every 5 Years)								**$4,639**	
Screening for Cleanup							$4,639		
Test Pits									
Backhoe & Operator - Local (100 feet/day)	0.005	days	@	$1,600	/day	$7			4 Test Pits per event to 10 feet per 2000 cy
Laboratory Analytical Sample Analysis									
Screening Samples (GRO, DRO, VOCs, SVOCs)	0.046	samples	@	$435	each	$20			Assumes 33% of total sample number required for cleanup conf
Environmental Consultant									
Project Management	0.01	hours	@	$140	/hour	$1			2 hours per work day
Monitoring and Sampling (1 person)	0.00	days	@	$900	/day	$4			Same hours as backhoe crew
Per Diem (1) and Vehicle	0.00	days	@	$240	/day	$1			Assumes shared between sites
Change Out Engineer/Geologist/Env. Scientist (1)	0.0002	ea	@	$1,500	ea	$0.3			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	40.0	hours	@	$100	/hour	$4,000			Assumes part of larger work plan and report effort for all sites included in Tables 6.0-2 and 6.0-3
Contingency (15%)						$605			
Future Capital Costs (One Time at End of Treatment)								**$14,945**	
Confirmation of Cleanup							$11,682		
Confirmation Test Pits									
Backhoe & Operator - Local (100 feet/day)	0.014	days	@	$4,500	/day	$62			10 test pits to 10 feet deep per 2000 cy
Laboratory Analytical Sample Analysis									
Confirmation Samples (GRO, DRO, VOCs, SVOCs)	0.14	samples	@	$435	each	$60			1 sample per 200 cubic yards to 2,000 cy and then 1 sample per 500 cubic yards plus 20% QC; Minimum 4 samples
Environmental Consultant									
Project Management	0.03	hours	@	$134	/hour	$4			2 hours per work day
Monitoring and Sampling (2 person)	0.01	days	@	$1,800	/day	$25			Same hours as drill crew
Per Diem (2) and Vehicle	0.01	days	@	$380	/day	$5			
Change Out Engineer/Geologist/Env. Scientist (2)	0.0007	ea	@	$3,000	ea	$2			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	100.0	hours	@	$100	/hour	$10,000			Assumes work plan effort shared with multiple sites and stand alone cleanup report combined with decom report for each site
Contingency (15%)						$1,524			
Decommissioning Efforts							$3,263		
Biopile Decommissioning									
Transport Clean Material to Excavation Site	23.0	cy	@	$10	/cy	$230			
Backfill Excavation with Treated Material	23.0	cy	@	$10	/cy	$230			
Remove Fence Excavation Area (150 feet/day)	0.11	days	@	$1,750	/day	$189			580 Backhoe with Operator and 2 Laborers
Remove Fence Treatment Area (150 feet/day)	0.03	days	@	$1,750	/day	$60			580 Backhoe with Operator and 2 Laborers
Per Diem (3) and Vehicle (1)	0.1	days	@	$520	/day	$30			
Change Out Operator (2) & Laborers (1)	0.0	ea	@	$4,500	ea	$12			Change out crew every 21 days (assumes work at multiple sites)
Environmental Consultant									
Project Management	0.1	hours	@	$140	/hour	$16			2 hours per work day
Decommissioning Monitoring	0.1	days	@	$900	/day	$52			Same hours as decommissioning crew
Per Diem (1) and Vehicle	0.1	days	@	$240	/day	$14			
Change Out Engineer/Geologist/Env. Scientist (1)	0.0	ea	@	$1,500	ea	$4			Change out crew every 21 days (assumes work at multiple sites)
Reporting	20.0	hours	@	$100	/hour	$2,000			Assumes decommissioning portion included in stand alone cleanup report
Contingency (15%)						$426			
							Alternative 8 - Biopiles Total:	**$78,156**	

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST		TOTAL COST PER YEAR		DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER CY*
Mobilization/Demobilization Costs	1	$5,520		$5,520		0.935	$5,159	-
Mobilization/Demobilization Costs	1	$5,520		$5,520		0.935	$5,159	-
Mobilization/Demobilization Costs	5	$5,520		$5,520		0.713	$3,936	-
Mobilization/Demobilization Costs	5	$5,520		$5,520		0.713	$3,936	-
Capital Cost	1	$47,854		$47,854		0.935	$44,723	$2,236
O&M Cost (Year 1)	1	$5,199		$5,199		0.935	$4,859	$243
O&M Cost (Year 2)	2	$5,199		$5,199		0.873	$4,541	$227
O&M Cost (Year 3)	3	$5,199		$5,199		0.816	$4,244	$212
O&M Cost (Year 4)	4	$5,199		$5,199		0.763	$3,967	$198
Future Capital Costs (Every 5 Years)	5	$4,639		$4,639		0.713	$3,308	$165
Future Capital Cost (one time)	5	$14,945		$14,945		0.713	$10,655	$533
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)							**$76,297**	$3,815

* Average cost per cubic yard is for treating a site having an estimated volume of 20 cubic yards of impacted soil.

TABLE C.8 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 8 - BIOPILES

Alternative 8 - Biopiles

Item	Qty	Unit	@	Rate	Per	Amount	Subtotal	COSTS	Notes
	20,000 Cubic Yards								
Mobilization/Demobilization Costs								**$5,520**	
Equipment and Personnel Mobilization/Demobilization Effort							$5,520		
Excavation Equipment and Personnel									Assumes mobilization/demobilization efforts for Year 1
Excavator/Backhoe - Local	1.0	lump sum	@	$500	ea	$500			(treatability study), Year 1 (excavation and biopile construction),
End Dump - Local	1.0	lump sum	@	$500	ea	$500			Year 5 (screening for cleanup), Year 10 (confirmation of
Loader - Local	1.0	lump sum	@	$500	ea	$500			cleanup), and Year 10 (decommission biopile) for this technology
Operator (2) & Laborers (1) - Local	1.0	lump sum	@	$300	ea	$300			for 2,000 cy - Present Value Analysis Table shows costs
Environmental Consultant									
Engineer/Geologist/Env. Scientist (2)	1.0	ea	@	$3,000	ea	$3,000			
Contingency (15%)						$720			
Capital Costs								**$4,862,012**	
(Assumes 2,000 cubic yards of impacted soil extending to depth of 11 feet over 5,000 square foot area)									
Biovent Treatability Study							$15,146		
(Assumes install 15 feet of horizontal injection piping to depth of 3 feet to measure radius of influence for air injection.)									
Biovent Manifold, Equipment and Personnel									
Excavator/Backhoe - Local (150 feet/day)	0.1	days	@	$1,750	/day	$175			1 horizontal line 15 feet long
Manifold Piping Materials and Shipping	15.0	lin ft	@	$25.00	/ft	$375			1 @ 15 feet each
Laboratory Analytical Sample Analysis									
N:P:K, Het/Oil Bacteria, Grainsize	2.0	samples	@	$200	each	$400			Assumes 2 samples collected along trench during horizontal pipe
GRO, DRO, VOCs, SVOCs	2.0	samples	@	$435	each	$870			installation
Environmental Consultant									
Project Management	0.2	hours	@	$140	/hour	$28			2 hours per work day
Monitoring and Sampling (2 person)	1.0	days	@	$1,800	/day	$1,800			1 day to monitor installation, set up, and to conduct treatability test
Blower Test Equipment	1.0	days	@	$500	/day	$500			Assumes 1 portable system for treatability studies at multiple sites
Miscellaneous Equipment	1.0	days	@	$500	/day	$500			Flow, pressure, carbon dioxide, and oxygen meters, and data logge
Per Diem (2) and Vehicle	1.0	days	@	$380	/day	$380			Assumes shared between multiple sites
Change Out Engineer/Geologist/Env. Scientist (2)	0.0	ea	@	$3,000	ea	$143			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$1,976			included in Tables 6.0-2 and 6.0-3
Excavation Effort							$1,404,819		
(Assumes 20,000 cubic yards of impacted soil extending to depth of 15 feet over 36,000 square foot area with 1800 cubic yards of clean overburden)									
Excavation Equipment and Personnel									
Clearing and Grubbing (10,000 square feet/day)	3.6	days	@	$5,000	/day	$18,000			Remove vegetation from 5,000 square feet site
Excavate and Stockpile Non-Impacted Material	1800	cy	@	$18	/cy	$32,400			
Excavate and Stockpile Impacted Material	20000	cy	@	$18	/cy	$360,000			
Backfill Excavation with Non-Impacted Material	1800	cy	@	$10	/cy	$18,000			
Liners and Covers	451260	sq ft	@	$0.26	/sf	$117,328			Stockpiled soil is mounded, after 15% bulking factor, about 3 feet high on liner and covered
Chain-Link Fence Around Excavation Area	760.0	lin ft	@	$132	/lf	$100,320			190 feet x 190 feet site for 36,000 sf site
Per Diem (3) and Vehicle	54.5	days	@	$520	/day	$28,340			
Change Out Operator (2) & Laborers (1)	2.6	ea	@	$4,500	ea	$11,679			Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis									1 sample per 250 square feet of excavation plus 1 sample per 50
Confirmation Samples (GRO, DRO, VOCs, SVOCs)	696.0	samples	@	$435	each	$302,760			cubic yards excavated soil plus 20% QC
Environmental Consultant									
Project Management	109.0	hours	@	$140	/hour	$15,260			2 hours per work day
Monitoring and Sampling (2 person)	54.5	days	@	$1,800	/day	$98,100			Same hours as excavation crew
Miscellaneous Equipment	54.5	days	@	$200	/day	$10,900			
Per Diem (2) and Vehicle	54.5	days	@	$380	/day	$20,710			
Change Out Engineer/Geologist/Env. Scientist (2)	2.6	ea	@	$3,000	ea	$7,786			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	800	hours	@	$100	/hour	$80,000			Assumes work plan effort shared with multiple sites and stand
Contingency (15%)						$183,237			alone cleanup report for each site
Biopile Installation Efforts							$3,442,046		
Biopiles									
Clearing and Grubbing (10,000 square feet/day)	8.6	days	@	$5,000	/day	$43,136			Remove vegetation from 5,000 square feet site per 1333 cy
Chain-Link Fence for Treatment Area	5176.3	lin ft	@	$132	/lf	$683,271			100 feet x 50 feet site per 1333 cy
Transport Impacted Material to Biopile	23000	cy	@	$10	/cy	$230,000			Includes bulking factor of 15%
Liners and Covers	172543	sq ft	@	$0.50	/sf	$86,272			Two 50 feet by 100 feet liners/covers for 1333 cy
Construct Biopiles at Site	23000	cy	@	$35	/cy	$805,000			Includes bulking factor of 15%
Manifold Piping Materials and Shipping	9489.9	lin ft	@	$25	/lf	$237,247			1 vent line every 10 feet = 550 feet per 1333 cy Biopile
Blower/Shed/Meters etc.	17.25	site	@	$25,000	/site	$431,358			1 Blower/Shed/Meters etc. per 1333 cy biopile
Per Diem (3) and Vehicle (1)	178.3	days	@	$520	/day	$92,706			Assume 400 cy per day (place liners, berms, pipe, and backfill) and 1 week for blower/shed setup per 1333 cy
Change Out Operator (2) & Laborers (1)	8.5	ea	@	$4,500	ea	$38,203			Change out crew every 21 days (assumes work at multiple sites)
Environmental Consultant									
Project Management	356.6	hours	@	$140	/hour	$49,918			2 hours per work day
Monitoring and Sampling (1 person)	178.3	days	@	$900	/day	$160,452			Same hours as installation crew
Per Diem (1) and Vehicle	178.3	days	@	$240	/day	$42,787			
Change Out Engineer/Geologist/Env. Scientist (1)	8.5	ea	@	$1,500	ea	$12,734			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	800	hours	@	$100	/hour	$80,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$448,963			included in Tables 6.0-2 and 6.0-3
O&M Costs								**$108,159**	
Biopile Treatment Efforts							$108,159		
Biopile									
Treatment System Maintenance Labor (12 Months)	24.0	days	@	$800	/day	$19,200			Assumes 2 events per month, 1 day per event
Treatment Electricity (12 months @ 1 hp per 1333 cy)	29.85	hp-months	@	$538	/hp-mo	$16,059			Assumes pulse operation for 2 (12 hour) days per week or 52 days = 1.73 mo; 1 hp blower per 1333 cy biopile
Rental Property for Treatment Area	12.0	mos	@	$862.72	/mo	$10,353			$0.01 per square foot per month; 5,000 sq feet per 1333 cy
Laboratory Analytical Sample Analysis									
N:P:K, Het/Oil Bacteria	17.3	samples	@	$150	each	$2,588			Assumes 1 sample of leachate per event per 1333 cy biopile
Environmental Consultant									
Project Management	48.0	hours	@	$140	/hour	$6,720			2 hours per work day
Treatment Monitoring and Sampling (1 person)	24.0	days	@	$900	/day	$21,600			Assumes 1 event per month, 0.5 day per event
Per Diem (1) and Vehicle	24.0	days	@	$240	/day	$5,760			Assumes shared between sites
Travel to Site (1 person)	2.4	ea	@	$1,500	ea	$3,600			Assumes travel shared between 10 other sites.
Change Out Engineer/Geologist/Env. Scientist (1)	0.1	ea	@	$1,500	ea	$171			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$14,108			included in Tables 6.0-2 and 6.0-3

TABLE C.8 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 8 - BIOPILES

Alternative 8 - Biopiles

Item	20,000 Cubic Yards						Subtotal	COSTS	Notes
Future Capital Costs (Every 5 Years)								**$24,789**	
Screening for Cleanup							$24,789		
Test Pits									
Backhoe & Operator - Local (100 feet/day)	1.8	days	@	$1,600	/day	$2,915			4 Test Pits per event to 11 feet
Laboratory Analytical Sample Analysis									
Screening Samples (GRO, DRO, VOCs, SVOCs)	18.2	samples	@	$435	each	$7,924			Assumes 33% of total sample number required for cleanup conf
Environmental Consultant									
Project Management	3.64	hours	@	$140	/hour	$510			2 hours per work day
Monitoring and Sampling (1 person)	1.82	days	@	$900	/day	$1,639			Same hours as backhoe crew
Per Diem (1) and Vehicle	1.82	days	@	$240	/day	$437			Assumes shared between sites
Change Out Engineer/Geologist/Env. Scientist (1)	0.0867	ea	@	$1,500	ea	$130			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80.0	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites
Contingency (15%)						$3,233			included in Tables 6.0-2 and 6.0-3
Future Capital Costs (One Time at End of Treatment)								**$925,954**	
Confirmation of Cleanup							$165,533		
Confirmation Test Pits									
Backhoe & Operator - Local (100 feet/day)	5.5	days	@	$4,500	/day	$24,840			10 test pits to 10 feet deep per 2000 cy
Laboratory Analytical Sample Analysis									1 sample per 200 cubic yards to 2,000 cy and then 1 sample per
Confirmation Samples (GRO, DRO, VOCs, SVOCs)	55.2	samples	@	$435	each	$24,012			500 cubic yards plus 20% QC; Minimum 4 samples
Environmental Consultant									
Project Management	11.0	hours	@	$134	/hour	$1,479			2 hours per work day
Monitoring and Sampling (2 person)	5.5	days	@	$1,800	/day	$9,936			Same hours as drill crew
Per Diem (2) and Vehicle	5.5	days	@	$380	/day	$2,098			
Change Out Engineer/Geologist/Env. Scientist (2)	0.5	ea	@	$3,000	ea	$1,577			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	800	hours	@	$100	/hour	$80,000			Assumes work plan effort shared with multiple sites and stand
Contingency (15%)						$21,591			alone cleanup report combined with decom report for each site
Decommissioning Efforts							$760,421		
Biopile Decommissioning									
Transport Clean Material to Excavation Site	23000	cy	@	$10	/cy	$230,000			
Backfill Excavation with Treated Material	23000	cy	@	$10	/cy	$230,000			
Remove Fence - Excavation Area (150 feet/day)	5.1	days	@	$1,750	/day	$8,867			580 Backhoe with Operator and 2 Laborers
Remove Fence - Treatment Area (150 feet/day)	34.5	days	@	$1,750	/day	$60,390			580 Backhoe with Operator and 2 Laborers
Per Diem (3) and Vehicle (1)	57.5	days	@	$520	/day	$29,900			
Change Out Operator (2) & Laborers (1)	2.7	ea	@	$4,500	ea	$12,321			Change out crew every 21 days (assumes work at multiple sites)
Environmental Consultant									
Project Management	115.0	hours	@	$140	/hour	$16,100			2 hours per work day
Decommissioning Monitoring	57.5	days	@	$900	/day	$51,750			Same hours as decommissioning crew
Per Diem (1) and Vehicle	57.5	days	@	$240	/day	$13,800			
Change Out Engineer/Geologist/Env. Scientist (1)	2.7	ea	@	$1,500	ea	$4,107			Change out crew every 21 days (assumes work at multiple sites)
Reporting	40.0	hours	@	$100	/hour	$4,000			Assumes decommissioning portion included in stand alone
Contingency (15%)						$99,185			cleanup report
							Alternative 8 - Biopiles Total:	**$5,926,434**	

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER CY*
Mobilization/Demobilization Costs	1	$5,520	$5,520	0.935	$5,159	-
Mobilization/Demobilization Costs	1	$5,520	$5,520	0.935	$5,159	-
Mobilization/Demobilization Costs	5	$5,520	$5,520	0.713	$3,936	-
Mobilization/Demobilization Costs	5	$5,520	$5,520	0.713	$3,936	-
Capital Cost	1	$4,862,012	$4,862,012	0.935	$4,543,936	$227
O&M Cost (Year 1)	1	$108,159	$108,159	0.935	$101,083	$5
O&M Cost (Year 2)	2	$108,159	$108,159	0.873	$94,470	$5
O&M Cost (Year 3)	3	$108,159	$108,159	0.816	$88,290	$4
O&M Cost (Year 4)	4	$108,159	$108,159	0.763	$82,514	$4
Future Capital Cost (Every 5 Years)	5	$24,789	$24,789	0.713	$17,674	$1
Future Capital Cost (one time)	5	$925,954	$925,954	0.713	$660,192	$33
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)					**$5,588,161**	$279

* Average cost per cubic yard is for treating a site having an estimated volume of 20,000 cubic yards of impacted soil.

TABLE C.8 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 8 - BIOPILES

Alternative 8 - Biopiles

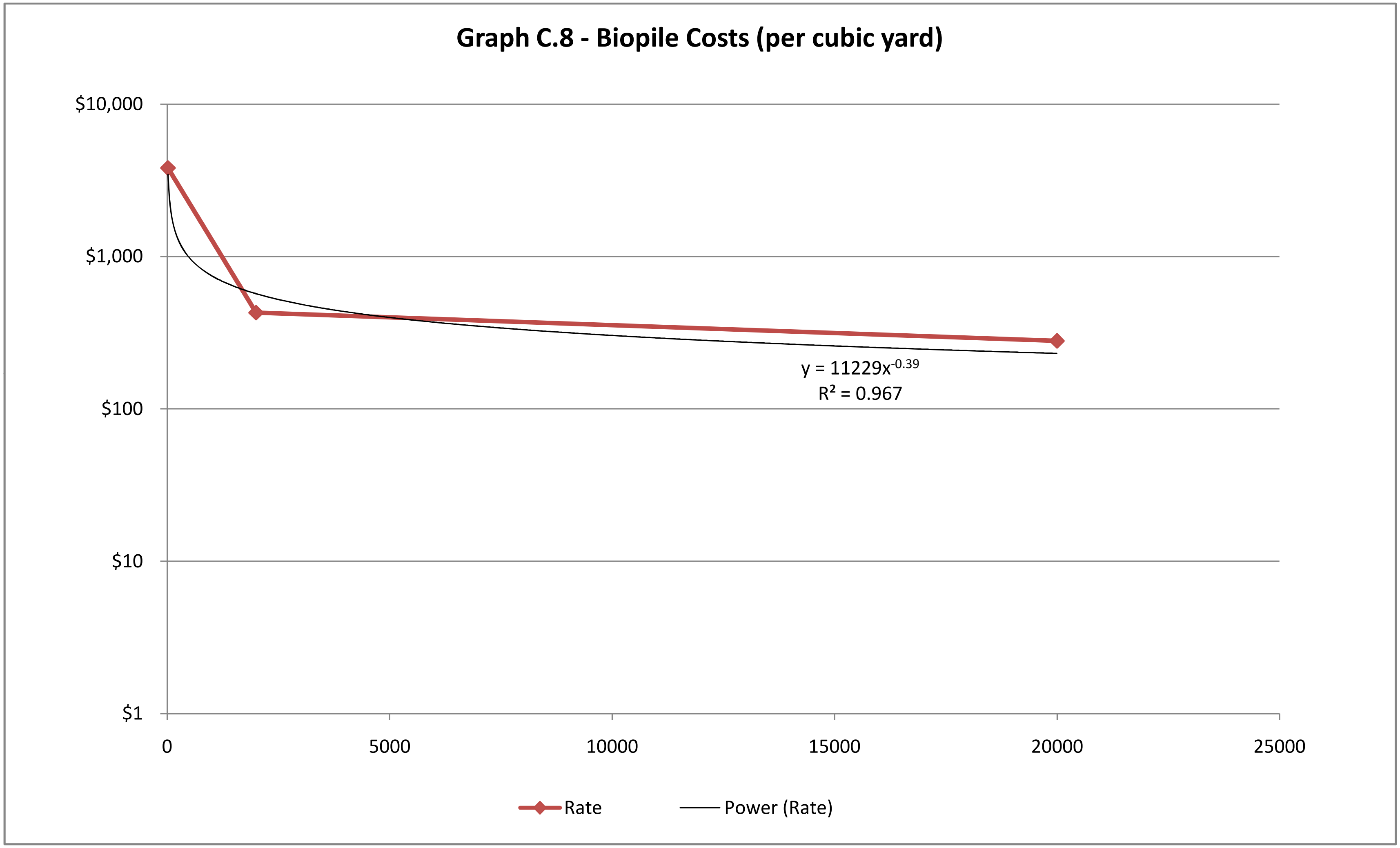


TABLE C.9 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 9 - EXCAVATION AND LOW-TEMPERATURE THERMAL DESORPTION

Alternative 9 - Excavation and Low-Temperature Thermal Desorption (LTTD)

2,000 Cubic Yards									
								COSTS	
Mobilization/Demobilization Costs								**$297,543**	
Equipment and Personnel Mobilization/Demobilization Effort							$297,543		
Excavation Equipment and Personnel									
Excavator/Backhoe - Local	1.0	lump sum	@	$500	ea	$500			Assumes mobilization/demobilization efforts for Year 1
End Dump - Local	1.0	lump sum	@	$500	ea	$500			(excavation, treatment and decommissioning) for this technology
Loader - Local	1.0	lump sum	@	$500	ea	$500			for 2,000 cy - Present Value Analysis Table shows costs
Operator (2) & Laborers (1) - Local	1.0	lump sum	@	$300	ea	$300			
Construct Chain-Link Fence for Treatment Area	800	lin ft	@	$132	/lf	$105,600			200 feet x 200 feet for a 1-acre treatment site
Liner for Soil Treatment Area	40000	sq ft	@	$0.50	/sf	$20,000			200 feet x 200 feet for a 1-acre treatment site
Construct Treatment Area	1.0	lump sum	@	$10,000	ea	$10,000			200 feet x 200 feet for a 1-acre treatment site
Remove Fence Treatment Area (150 feet/day)	5.3	days	@	$1,750	/day	$9,333			580 Backhoe with Operator and 2 Laborers
LTTD Equipment and Personnel									
LTTD Mob/Decon/Demob Labor	1.0	lump sum	@	$10,000	ea	$10,000			
LTTD Equipment Shipping	1.0	lump sum	@	$90,000	ea	$90,000			
Operator (2) & Laborers (4)	1.0	trip	@	$9,000	ea	$9,000			
Environmental Consultant									
Engineer/Geologist/Env. Scientist (2)	1.0	ea	@	$3,000	ea	$3,000			
Contingency (15%)						$38,810			
Capital Costs								**$777,373**	
Excavation Effort							$219,691		
(Assumes 2,000 cubic yards of impacted soil extending to depth of 11 feet over 5,000 square foot area with 250 cubic yards of clean overburden)									
Excavation Equipment and Personnel									
Clearing and Grubbing (10,000 square feet/day)	0.5	days	@	$5,000	/day	$2,500			Remove vegetation from 5,000 square feet site
Excavate and Stockpile Non-Impacted Material	250	cy	@	$18	/cy	$4,500			
Excavate and Stockpile Impacted Material	2000	cy	@	$18	/cy	$36,000			
Backfill Excavation with Non-Impacted Material	250	cy	@	$10	/cy	$2,500			
Liners and Covers	46575	sq ft	@	$0.26	/sf	$12,110			Stockpiled soil is mounded, after 15% bulking factor, about 3 feet high on liner and covered
Chain-Link Fence Around Excavation Area	300	lin ft	@	$132	/lf	$39,600			75 feet x 75 feet site 5,000 sf site
Per Diem (3) and Vehicle	5.6	days	@	$520	/day	$2,925			
Change Out Operator (2) & Laborers (1)	0.3	ea	@	$4,500	ea	$1,205			Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis									
Confirmation Samples (GRO, DRO, VOCs, SVOCs)	78	samples	@	$435	each	$33,930			1 sample per 250 square feet of excavation plus 1 sample per 50 cubic yards excavated soil plus 20% QC
Environmental Consultant									
Project Management	11.3	hours	@	$140	/hour	$1,575			2 hours per work day
Monitoring and Sampling (2 person)	5.6	days	@	$1,800	/day	$10,125			Same hours as excavation crew
Miscellaneous Equipment	5.6	days	@	$200	/day	$1,125			
Per Diem (2) and Vehicle	5.6	days	@	$380	/day	$2,138			
Change Out Engineer/Geologist/Env. Scientist (2)	0.3	ea	@	$3,000	ea	$804			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	400	hours	@	$100	/hour	$40,000			Assumes work plan effort shared with multiple sites and stand alone cleanup report for each site
Contingency (15%)						$28,655			
Treatment Efforts							$557,682		
Low-Temperature Thermal Desorption (LTTD) Unit									
Chain-Link Fence Around Excavation Area	300	lin ft	@	$132	/lf	$39,600			75 feet x 75 feet site, 4 feet outside perimeter of excavation
Rental Property for Treatment Area (40,000 sq ft)	0.5	mos	@	$400.00	/mo	$208			$0.01 per square foot per month; 3000 tons @ 16 tons per hour for 12-hour day = 15 days for 2,000 cy
Secondary Liner for Impacted Soil at Treatment Area	20700	sq ft	@	$0.50	/sf	$10,350			Stockpiled soil is mounded, after 15% bulking factor, about 6 feet high on liner and covered
Transport Impacted Material to Soil Treatment Area	2000	cy	@	$10	/cy	$20,000			
Process Soil Labor and Fuel	3000	tons	@	$115	/ton	$345,000			Midwest Soil Remediation Mike Fetherling (800) 870-0375 Ext 312
Per Diem (6) and Vehicle	15.6	days	@	$940	/day	$14,688			Assume 16 tons per hour for 12-hour day and 1 week to set-up
Laboratory Analytical Sample Analysis									
Confirmation Samples (GRO, DRO, VOCs, SVOCs)	12	samples	@	$435	each	$5,220			1 sample per 200 cubic yards to 2,000 cy and then 1 sample per 500 cubic yards plus 20% QC; Minimum 4 samples
Environmental Consultant									
Project Management	31.3	hours	@	$140	/hour	$4,375			2 hours per work day
Treatment Monitoring and Sampling (1 person)	2.1	days	@	$900	/day	$1,875			1 day per week
Per Diem (1) and Vehicle	2.1	days	@	$240	/day	$500			
Travel to Site (1 person)	2.1	ea	@	$1,500	ea	$3,125			1 day per week
Work Plan and Reporting	400	hours	@	$100	/hour	$40,000			Assumes work plan effort shared with multiple sites and stand alone cleanup report combined with decom report for each site
Contingency (15%)						$72,741			
Annual O&M Costs								**$0**	
Future Costs								**$72,003**	
Decommissioning Efforts							$72,003		
Decommissioning LTTD									
Transport Clean Material to Excavation Site	2000	cy	@	$10	/cy	$20,000			
Backfill Excavation with Treated Material	2000	cy	@	$10	/cy	$20,000			
Remove Fence Excavation Area (150 feet/day)	2.0	days	@	$1,750	/day	$3,500			580 Backhoe with Operator and 2 Laborers @ 150 feet per day
Per Diem (3) and Vehicle (1)	5.0	days	@	$520	/day	$2,600			
Change Out Operator (2) & Laborers (1)	0.2	ea	@	$4,500	ea	$1,071			Change out crew every 21 days (assumes work at multiple sites)
Environmental Consultant									
Project Management	14.0	hours	@	$140	/hour	$1,960			2 hours per work day
Decommissioning Monitoring	7.0	days	@	$900	/day	$6,300			Same hours as treatment crew
Per Diem (1) and Vehicle	7.0	days	@	$240	/day	$1,680			
Travel to Site (1 person)	1.0	days	@	$1,500	/day	$1,500			
Work Plan and Reporting	40	hours	@	$100	/hour	$4,000			Assumes work plan effort shared with multiple sites and stand alone cleanup report combined with decom report for each site
Contingency (15%)						$9,392			
Alternative 9 - Excavation and Low-Temperature Thermal Desorption (LTTD) Total:								**$1,146,920**	

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER CY*
Mobilization/Demobilization Costs	1	$297,543	$297,543	0.935	$278,078	-
Capital Cost	1	$777,373	$777,373	0.935	$726,517	$363
Annual O&M Cost	1	$0	$0	0.935	$0	$0
Future Cost	1	$72,003	$72,003	0.935	67292.657	$34
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)					**$793,810**	$397

* Average cost per cubic yard is for treating a site having an estimated volume of 2000 cubic yards of impacted soil.

TABLE C.9 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 9 - EXCAVATION AND LOW-TEMPERATURE THERMAL DESORPTION

Alternative 9 - Excavation and Low-Temperature Thermal Desorption (LTTD)

20 Cubic Yards

Item	Quantity	Unit		Unit Cost	Per	Amount	Subtotal	COSTS	Notes
Mobilization/Demobilization Costs								**$297,543**	
Equipment and Personnel Mobilization/Demobilization Effort							$297,543		
Excavation Equipment and Personnel									
Excavator/Backhoe - Local	1.0	lump sum	@	$500	ea	$500			Assumes mobilization/demobilization efforts for Year 1
End Dump - Local	1.0	lump sum	@	$500	ea	$500			(excavation, treatment and decommissioning) for this technology
Loader - Local	1.0	lump sum	@	$500	ea	$500			for 20 cy - Present Value Analysis Table shows costs
Operator (2) & Laborers (1) - Local	1.0	lump sum	@	$300	ea	$300			
Construct Chain-Link Fence for Treatment Area	800	lin ft	@	$132	/lf	$105,600			200 feet x 200 feet for a 1-acre treatment site
Liner for Soil Treatment Area	40000	sq ft	@	$0.50	/sf	$20,000			200 feet x 200 feet for a 1-acre treatment site
Construct Treatment Area	1.0	lump sum	@	$10,000	ea	$10,000			200 feet x 200 feet for a 1-acre treatment site
Remove Fence Treatment Area (150 feet/day)	5.3	days	@	$1,750	/day	$9,333			580 Backhoe with Operator and 2 Laborers
LTTD Equipment and Personnel									
LTTD Mob/Decon/Demob Labor	1.0	lump sum	@	$10,000	ea	$10,000			
LTTD Equipment Shipping	1.0	lump sum	@	$90,000	ea	$90,000			
Operator (2) & Laborers (4)	1.0	trip	@	$9,000	ea	$9,000			
Environmental Consultant									
Engineer/Geologist/Env. Scientist (2)	1.0	ea	@	$3,000	ea	$3,000			
Contingency (15%)						$38,810			
Capital Costs								**$34,892**	
(Assumes 20 cubic yards of impacted soil extending to depth of 2 feet over 270 square foot area with 0 cubic yards of clean overburden)									
Excavation Effort							$16,790		
Excavation Equipment and Personnel									
Clearing and Grubbing (10,000 square feet/day)	0.03	days	@	$5,000	/day	$135			Remove vegetation from 270 square feet site
Excavate and Stockpile Non-Impacted Material	0.0	cy	@	$18	/cy	$0			
Excavate and Stockpile Impacted Material	20.0	cy	@	$18	/cy	$360			
Backfill Excavation with Non-Impacted Material	0.0	cy	@	$10	/cy	$0			
Backfill Excavation with Imported Gravel	20.0	cy	@	$38	/cy	$760			
Liners and Covers	207	sq ft	@	$0.26	/sf	$54			Stockpiled soil is mounded, after 15% bulking factor, about 6 feet high on liner and covered
Per Diem (3) and Vehicle	0.1	days	@	$520	/day	$26			
Change Out Operator (2) & Laborers (1)	0.0	ea	@	$4,500	ea	$11			Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis									
Confirmation Samples (GRO, DRO, VOCs, SVOCs)	7.2	samples	@	$435	each	$3,132			1 sample per 250 square feet of excavation plus 1 sample per 50
Environmental Consultant									
Project Management	0.10	hours	@	$140	/hour	$14			2 hours per work day
Monitoring and Sampling (2 person)	0.05	days	@	$1,800	/day	$90			Same hours as excavation crew
Per Diem (2) and Vehicle	0.05	days	@	$380	/day	$19			
Miscellaneous Equipment	0.05	days	@	$200	/day	$10			
Change Out Engineer/Geologist/Env. Scientist (2)	0.002	ea	@	$3,000	ea	$7			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	100	hours	@	$100	/hour	$10,000			Assumes work plan effort shared with multiple sites and stand alone cleanup report for each site
Contingency (15%)						$2,172			
Treatment Efforts							$18,102		
Low-Temperature Thermal Desorption (LTTD) Unit									
Rental Property for Treatment Area (40,000 sq ft)	0.01	mos	@	$400.00	/mo	$2			$0.01 per square foot per month; 30 tons @ 16 tons per hour for 12-hour day = 0.16 days for 20 cy
Secondary Liner for Impacted Soil at Treatment Area	207	sq ft	@	$0.50	/sf	$104			Stockpiled soil is mounded, after 15% bulking factor, about 6 feet high on liner and covered
Transport Impacted Material to Soil Treatment Area	20.0	cy	@	$10	/cy	$200			
Process Soil Labor and Fuel	30.0	tons	@	$115	/ton	$3,450			Midwest Soil Remediation Mike Fetherling (800) 870-0375 Ext 312
Per Diem (6) and Vehicle	0.2	days	@	$940	/day	$147			Assume 16 tons per hour for 12-hour day and 1 week to set-up
Laboratory Analytical Sample Analysis									
Confirmation Samples (GRO, DRO, VOCs, SVOCs)	4.0	samples	@	$435	each	$1,740			1 sample per 200 cubic yards to 2,000 cy and then 1 sample per 500 cubic yards plus 20% QC; Minimum 4 samples
Environmental Consultant									
Project Management	0.31	hours	@	$140	/hour	$44			2 hours per work day
Treatment Monitoring and Sampling (1 person)	0.02	days	@	$900	/day	$19			1 day per week
Per Diem (1) and Vehicle	0.02	days	@	$240	/day	$5			
Travel to Site (1 person)	0.02	ea	@	$1,500	ea	$31			1 day per week
Work Plan and Reporting	100	hours	@	$100	/hour	$10,000			Assumes part of larger work plan and report effort for all sites included in Tables 6.0-2 and 6.0-3
Contingency (15%)						$2,361			
Annual O&M Costs								**$0**	
Future Costs								**$4,609**	
Decommissioning Efforts							$4,609		
Decommissioning LTTD									
Transport Clean Material to Excavation Site	20	cy	@	$10	/cy	$200			
Backfill Excavation with Treated Material	20	cy	@	$10	/cy	$200			
Per Diem (3) and Vehicle (1)	0.05	days	@	$520	/day	$26			
Change Out Operator (2) & Laborers (1)	0.002	ea	@	$4,500	ea	$11			Change out crew every 21 days (assumes work at multiple sites)
Environmental Consultant									
Project Management	0.10	hours	@	$140	/hour	$14			2 hours per work day
Decommissioning Monitoring	0.05	days	@	$900	/day	$45			Same hours as treatment crew
Per Diem (1) and Vehicle	0.05	days	@	$240	/day	$12			
Travel to Site (1 person)	1	days	@	$1,500	/day	$1,500			
Reporting	20	hours	@	$100	/hour	$2,000			Assumes part of larger work plan and report effort for all sites included in Tables 6.0-2 and 6.0-3
Contingency (15%)						$601			
Alternative 9 - Excavation and Low-Temperature Thermal Desorption (LTTD) Total:								**$337,045**	

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER CY*
Mobilization/Demobilization Costs	1	$297,543	$297,543	0.935	$278,078	-
Capital Cost	1	$34,892	$34,892	0.935	$32,610	$1,630
Annual O&M Cost	1	$0	$0	0.935	0	$0
Future Cost	1	$4,609	$4,609	0.935	4307	$215
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)					**$36,917**	$1,846

* Average cost per cubic yard is for treating a site having an estimated volume of 20 cubic yards of impacted soil.

TABLE C.9 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 9 - EXCAVATION AND LOW-TEMPERATURE THERMAL DESORPTION

Alternative 9 - Excavation and Low-Temperature Thermal Desorption (LTTD)

20,000 Cubic Yards

Item	Quantity	Unit		Unit Cost	Per	Amount	Subtotal	COSTS	Notes
Mobilization/Demobilization Costs								**$297,543**	
Equipment and Personnel Mobilization/Demobilization Effort							$297,543		
Excavation Equipment and Personnel									
Excavator/Backhoe - Local	1.0	lump sum	@	$500	ea	$500			Assumes mobilization/demobilization efforts for Year 1
End Dump - Local	1.0	lump sum	@	$500	ea	$500			(excavation, treatment and decommissioning) for this technology
Loader - Local	1.0	lump sum	@	$500	ea	$500			for 20,000 cy - Present Value Analysis Table shows costs
Operator (2) & Laborers (1) - Local	1.0	lump sum	@	$300	ea	$300			
Construct Chain-Link Fence for Treatment Area	800	lin ft	@	$132	/lf	$105,600			200 feet x 200 feet for a 1-acre treatment site
Liner for Soil Treatment Area	40000	sq ft	@	$0.50	/sf	$20,000			200 feet x 200 feet for a 1-acre treatment site
Construct Treatment Area	1.0	lump sum	@	$10,000	ea	$10,000			200 feet x 200 feet for a 1-acre treatment site
Remove Fence Treatment Area (150 feet/day)	5.3	days	@	$1,750	/day	$9,333			580 Backhoe with Operator and 2 Laborers
LTTD Equipment and Personnel									
LTTD Mob/Decon/Demob Labor	1.0	lump sum	@	$10,000	ea	$10,000			
LTTD Equipment Shipping	1.0	lump sum	@	$90,000	ea	$90,000			
Operator (2) & Laborers (4)	1.0	trip	@	$9,000	ea	$9,000			
Environmental Consultant									
Engineer/Geologist/Env. Scientist (2)	1.0	ea	@	$3,000	ea	$3,000			
Contingency (15%)						$38,810			
Capital Costs								**$6,223,182**	
(Assumes 20,000 cubic yards of impacted soil extending to depth of 15 feet over 36,000 square foot area with 1800 cubic yards of clean overburden)									
Excavation Effort							$1,366,400		
(Assumes 20,000 cubic yards of impacted soil extending to depth of 15 feet over 36,000 square foot area with 1800 cubic yards of clean overburden)									
Excavation Equipment and Personnel									
Clearing and Grubbing (10,000 square feet/day)	3.6	days	@	$5,000	/day	$18,000			Remove vegetation from 5,000 square feet site
Excavate and Stockpile Non-Impacted Material	1800	cy	@	$18	/cy	$32,400			
Excavate and Stockpile Impacted Material	20000	cy	@	$18	/cy	$360,000			
Backfill Excavation with Non-Impacted Material	1800	cy	@	$10	/cy	$18,000			
Liners and Covers	451260	sq ft	@	$0.26	/sf	$117,328			Stockpiled soil is mounded, after 15% bulking factor, about 3 feet high on liner and covered
Chain-Link Fence Around Excavation Area	760.0	lin ft	@	$132	/lf	$100,320			190 feet x 190 feet site for 36,000 sf site
Per Diem (3) and Vehicle	54.5	days	@	$520	/day	$28,340			
Change Out Operator (2) & Laborers (1)	2.6	ea	@	$4,500	ea	$11,679			Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis									1 sample per 250 square feet of excavation plus 1 sample per 50
Confirmation Samples (GRO, DRO, VOCs, SVOCs)	619.2	samples	@	$435	each	$269,352			cubic yards excavated soil plus 20% QC
Environmental Consultant									
Project Management	109	hours	@	$140	/hour	$15,260			2 hours per work day
Monitoring and Sampling (2 person)	54.5	days	@	$1,800	/day	$98,100			Same hours as excavation crew
Miscellaneous Equipment	54.5	days	@	$200	/day	$10,900			
Per Diem (2) and Vehicle	54.5	days	@	$380	/day	$20,710			
Change Out Engineer/Geologist/Env. Scientist (2)	2.6	ea	@	$3,000	ea	$7,786			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	800	hours	@	$100	/hour	$80,000			Assumes work plan effort shared with multiple sites and stand
Contingency (15%)						$178,226			alone cleanup report for each site
Treatment Efforts							$4,856,782		
Low-Temperature Thermal Desorption (LTTD) Unit									
Chain-Link Fence Around Excavation Area	776	lin ft	@	$132	/lf	$102,432			36,000 square feet plus 4 feet around excavation perimeter = 194 feet x 194 feet site
Rental Property for Treatment Area (40,000 sq ft)	5.21	mos	@	$400.00	/mo	$2,083			$0.01 per square foot per month; 30000 tons @ 16 tons per hour for 12-hour day = 156 days for 20,000 cy
Rental Property for Storage Area (200,000 sq ft)	5.2	mos	@	$2,000.00	/mo	$10,417			$0.01 per square foot per month; 30000 tons @ 16 tons per hour for 12-hour day = 156 days for 20,000 cy
Secondary Liner for Impacted Soil at Treatment Area	207000	sq ft	@	$0.50	/sf	$103,500			Stockpiled soil is mounded, after 15% bulking factor, about 3 feet high on liner and covered
Transport Impacted Material to Soil Treatment Area	20000	cy	@	$10	/cy	$200,000			
Process Soil Labor and Fuel	30000	tons	@	$115	/ton	$3,450,000			Midwest Soil Remediation Mike Fetherling (800) 870-0375 Ext 312
Per Diem (6) and Vehicle	156.3	days	@	$940	/day	$146,875			Assume 16 tons per hour for 12-hour day and 1 week to set-up
Laboratory Analytical Sample Analysis									1 sample per 200 cubic yards to 2,000 cy and then 1 sample per
Confirmation Samples (GRO, DRO, VOCs, SVOCs)	67.2	samples	@	$435	each	$29,232			500 cubic yards plus 20% QC; Minimum 4 samples
Environmental Consultant									
Project Management	312.5	hours	@	$140	/hour	$43,750			2 hours per work day
Treatment Monitoring and Sampling (1 person)	20.8	days	@	$900	/day	$18,750			1 day per week
Per Diem (1) and Vehicle	20.8	days	@	$240	/day	$5,000			
Travel to Site (1 person)	20.8	ea	@	$1,500	ea	$31,250			1 day per week
Work Plan and Reporting	800	hours	@	$100	/hour	$80,000			Assumes work plan effort shared with multiple sites and stand
Contingency (15%)						$633,493			alone cleanup report combined with decom report for each site
Annual O&M Costs								**$0**	
Future Costs								**$609,639**	
Decommissioning Efforts							$609,639		
Decommissioning LTTD									
Transport Clean Material to Excavation Site	20000	cy	@	$10	/cy	$200,000			
Backfill Excavation with Treated Material	20000	cy	@	$10	/cy	$200,000			
Remove Fence Excavation Area (150 feet/day)	5.3	days	@	$1,750	/day	$9,333			580 Backhoe with Operator and 2 Laborers @ 150 feet per day
Per Diem (3) and Vehicle (1)	50.0	days	@	$520	/day	$26,000			
Change Out Operator (2) & Laborers (1)	2.4	ea	@	$4,500	ea	$10,714			Change out crew every 21 days (assumes work at multiple sites)
Environmental Consultant									
Project Management	110.7	hours	@	$140	/hour	$15,493			2 hours per work day
Decommissioning Monitoring	55.3	days	@	$900	/day	$49,800			Same hours as treatment crew
Per Diem (1) and Vehicle	55.3	days	@	$240	/day	$13,280			
Travel to Site (1 person)	1.0	days	@	$1,500	/day	$1,500			
Reporting	40.0	hours	@	$100	/hour	$4,000			Assumes decommissioning portion included in stand alone cleanup
Contingency (15%)						$79,518			report
Alternative 9 - Excavation and Low-Temperature Thermal Desorption (LTTD) Total:								**$7,130,365**	

TABLE C.9 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 9 - EXCAVATION AND LOW-TEMPERATURE THERMAL DESORPTION

Alternative 9 - Excavation and Low-Temperature Thermal Desorption (LTTD)

20,000 Cubic Yards

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST		TOTAL COST PER YEAR		DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER CY*
Mobilization/Demobilization Costs	1	$297,543		$297,543		0.935	$278,078	-
Capital Cost	1	$6,223,182		$6,223,182		0.935	$5,816,058	$291
Annual O&M Cost	1	$0		$0		0.935	0	$0
Future Costs	1	$609,639		$609,639		0.935	569756.16	$28
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)							**$6,385,814**	$319

* Average cost per cubic yard is for treating a site having an estimated volume of 20,000 cubic yards of impacted soil.

TABLE C.9 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 9 - EXCAVATION AND LOW-TEMPERATURE THERMAL DESORPTION

Alternative 9 - Excavation and Low-Temperature Thermal Desorption (LTTD)

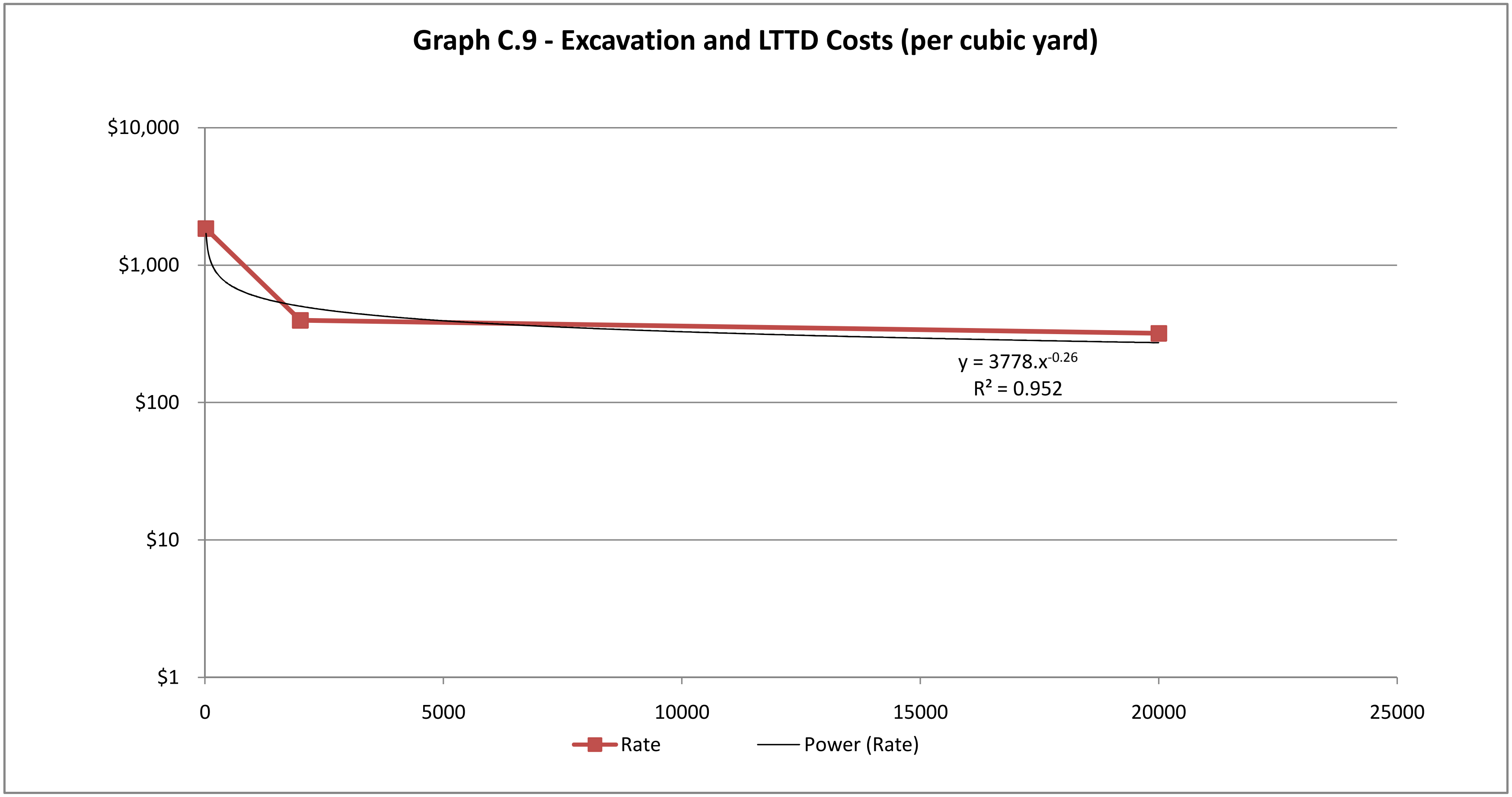


TABLE C.10 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 10 - EXCAVATION AND OFF-SITE DISPOSAL

Alternative 10 - Excavation and Off-Site Disposal

Item	Qty	Unit		Unit Cost	Per	Cost	Subtotal	COSTS	Notes
2,000 Cubic Yards									
Mobilization/Demobilization Costs								**$172,768**	
Equipment and Personnel Mobilization/Demobilization Effort							$172,768		
Excavation Equipment and Personnel									Assumes mobilization/demobilization efforts for Year 1
Excavator/Backhoe - Local	1.0	lump sum	@	$500	ea	$500			(excavation, treatment and decommissioning) for this technology
End Dump - Local	1.0	lump sum	@	$500	ea	$500			for 2,000 cy - Present Value Analysis Table shows costs
Flat Bed Trailer - Local	1.0	lump sum	@	$500	ea	$500			
Loader - Local	1.0	lump sum	@	$500	ea	$500			
Operator (2) & Laborers (1) - Local	1.0	lump sum	@	$300	ea	$300			
Construct Chain-Link Fence for Storage Area	800	lin ft	@	$132	/lf	$105,600			200 feet x 200 feet for a 1-acre treatment site
Liner for Soil Storage Area	40000	sq ft	@	$0.50	/sf	$20,000			200 feet x 200 feet for a 1-acre treatment site
Construct Storage Area	1.0	lump sum	@	$10,000	ea	$10,000			200 feet x 200 feet for a 1-acre treatment site
Remove Fence Treatment Area (150 feet/day)	5.3	days	@	$1,750	/day	$9,333			580 Backhoe with Operator and 2 Laborers
Environmental Consultant									
Engineer/Geologist/Env. Scientist (2)	1.0	trip	@	$3,000	ea	$3,000			
Contingency (15%)						$22,535			
Capital Costs								**$2,143,740**	
Excavation Effort							$307,091		
(Assumes 2,000 cubic yards of impacted soil extending to depth of 11 feet over 5,000 square foot area with 250 cubic yards of clean overburden)									
Excavation Equipment and Personnel									
Clearing and Grubbing (10,000 square feet/day)	0.5	days	@	$5,000	/day	$2,500			Remove vegetation from 5,000 square feet site
Excavate and Stockpile Non-Impacted Material	250	cy	@	$18	/cy	$4,500			
Excavate and Stockpile Impacted Material	2000	cy	@	$18	/cy	$36,000			
Backfill Excavation with Non-Impacted Material	250	cy	@	$10	/cy	$2,500			
Backfill Excavation with Imported Gravel	2000	cy	@	$38	/cy	$76,000			Stockpiled soil is mounded, after 15% bulking factor, about 3 feet
Liners and Covers	46575	sq ft	@	$0.26	/sf	$12,110			high on liner and covered
Chain-Link Fence Around Excavation Area	300	lin ft	@	$132	/lf	$39,600			75 feet x 75 feet site 5,000 sf site
Per Diem (3) and Vehicle	5.6	days	@	$520	/day	$2,925			
Change Out Operator (2) & Laborers (1)	0.3	ea	@	$4,500	ea	$1,205			Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis									1 sample per 250 square feet of excavation plus 1 sample per 50
Confirmation Samples (GRO, DRO, VOCs, SVOCs)	78	samples	@	$435	each	$33,930			cubic yards excavated soil plus 20% QC
Environmental Consultant									
Project Management	11.3	hours	@	$140	/hour	$1,575			2 hours per work day
Monitoring and Sampling (2 person)	5.6	days	@	$1,800	/day	$10,125			Same hours as excavation crew
Miscellaneous Equipment	5.6	days	@	$200	/day	$1,125			
Per Diem (2) and Vehicle	5.6	days	@	$380	/day	$2,138			
Change Out Engineer/Geologist/Env. Scientist (2)	0.3	ea	@	$3,000	ea	$804			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	400	hours	@	$100	/hour	$40,000			Assumes work plan effort shared with multiple sites and stand
Contingency (15%)						$40,055			alone cleanup report for each site
Transportation and Disposal Effort							$1,836,649		
Waste Management									
Load 5-cy Lift-Liner Bags	2000	cy	@	$70	/cy	$140,000			Assumes $280 per 3.5 cy to load and transport = $80/cy - $10/cy
5-cy Lift-Liner Bags (3.5 cy or 4.5 tons) per bag	571	bags	@	$250	ea	$142,857			for transport = $70/cy; each 5 cy bag costs $250
Rental Property for Storage Area (40,000 sq ft)	1	mos	@	$400.00	/mo	$400			$0.01 per square foot per month
Weigh and Transport Bags to Containment Cell	2000	cy	@	$10	/cy	$20,000			
Transport Bags to Disposal Facility	3000	ton	@	$340	/ton	$1,020,000			Emerald Verbal Quote
Disposal	3000	ton	@	$58	/ton	$174,000			Emerald Verbal Quote
HW Specialist Labor	8	days	@	$900	/day	$6,750			Emerald Verbal Quote
Placards, Labels, Markers, Scale, etc.	571	bags	@	$57	/bag	$32,571			Emerald Verbal Quote
Per Diem (1) and Vehicle	8	days	@	$240	/day	$1,800			
Change Out HW Specialist	0.4	ea	@	$3,000	ea	$1,071			Change out crew every 21 days (assumes work at multiple sites)
Travel and Airfare	1	trip	@	$1,500	each	$1,500			
Environmental Consultant									
Project Management	15.0	hours	@	$140	/hour	$2,100			2 hours per work day
Disposal Monitoring	7.5	days	@	$1,800	/day	$13,500			Same hours as disposal crew
Change Out Engineer/Geologist/Env. Scientist (1)	0.4	ea	@	$1,500	ea	$536			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	400	hours	@	$100	/hour	$40,000			Assumes work plan effort shared with multiple sites and stand
Contingency (15%)						$239,563			alone cleanup report for each site
O&M Costs								**$0**	
							Alternative 10 - Excavation and Off-Site Disposal Total:	**$2,316,508**	

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER CY*
Mobilization/Demobilization Costs	1	$172,768	$172,768	0.935	$161,466	-
Capital Cost	1	$2,143,740	$2,143,740	0.935	$2,003,495	$1,002
O&M Cost	1	$0	$0	0.935	0	$0
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)					**$2,003,495**	$1,002

* Average cost per cubic yard is for treating a site having an estimated volume of 2000 cubic yards of impacted soil.

TABLE C.10 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 10 - EXCAVATION AND OFF-SITE DISPOSAL

Alternative 10 - Excavation and Off-Site Disposal

20 Cubic Yards

Item	Qty	Unit		Rate	Per	Amount	Subtotal	COSTS	Notes
Mobilization/Demobilization Costs								**$172,768**	
Equipment and Personnel Mobilization/Demobilization Effort							$172,768		
Excavation Equipment and Personnel									Assumes mobilization/demobilization efforts for Year 1 (excavation, treatment and decommissioning) for this technology for 20 cy - Present Value Analysis Table shows costs
Excavator/Backhoe - Local	1.0	lump sum	@	$500	ea	$500			
End Dump - Local	1.0	lump sum	@	$500	ea	$500			
Flat Bed Trailer - Local	1.0	lump sum	@	$500	ea	$500			
Loader - Local	1.0	lump sum	@	$500	ea	$500			
Operator (2) & Laborers (1) - Local	1.0	lump sum	@	$300	ea	$300			
Construct Chain-Link Fence for Storage Area	800	lin ft	@	$132	/lf	$105,600			200 feet x 200 feet for a 1-acre treatment site
Liner for Soil Storage Area	40000	sq ft	@	$0.50	/sf	$20,000			200 feet x 200 feet for a 1-acre treatment site
Construct Storage Area	1.0	lump sum	@	$10,000	ea	$10,000			200 feet x 200 feet for a 1-acre treatment site
Remove Fence Treatment Area (150 feet/day)	5.3	days	@	$1,750	/day	$9,333			580 Backhoe with Operator and 2 Laborers
Environmental Consultant									
Engineer/Geologist/Env. Scientist (2)	1.0	trip	@	$3,000	ea	$3,000			
Contingency (15%)						$22,535			
Capital Costs								**$47,517**	
Excavation Effort							$16,190		
(Assumes 20 cubic yards of impacted soil extending to depth of 2 feet over 235 square foot area with 0 cubic yards of clean overburden)									
Excavation Equipment and Personnel									
Clearing and Grubbing (10,000 square feet/day)	0.02	days	@	$5,000	/day	$118			Remove vegetation from 235 square feet site
Excavate and Stockpile Non-Impacted Material	0.0	cy	@	$18	/cy	$0			
Excavate and Stockpile Impacted Material	20	cy	@	$18	/cy	$360			
Backfill Excavation with Non-Impacted Material	0.0	cy	@	$10	/cy	$0			
Backfill Excavation with Imported Gravel	20.0	cy	@	$38	/cy	$760			
Liners and Covers	207	sq ft	@	$0.26	/sf	$54			Stockpiled soil is mounded, after 15% bulking factor, about 6 feet high on liner and covered
Per Diem (3) and Vehicle	0.1	days	@	$520	/day	$26			
Change Out Operator (2) & Laborers (1)	0.0	ea	@	$4,500	ea	$11			Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis									1 sample per 250 square feet of excavation plus 1 sample per 50 cubic yards excavated soil plus 20% QC; 3 samples minimum
Confirmation Samples (GRO, DRO, VOCs, SVOCs)	6.0	samples	@	$435	each	$2,610			
Environmental Consultant									
Project Management	0.1	hours	@	$140	/hour	$14			2 hours per work day
Monitoring and Sampling (2 person)	0.1	days	@	$1,800	/day	$90			Same hours as excavation crew
Per Diem (2) and Vehicle	0.1	days	@	$380	/day	$19			
Miscellaneous Equipment	0.1	days	@	$200	/day	$10			
Change Out Engineer/Geologist/Env. Scientist (2)	0.0	ea	@	$3,000	ea	$7			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	100	hours	@	$100	/hour	$10,000			Assumes work plan effort shared with multiple sites and stand alone cleanup report for each site
Contingency (15%)						$2,112			
Transportation and Disposal Effort							$31,327		
Waste Management									
Load 5-cy Lift-Liner Bags	20	cy	@	$70	/cy	$1,400			Assumes $280 per 3.5 cy to load and transport = $80/cy - $10/cy for transport = $70/cy
5-cy Lift-Liner Bags (3.5 cy or 4.5 tons) per bag	5.7	bags	@	$250	ea	$1,429			
Rental Property for Storage Area (20,000 sq ft)	1.0	mos	@	$200.00	/mo	$200			$0.01 per square foot per month
Weigh and Transport Bags to Containment Cell	20	cy	@	$10	/cy	$200			
Transport Bags to Disposal Facility	30	ton	@	$340	/ton	$10,200			Emerald Verbal Quote
Disposal	30	ton	@	$58	/ton	$1,740			Emerald Verbal Quote
HW Specialist Labor	0.1	days	@	$900	/day	$68			Emerald Verbal Quote
Placards, Labels, Markers, Scale, etc.	5.7	bags	@	$57	/bag	$326			Emerald Verbal Quote
Per Diem (1) and Vehicle	0.1	days	@	$240	/day	$18			
Travel and Airfare	1.0	trip	@	$1,500	each	$1,500			
Environmental Consultant									
Project Management	0.2	hours	@	$140	/hour	$21			2 hours per work day
Disposal Monitoring	0.1	days	@	$1,800	/day	$135			Same hours as disposal crew
Change Out Engineer/Geologist/Env. Scientist (1)	0.004	ea	@	$1,500	ea	$5			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	100	hours	@	$100	/hour	$10,000			Assumes work plan effort shared with multiple sites and stand alone cleanup report for each site
Contingency (15%)						$4,086			
Annual O&M Costs								**$0**	
							Alternative 10 - Excavation and Off-Site Disposal Total:	**$220,286**	

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST		TOTAL COST PER YEAR		DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER CY*
Mobilization/Demobilization Costs	1	$172,768		$172,768		0.935	$161,466	-
Capital Cost	1	$47,517		$47,517		0.935	$44,409	$2,220
O&M Cost	1	$0		$0		0.935	0	$0
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)							**$44,409**	$2,220

* Average cost per cubic yard is for treating a site having an estimated volume of 20 cubic yards of impacted soil.

TABLE C.10 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 10 - EXCAVATION AND OFF-SITE DISPOSAL

Alternative 10 - Excavation and Off-Site Disposal

20,000 Cubic Yards

Item	Quantity	Unit		Unit Cost	Per	Cost	Subtotal	COSTS	Notes
Mobilization/Demobilization Costs								**$172,768**	
Equipment and Personnel Mobilization/Demobilization Effort							$172,768		
Excavation Equipment and Personnel									
Excavator/Backhoe - Local	1.0	lump sum	@	$500	ea	$500			Assumes mobilization/demobilization efforts for Year 1
End Dump - Local	1.0	lump sum	@	$500	ea	$500			(excavation, treatment and decommissioning) for this technology
Flat Bed Trailer - Local	1.0	lump sum	@	$500	ea	$500			for 20,000 cy - Present Value Analysis Table shows costs
Loader - Local	1.0	lump sum	@	$500	ea	$500			
Operator (2) & Laborers (1) - Local	1.0	lump sum	@	$300	ea	$300			
Construct Chain-Link Fence for Storage Area	800	lin ft	@	$132	/lf	$105,600			200 feet x 200 feet for a 1-acre treatment site
Liner for Soil Storage Area	40000	sq ft	@	$0.50	/sf	$20,000			200 feet x 200 feet for a 1-acre treatment site
Construct Storage Area	1.0	lump sum	@	$10,000	ea	$10,000			200 feet x 200 feet for a 1-acre treatment site
Remove Fence Treatment Area (150 feet/day)	5.3	days	@	$1,750	/day	$9,333			580 Backhoe with Operator and 2 Laborers
Environmental Consultant									
Engineer/Geologist/Env. Scientist (2)	1.0	trip	@	$3,000	ea	$3,000			
Contingency (15%)						$22,535			
Capital Costs								**$20,259,480**	
(Assumes 20,000 cubic yards of impacted soil extending to depth of 15 feet over 36,000 square foot area with 2500 cubic yards of clean overburden)									
Excavation Effort							$2,278,819		
(Assumes 20,000 cubic yards of impacted soil extending to depth of 15 feet over 36,000 square foot area with 1800 cubic yards of clean overburden)									
Excavation Equipment and Personnel									
Clearing and Grubbing (10,000 square feet/day)	3.6	days	@	$5,000	/day	$18,000			Remove vegetation from 5,000 square feet site
Excavate and Stockpile Non-Impacted Material	1800	cy	@	$18	/cy	$32,400			
Excavate and Stockpile Impacted Material	20000	cy	@	$18	/cy	$360,000			
Backfill Excavation with Non-Impacted Material	1800	cy	@	$10	/cy	$18,000			
Backfill Excavation with Imported Gravel	20000	cy	@	$38	/cy	$760,000			
									Stockpiled soil is mounded, after 15% bulking factor, about 3 feet
Liners and Covers	451260	sq ft	@	$0.26	/sf	$117,328			high on liner and covered
Chain-Link Fence Around Excavation Area	760.0	lin ft	@	$132	/lf	$100,320			190 feet x 190 feet site for 36,000 sf site
Per Diem (3) and Vehicle	54.5	days	@	$520	/day	$28,340			
Change Out Operator (2) & Laborers (1)	2.6	ea	@	$4,500	ea	$11,679			Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis									1 sample per 250 square feet of excavation plus 1 sample per 50
Confirmation Samples (GRO, DRO, VOCs, SVOCs)	696	samples	@	$435	each	$302,760			cubic yards excavated soil plus 20% QC
Environmental Consultant									
Project Management	109.0	hours	@	$140	/hour	$15,260			2 hours per work day
Monitoring and Sampling (2 person)	54.5	days	@	$1,800	/day	$98,100			Same hours as excavation crew
Miscellaneous Equipment	54.5	days	@	$200	/day	$10,900			
Per Diem (2) and Vehicle	54.5	days	@	$380	/day	$20,710			
Change Out Engineer/Geologist/Env. Scientist (2)	2.6	ea	@	$3,000	ea	$7,786			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	800	hours	@	$100	/hour	$80,000			Assumes work plan effort shared with multiple sites and stand
Contingency (15%)						$297,237			alone cleanup report for each site
Transportation and Disposal Effort							$17,980,661		
Waste Management									
Load 5-cy Lift-Liner Bags	20000	cy	@	$70	/cy	$1,400,000			Assumes $280 per 3.5 cy to load and transport = $80/cy - $10/cy
5-cy Lift-Liner Bags (3.5 cy or 4.5 tons) per bag	5714.3	bags	@	$250	ea	$1,428,571			for transport = $70/cy
Rental Property for Storage Area (200,000 sq ft)	1.0	mos	@	$2,000	/mo	$2,000			$0.01 per square foot per month
Weigh and Transport Bags to Containment Cell	20000	cy	@	$10	/cy	$200,000			
Transport Bags to Disposal Facility	30000	ton	@	$340	/ton	$10,200,000			Emerald Verbal Quote
Disposal	30000	ton	@	$58	/ton	$1,740,000			Emerald Verbal Quote
HW Specialist Labor	75.0	days	@	$900	/day	$67,500			Emerald Verbal Quote
Placards, Labels, Markers, Scale, etc.	5714.3	bags	@	$57	/bag	$325,714			Emerald Verbal Quote
Per Diem (1) and Vehicle	75	days	@	$240	/day	$18,000			
Change Out HW Specialist	3.6	ea	@	$3,000	ea	$10,714			Change out crew every 21 days (assumes work at multiple sites)
Travel and Airfare	1.0	trip	@	$1,500	each	$1,500			
Environmental Consultant									
Project Management	150	hours	@	$140	/hour	$21,000			2 hours per work day
Disposal Monitoring	75	days	@	$1,800	/day	$135,000			Same hours as disposal crew
Change Out Engineer/Geologist/Env. Scientist (1)	3.6	ea	@	$1,500	ea	$5,357			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	800	hours	@	$100	/hour	$80,000			Assumes work plan effort shared with multiple sites and stand
Contingency (15%)						$2,345,304			alone cleanup report combined with decom report for each site
Annual O&M Costs								**$0**	
							Alternative 10 - Excavation and Off-Site Disposal Total:	**$20,432,248**	

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST		TOTAL COST PER YEAR		DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER CY*
Mobilization/Demobilization Costs	1	$172,768		$172,768		0.935	$161,466	-
Capital Cost	1	$20,259,480		$20,259,480		0.935	$18,934,093	$947
O&M Cost	1	$0		$0		0.935	0	$0
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)							**$18,934,093**	$947

* Average cost per cubic yard is for treating a site having an estimated volume of 20,000 cubic yards of impacted soil.

TABLE C.10 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 10 - EXCAVATION AND OFF-SITE DISPOSAL

Alternative 10 - Excavation and Off-Site Disposal

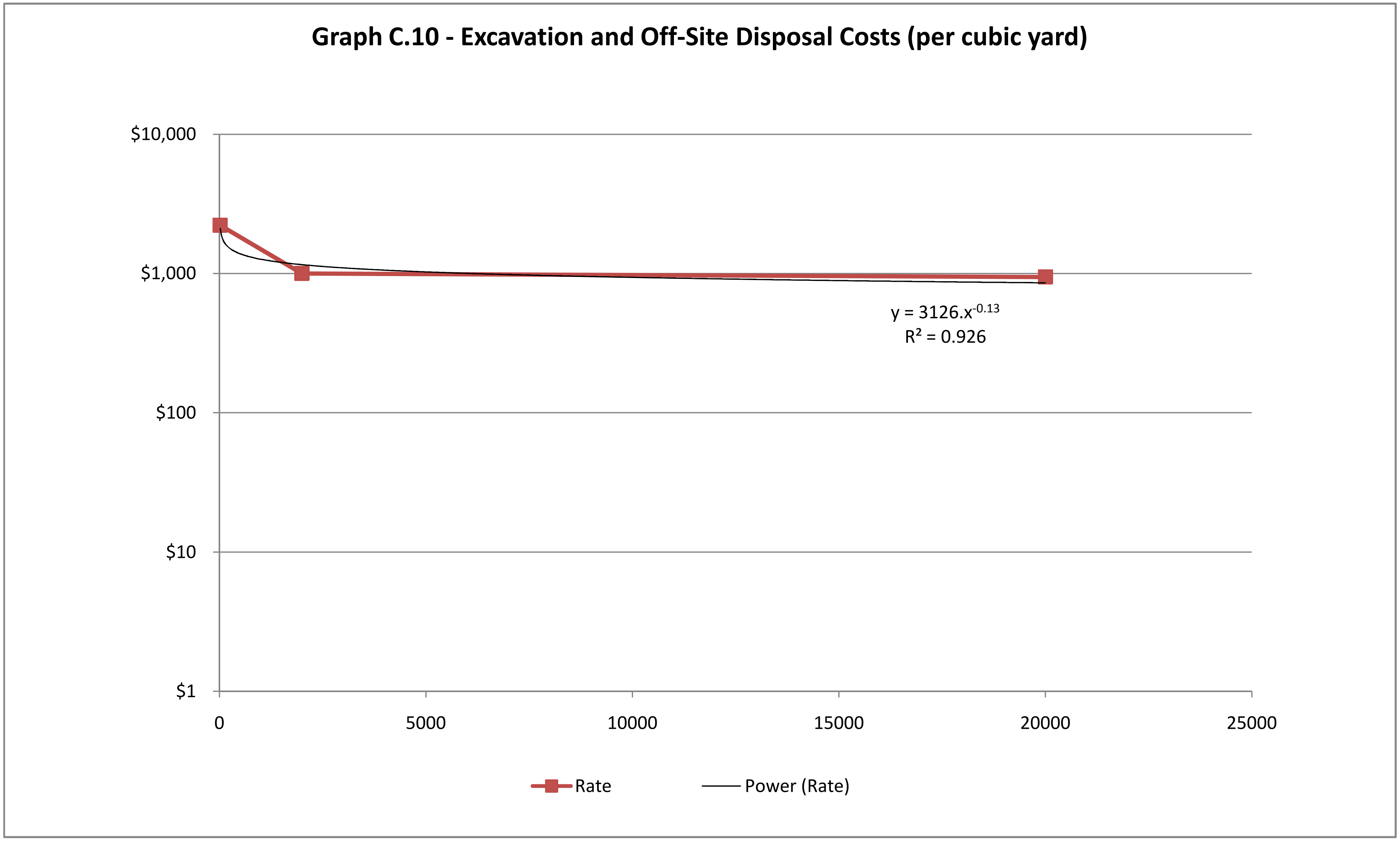


TABLE C.11 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 11 - EXCAVATION AND SOIL WASHING

Item	Quantity	Unit		Unit Cost	Per	Cost	Subtotal	COSTS	Notes
Alternative 11 - Excavation and Soil Washing									
Mobilization/Demobilization Costs								**$132,667**	
Equipment and Personnel Mobilization/Demobilization Effort							$132,667		
Excavation Equipment and Personnel									Assumes mobilization/demobilization efforts for Year 1
Excavator/Backhoe - Local	1.0	lump sum	@	$500	ea	$500			(excavation, treatment and decommissioning) for this
End Dump - Local	1.0	lump sum	@	$500	ea	$500			technology for 400 cy - Present Value Analysis Table shows
Loader - Local	1.0	lump sum	@	$500	ea	$500			costs
Operator (2) & Laborers (1) - Local	1.0	lump sum	@	$300	ea	$300			
Liner for Soil Treatment Area	15625.0	sq ft	@	$0.50	/sf	$7,813			125 feet x 125 feet treatment site
Construct Storage Treatment Area	1.0	lump sum	@	$10,000	ea	$10,000			125 feet x 125 feet treatment site
Soil Washing Equipment and Personnel									
Soil Washing Mob/Decon/Demob Labor (3)	1	lump sum	@	$8,250	ea	$8,250			TerraWash
Soil Washing Equipment Shipping	1	lump sum	@	$80,000	ea	$80,000			TerraWash
Operator (1) & Laborers (2)	1	trip	@	$4,500	ea	$4,500			TerraWash
Environmental Consultant									
Engineer/Geologist/Env. Scientist (2)	1	ea	@	$3,000	ea	$3,000			
Contingency (15%)						$17,304			
Capital Costs								**$393,821**	
Excavation Effort							$65,937		
(Assumes 400 cubic yards of impacted soil extending to depth of about 2 feet over 5,000 square foot area with 0 cubic yards of clean overburden. Assumes Soil Washing Unit set-up at Rifle Range behind security									
Excavation Equipment and Personnel									
Clearing and Grubbing (10,000 square feet/day)	0.50	days	@	$5,000	/day	$2,500			
Excavate and Stockpile Non-Impacted Material	0	cy	@	$18	/cy	$0			
Excavate and Stockpile Impacted Material	400	cy	@	$18	/cy	$7,200			
Backfill Excavation with Non-Impacted Material	0	cy	@	$10	/cy	$0			
Backfill Excavation with Imported Gravel	0	cy	@	$38	/cy	$0			
Liners and Covers for Stockpiles	8280.0	sq ft	@	$0.26	/sf	$2,153			
Per Diem (3) and Vehicle	5	days	@	$520	/day	$2,600			
Change Out Operator (2) & Laborers (1)	0.2	ea	@	$4,500	ea	$1,071			Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis									Assumes 3 samples from each hotspot + 3 dupes from RR
Confirmation Samples (RCRA metals)	27	samples	@	$194	each	$5,238			
Confirmation Samples (Total lead, TCLP-lead)	16	samples	@	$160	each	$2,560			
Environmental Consultant									
Project Management	10	hours	@	$140	/hour	$1,400			2 hours per work day
Excavation Monitoring and Sampling (2 person)	5	days	@	$1,800	/day	$9,000			Same hours as excavation crew
Per Diem (2) and Vehicle	5	days	@	$380	/day	$1,900			
Miscellaneous Equipment	5	days	@	$200	/day	$1,000			
Change Out Engineer/Geologist/Env. Scientist (2)	0.2	ea	@	$3,000	ea	$714			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	200	hours	@	$100	/hour	$20,000			Assumes work plan effort shared with multiple sites and stand
Contingency (15%)						$8,600			alone cleanup report for each site
Treatment Efforts							$327,884		
Soil Washing									
Rental Property for Treatment Area (15,000 sq ft)	2.0	mos	@	$150.00	/mo	$300			$0.01 per square foot per month
Transport Impacted Material to Soil Treatment Area	400	cy	@	$5	/cy	$2,000			Assumes set-up at Rifle Range behind security fence
Process Soil Labor and Fuel	600	tons	@	$300	/ton	$180,000			TerraWash
Stockpile Cleaned Material	400	cy	@	$18	/cy	$7,200			
Per Diem (4) and Vehicle	60	days	@	$660	/day	$39,600			
Laboratory Analytical Sample Analysis									1 sample per 200 cubic yards to 2,000 cy and then 1 sample per
Confirmation Samples (RCRA metals)	5	samples	@	$194	each	$970			500 cubic yards plus 20% QC; Minimum 4 samples
Confirmation Samples (Total lead, TCLP-lead)	5	samples	@	$160	each	$800			Assumes 351 cy from RR (includes 1 dupe)
Environmental Consultant									
Project Management	120	hours	@	$140	/hour	$16,800			2 hours per work day
Treatment Monitoring	5.0	days	@	$900	/day	$4,500			1 day per week
Per Diem (1) and Vehicle	5.0	days	@	$240	/day	$1,200			
Travel to Site (1 person)	5.0	ea	@	$1,500	ea	$7,500			1 day per week
Change Out Engineer/Geologist/Env. Scientist (1)	2.9	ea	@	$1,500	ea	$4,286			
Work Plan and Reporting	200	hours	@	$100	/hour	$20,000			Assumes work plan effort shared with multiple sites and stand
Contingency (15%)						$42,728			alone cleanup report for each site
Annual O&M Costs								**$0**	
Future Costs								**$18,002**	
Decommissioning Efforts							$18,002		
Decommissioning LTTD									
Transport Clean Material to Excavation Site	400.0	cy	@	$10	/cy	$4,000			Assumes set-up at Rifle Range behind security fence
Backfill Excavation with Treated Material	400.0	cy	@	$10	/cy	$4,000			
Per Diem (3) and Vehicle (1)	1.00	days	@	$520	/day	$520			
Change Out Operator (2) & Laborers (1)	0.05	ea	@	$4,500	ea	$214			Change out crew every 21 days (assumes work at multiple sites)
Environmental Consultant									
Project Management	2.00	hours	@	$140	/hour	$280			2 hours per work day
Decommissioning Monitoring	1.00	days	@	$900	/day	$900			Same hours as treatment crew
Per Diem (1) and Vehicle	1.00	days	@	$240	/day	$240			
Travel to Site (1 person)	1.00	days	@	$1,500	/day	$1,500			
Reporting	40.0	hours	@	$100	/hour	$4,000			Assumes work plan effort shared with multiple sites and stand
Contingency (15%)						$2,348			alone cleanup report for each site
							Alternative 11 - Soil Washing Total:	**$544,490**	

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST		TOTAL COST PER YEAR		DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER CY*
Mobilization/Demobilization Costs	1	$132,667		$132,667		0.935	$123,988	-
Capital Cost	1	$393,821		$393,821		0.935	$368,057	$920
Annual O&M Cost	1	$0		$0		0.935	0	$0
Future Cost	1	$18,002		$18,002		0.935	16825	$42
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)							**$384,882**	$962

* Average cost per cubic yard is for treating a site having an estimated volume of 400 cubic yards of impacted soil.

TABLE C.12 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 12 - CAPPING

Alternative 12 - Capping								COSTS	Notes
Mobilization/Demobilization Costs								**$5,520**	
Equipment and Personnel Mobilization/Demobilization Effort							$5,520		
Earthwork Equipment and Personnel									
Excavator/Backhoe - Local	1.0	lump sum	@	$500	ea	$500			Assumes mobilization/demobilization efforts for Year 1 (clearing and capping) for this technology for 82,150 sq ft - Present Value Analysis Table shows costs
End Dump - Local	1.0	lump sum	@	$500	ea	$500			
Loader - Local	1.0	lump sum	@	$500	ea	$500			
Operator (2) & Laborers (1) - Local	1.0	lump sum	@	$300	ea	$300			
Environmental Consultant									
Engineer/Geologist/Env. Scientist (2)	1.0	ea	@	$3,000	ea	$3,000			
Contingency (15%)						$720			
Capital Costs								**$489,887**	
Cap Construction Effort							$489,887		
(Assumes cap installed over 82,150 square foot area)									
Earthwork Equipment and Personnel									
Clearing and Grubbing (10,000 square feet/day)	8.2	days	@	$5,000	/day	$41,000			Remove vegetation from 82,150 square feet site
Place Geotextile Liner	20.0	hours	@	$310	/hr	$6,200			Excavator and 2 Laborers
Place Infiltration Layer (1.5 feet)	5248.5	cy	@	$38	/cy	$199,442			
Place Erosion Control Layer (0.5 feet)	1749.5	cy	@	$38	/cy	$66,481			
Vegetate Capped Area - Hydroseed	82150.0	sq ft	@	$0.15	/sf	$12,323			
Geotextile Liner	82150.0	sq ft	@	$0.50	/sf	$41,075			20-mil petroleum resistant liner
Per Diem (3) and Vehicle	10.0	days	@	$520	/day	$5,200			
Change Out Operator (2) & Laborers (1)	1.0	ea	@	$4,500	ea	$4,500			Change out crew every 21 days (assumes work at multiple sites)
Laboratory Analytical Sample Analysis									
Fill Samples (DRO, VOCs, SVOCs, metals)	4.0	samples	@	$435	each	$1,740			Analyze samples of fill material to document that it is clean
Environmental Consultant									
Project Management	20.0	hours	@	$140	/hour	$2,800			2 hours per work day
Monitoring and Sampling (2 person)	10.0	days	@	$1,800	/day	$18,000			Same hours as capping crew
Per Diem (2) and Vehicle	10.0	days	@	$380	/day	$3,800			
Miscellaneous Equipment	10.0	days	@	$200	/day	$2,000			
Change Out Engineer/Geologist/Env. Scientist (2)	0.5	ea	@	$3,000	ea	$1,429			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	200	hours	@	$100	/hour	$20,000			Assumes work plan effort shared with multiple sites and stand alone cleanup report for each site
Contingency (15%)						$63,898			
							Alternative 12 - Capping Total:	**$495,407**	

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST		TOTAL COST PER YEAR		DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER CY*
Mobilization/Demobilization Costs	1	$5,520		$5,520		1	$5,520	-
Capital Cost	1	$489,887		$489,887		1	$489,887	$70
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)							**$489,887**	$70

* Average cost per cubic yard is for capping a site having an estimated impacted surface area of 82,150 square feet.

TABLE C.13 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 13 - AIR SPARGING AND VAPOR EXTRACTION SYSTEM

Alternative 13 - Air Sparging and Vapor Extraction System

AOC C6									
								COSTS	
Mobilization/Demobilization Costs								**$0**	
Equipment and Personnel Mobilization/Demobilization Effort							$0		
Air Sparge Well Equipment and Personnel									
Tubex Drill Rig Mob/Demob	0	lump sum	@	$32,500	ea	$0			Assumes that Alternative 6 - Bioventing will be implemented at AOC C6 to treat the impacted soil and that the Vapor Extraction System (VES) will have similar components and costs as the Alternative 6 - Bioventing. Assumes mobilization/demobilization costs for the Air Sparging component for this alternative for Year 1 (treatability study), Year 2 (system installation), and Year 10 (system decommissioning) will be paid for with the Biovent/VES alternative.
Driller (1), Helper (1) and Laborer	0	ea	@	$4,500	ea	$0			
Air Sparge and VES Manifold, Equipment and Personnel									
Excavator/Backhoe - Local	0	lump sum	@	$500	ea	$0			
Operator (1) & Laborers (2) - Local	0	lump sum	@	$300	ea	$0			
Environmental Consultant									
Engineer/Geologist/Env. Scientist (2)	0	ea	@	$3,000	ea	$0			
Contingency (15%)						$0			
Capital Costs								**$853,845**	
Treatability Study							$22,394		See Site Plan Figure AS-1(C6) for 5,000 sf site. C6 has 3 monitoring wells. Assumes 3 additional monitoring points for conducting VES test will be installed when Biovent alternative is installed.
(Assumes 1 injection well to 27 feet)									
Well Installation									
Tubex Drill Rig (100 ft well/day)	0.3	days	@	$4,500	/day	$1,215			1-2" well to 27 feet
2-inch Well Piping Materials and Shipping	29	lin ft	@	$25	/lf	$725			1 well to 27 feet plus 2 foot stickup
Per Diem (3)	0.3	days	@	$420	/day	$113			Same days as drill crew
Change Out Driller (1), Helper (1) and Laborer	0.01	ea	@	$4,500	ea	$58			Change out drill crew every 21 days
Laboratory Analytical Sample Analysis									
N:P:K, Het/Oil Bacteria, FOC, Grainsize, etc.	1	samples	@	$200	ea	$200			One sample per boring
Organic Vapors	4	samples	@	$200	ea	$800			Vapor samples collected at 0, 2, 4, and 8 hours after startup
GRO, DRO, VOCs, SVOCs	1	samples	@	$435	ea	$435			One sample per boring
Environmental Consultant									
Project Management	0.5	hours	@	$140	/hour	$76			2 hours per work day
Monitoring and Sampling (2 person)	2.3	days	@	$1,800	/day	$4,086			Same days as drill crew plus two days for feasibility test.
Blower Test Equipment	0.3	weeks	@	$1,800	/week	$584			1 AIS Blower and 1 VES Blower and 1 generator
Miscellaneous Equipment	2.3	days	@	$1,000	/day	$2,270			
Per Diem (2) and Vehicle	2.3	days	@	$380	/day	$863			
Change Out Engineer/Geologist/Env. Scientist (2)	0.1	ea	@	$3,000	ea	$324			
Work Plan and Reporting	80.0	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites included in Tables 6.0-2 and 6.0-3
Contingency (15%)						$2,646			
Air Sparging and VES System Installation Effort							$831,451		
(Assumes 40,000 square foot groundwater plume and air injection Radius of Influence of 13 feet. Assumes 9 injection wells per 5,000 square feet and 3 monitoring wells for first 5,000 square foot and 1 monitoring well for each additional 5,000 square foot area are needed. Assumes VES lines are installed under Biovent alternative.)									72 injection wells and 10 monitoring wells needed. C6 has 3 monitoring wells and 1 injection well will be installed for treatability study. Need 7 monitoring wells to 20 feet and 71 more injection wells to 27 feet.
Well Installation									
Tubex Drill Rig (100 ft well/day)	21	days	@	$4,500	/day	$92,565			71 injection wells to 27 feet and 7 additional 20 foot monitoring wells
2-inch Well Piping Materials and Shipping	2057	lin ft	@	$25	/lf	$51,425			71 injection wells to 27 feet and 7 monitoring wells to 20 feet
Per Diem (3)	21	days	@	$420	/day	$8,639			
Change Out Driller (1), Helper (1) and Laborer	1.0	ea	@	$4,500	ea	$4,408			Change out drill crew every 21 days
Manifold Piping and Equipment Installation									
Clearing and Grubbing (10,000 square feet/day)	0	days	@	$5,000	/day	$0			Assumes vegetation removed from site for biovent alternative
1-inch Manifold Piping Materials and Shipping	3960	lin ft	@	$20	/lf	$79,200			Piping to individual injection wells = 9 @ 55 for a 5,000 square foot site.
Excavate Trenches 3 feet wide by 4 feet deep	3360	lin ft	@	$18	/lf	$60,480			Common Trenches for manifold piping
Blower/Shed/Knockout Drum/Meters etc.	1	site	@	$50,000	/site	$50,000			8 hp air sparging blower; Assume 8 hp blower installed for biovent
Install Three-phase Electrical Supply	1	site	@	$50,000	/site	$50,000			3-Phase needed for 8 hp blowers
Chain-Link Fence for Treatment Area	35	lin ft	@	$132	/lf	$4,620			65 square foot area, 35 linear feet - assumes 100 ft of fence per day
20-mil petroleum resistant liner	46225	sf	@	$0.50	/sf	$23,113			215 feet x 215 feet liner for a 40,000 square foot site
Clean gravel cover	856	cy	@	$38	/cy	$32,529			215 feet x 215 feet liner for a 40,000 square foot site covered with 0.5 foot gravel
Per Diem (3) and Vehicle (1)	47.6	days	@	$520	/day	$24,752			Assume 100 feet per day (excavate trench, place pipe, and backfill) and 2 weeks for blower/shed setup and testing
Change Out Operator (2) & Laborers (1)	2.3	ea	@	$4,500	ea	$10,200			
Environmental Consultant									
Project Management	136.3	hours	@	$140	/hour	$19,088			2 hours per work day
Excavation Monitoring and Sampling (2 person)	68.2	days	@	$1,800	/day	$122,706			Same hours as drill and excavation crew
Miscellaneous Equipment	68.2	days	@	$200	/day	$13,634			
Per Diem (2) and Vehicle	68.2	days	@	$380	/day	$25,905			
Change Out Engineer/Geologist/Env. Scientist (2)	3.2	ea	@	$3,000	ea	$9,739			
Work Plan and Reporting	400	hours	@	$100	/hour	$40,000			Assumes part of larger work plan and report effort for all sites included in Tables 6.0-2 and 6.0-3
Contingency (15%)						$108,450			
O&M Costs								**$75,260**	
Long-Term Treatment Efforts							$75,260		
Air Sparge and VES									
Treatment System Maintenance Labor (12 Months)	12.0	days	@	$800	/day	$9,600			Assumes 2 events per month, 0.5 day per event
Treatment Electricity (12 months @ 16 hp)	25.0	hp-months	@	$538	/hp-mo	$13,428			1 blower to inject 3 psi and 10 cfm into each of 9 injection wells (90 cfm) and a second blower to vacuum an equal amount of air (90 cfm) from VES lines for each 5,000 square foot site. Need two 1 hp blower for each 5,000 square foot of site. Assume pulse operation for 2 (12 hour) days per week or 4 days per month = 0.13 months.
Laboratory Analytical Sample Analysis									
GRO, RRO, VOCs, SVOCs - water	48.0	samples	@	$435	ea	$20,880			Assume 10 monitoring wells plus 20% QC each quarter
Organic Vapors	19.2	samples	@	$200	ea	$3,840			Assume 4 vapor samples plus 20% QC each quarter
Environmental Consultant									
Project Management	12.0	hours	@	$134	/hour	$1,608			2 hours per work day
Treatment Monitoring and Sampling (1 person)	6.0	days	@	$900	/day	$5,400			Assumes 1 event per month, 0.5 day per event
Per Diem (1) and Vehicle	6.0	days	@	$240	/day	$1,440			Assumes shared between sites
Travel to Site (1 person)	0.55	ea	@	$1,500	ea	$818			Assumes travel shared between 22 sites eligible for bioventing
Change Out Engineer/Geologist/Env. Scientist (1)	0.3	ea	@	$1,500	ea	$429			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80.0	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites included in Tables 6.0-2 and 6.0-3
Contingency (15%)						$9,816			

TABLE C.13 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 13 - AIR SPARGING AND VAPOR EXTRACTION SYSTEM

Alternative 13 - Air Sparging and Vapor Extraction System

	AOC C6								
								COSTS	
Future Capital Costs (One Time at End of Treatment)								**$210,478**	
Decommissioning Efforts							$210,478		
Well Decommissioning									
Remove Chain-Link Fence (150 feet/day)	0.2	days	@	$1,750	/day	$408			580 Backhoe with Operator and 2 laborers
Tubex Drill Rig (100 feet/day)	21.4	days	@	$4,500	/day	$96,480			72 injection wells to 27 feet plus 10 monitoring wells to 20 feet
Per Diem (3)	21.4	days	@	$420	/day	$9,005			
Change Out Driller (1), Helper (1) and Laborer	1.0	ea	@	$4,500	ea	$4,594			
Environmental Consultant									
Project Management	42.9	hours	@	$134	/hour	$5,746			2 hours per work day
Decommissioning Monitoring	21.4	days	@	$900	/day	$19,296			Same hours as drill crew
Per Diem (1) and Vehicle	21.4	days	@	$240	/day	$5,146			
Travel to Site (1 person)	0.55	ea	@	$1,500	ea	$818			Assumes travel shared between 22 sites eligible for bioventing
Change Out Engineer/Geologist/Env. Scientist (1)	1.0	ea	@	$1,500	ea	$1,531			Change out crew every 21 days (assumes work at multiple sites)
Reporting	400.0	hours	@	$100	/hour	$40,000			Assumes stand alone cleanup report for each site
Contingency (15%)						$27,454			
				Alternative 13 - Air Sparge/Vapor Extraction Total (C6):				**$1,139,583**	

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST		TOTAL COST PER YEAR		DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER SQUARE FOOT*
Mobilization/Demobilization Costs	1	$0		$0		0.935	$0	-
Mobilization/Demobilization Costs	10	$0		$0		0.508	$0	-
Capital Cost	1	$853,845		$853,845		0.935	$797,986	$20
O&M Cost (Year 1)	1	$75,260		$75,260		0.935	$70,336	$2
O&M Cost (Year 2)	2	$75,260		$75,260		0.873	$65,735	$2
O&M Cost (Year 3)	3	$75,260		$75,260		0.816	$61,434	$2
O&M Cost (Year 4)	4	$75,260		$75,260		0.763	$57,415	$1
O&M Cost (Year 5)	5	$75,260		$75,260		0.713	$53,659	$1
O&M Cost (Year 6)	6	$75,260		$75,260		0.666	$50,149	$1
O&M Cost (Year 7)	7	$75,260		$75,260		0.623	$46,868	$1
O&M Cost (Year 8)	8	$75,260		$75,260		0.582	$43,802	$1
O&M Cost (Year 9)	9	$75,260		$75,260		0.544	$40,936	$1
Future Capital Cost (one time)	10	$210,478		$210,478		0.508	$106,996	$3
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)							**$1,395,317**	$35

* Average cost per square feet is for treating AOC C6 having a groundwater plume with an areal extent of 40,000 square feet.

TABLE C.13 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 13 - AIR SPARGING AND VAPOR EXTRACTION SYSTEM

Alternative 13 - Air Sparging and Vapor Extraction System

AOC DAST7									
								COSTS	
Mobilization/Demobilization Costs								**$0**	
Equipment and Personnel Mobilization/Demobilization Effort							$0		
Air Sparge Well Equipment and Personnel									
Tubex Drill Rig Mob/Demob	0	lump sum	@	$32,500	ea	$0			Assumes that Alternative 6 - Bioventing will be implemented at AOC DAST7 to treat the impacted soil and that the Vapor Extraction System (VES) will have similar components and costs as the Alternative 6 - Bioventing. Assumes mobilization/demobilization costs for the Air Sparging component for this alternative for Year 1 (treatability study), Year 2 (system installation), and Year 10 (system decommissioning) will be paid for with the Biovent/VES alternative.
Driller (1), Helper (1) and Laborer	0	ea	@	$4,500	ea	$0			
Air Sparge and VES Manifold, Equipment and Personnel									
Excavator/Backhoe - Local	0	lump sum	@	$500	ea	$0			
Operator (1) & Laborers (2) - Local	0	lump sum	@	$300	ea	$0			
Environmental Consultant									
Engineer/Geologist/Env. Scientist (2)	0	ea	@	$3,000	ea	$0			
Contingency (15%)						$0			
Capital Costs								**$882,684**	
Treatability Study							$70,193		See Site Plan Figure AS-1(AST7) for 5,000 sf site. AST7 has 1 monitoring wells. Assumes 3 additional monitoring points for conducting VES test will be installed when Biovent alternative is installed.
(Assumes 1 injection well to 66 feet and 2 additional monitoring wells to 58 feet.)									
Well Installation									
Tubex Drill Rig (50 ft well/day)	3.6	days	@	$4,500	/day	$16,290			1-2" wells to 66 feet and 2-2" wells to 58 feet
2-inch Well Piping Materials and Shipping	188.0	lin ft	@	$25	/lf	$4,700			1 well to 66 feet and 2 wells to 58 feet plus 2 foot stickup
Per Diem (3)	3.6	days	@	$420	/day	$1,520			Same days as drill crew
Change Out Driller (1), Helper (1) and Laborer	0.2	ea	@	$4,500	ea	$776			Change out drill crew every 21 days
Laboratory Analytical Sample Analysis									
N:P:K, Het/Oil Bacteria, FOC, Grainsize, etc.	3	samples	@	$200	ea	$600			One sample per boring
Organic Vapors	3	samples	@	$200	ea	$600			Vapor samples collected at 0, 2, 4, and 8 hours after startup
GRO, DRO, VOCs, SVOCs	5	samples	@	$435	ea	$2,175			One sample per boring and one sample per monitoring well
Environmental Consultant									
Project Management	15.2	hours	@	$140	/hour	$2,134			2 hours per work day
Monitoring and Sampling (2 person)	7.6	days	@	$1,800	/day	$13,716			Same days as drill crew plus two days to develop wells and two days for feasibility test.
Blower Test Equipment	1.1	weeks	@	$1,800	/week	$1,959			1 AIS Blower and 1 VES Blower and 1 generator
Miscellaneous Equipment	7.6	days	@	$1,000	/day	$7,620			
Per Diem (2) and Vehicle	7.6	days	@	$380	/day	$2,896			
Change Out Engineer/Geologist/Env. Scientist (2)	0.4	ea	@	$3,000	ea	$1,089			
Work Plan and Reporting	80	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites included in Tables 6.0-2 and 6.0-3
Contingency (15%)						$6,118			
Air Sparging and VES System Installation Effort							$812,491		
(Assumes 16,000 square foot groundwater plume and air injection Radius of Influence of 13 feet. Assumes 9 injection wells per 5,000 square feet and 3 monitoring wells for first 5,000 square foot and 1 monitoring well for each additional 5,000 square foot area are needed. Assumes VES wells are installed under Biovent alternative.)									30 injection wells and 6 monitoring wells needed. D-AST7 has 1 monitoring well and 2 monitoring wells and 1 injection well will be installed for treatability study. Need 3 monitoring wells to 58 feet and 29 more injection wells to 66 feet.
Well Installation									
Tubex Drill Rig (50 ft well/day)	42	days	@	$4,500	/day	$187,920			29 injection wells to 66 feet and 3 monitoring wells to 58.
2-inch Well Piping Materials and Shipping	2088	lin ft	@	$25	/lf	$52,200			29 injection wells to 66 feet and 3 monitoring wells to 58.
Per Diem (3)	42	days	@	$420	/day	$17,539			
Change Out Driller (1), Helper (1) and Laborer	2.0	ea	@	$4,500	ea	$8,949			Change out drill crew every 21 days
Manifold Piping and Equipment Installation									
Clearing and Grubbing (10,000 square feet/day)	0	days	@	$5,000	/day	$0			Assumes vegetation removed from site for biovent alternative
1-inch Manifold Piping Materials and Shipping	1584	lin ft	@	$20	/lf	$31,680			Piping to individual injection wells = 9 @ 55 for a 5,000 square foot site.
Excavate Trenches 3 feet wide by 4 feet deep	1344	lin ft	@	$18	/lf	$24,192			Common Trenches for manifold piping
Blowers/Shed/Knockout Drum/Meters etc.	1	site	@	$50,000	/site	$50,000			4 hp air sparging blower; Assume 4 hp blower installed for biovent
Install Three-phase Electrical Supply	1	site	@	$50,000	/site	$50,000			3-Phase needed for 4 hp blowers
Chain-Link Fence for Treatment Area	35	lin ft	@	$132	/lf	$4,620			65 square foot area, 35 linear feet - assumes 100 ft of fence per day
20-mil petroleum resistant liner	21025	sf	@	$0.50	/sf	$10,513			145 feet x 145 feet liner for a 16,000 square foot site
Clean gravel cover	389	cy	@	$38	/cy	$14,795			145 feet x 145 feet liner for a 16,000 square foot site covered with 0.5 foot gravel
Per Diem (3) and Vehicle (1)	27.4	days	@	$520	/day	$14,269			Assume 100 feet per day (excavate trench, place pipe, and backfill) and 2 weeks for blower/shed setup and testing
Change Out Operator (2) & Laborers (1)	1.3	ea	@	$4,500	ea	$5,880			
Environmental Consultant									
Project Management	138.4	hours	@	$140	/hour	$19,376			2 hours per work day
Excavation Monitoring and Sampling (2 person)	69.2	days	@	$1,800	/day	$124,560			Same hours as drill and excavation crew
Miscellaneous Equipment	69.2	days	@	$200	/day	$13,840			
Per Diem (2) and Vehicle	69.2	days	@	$380	/day	$26,296			
Change Out Engineer/Geologist/Env. Scientist (2)	3.3	ea	@	$3,000	ea	$9,886			
Work Plan and Reporting	400.0	hours	@	$100	/hour	$40,000			Assumes part of larger work plan and report effort for all sites included in Tables 6.0-2 and 6.0-3
Contingency (15%)						$105,977			
O&M Costs								**$63,398**	
Long-Term Treatment Efforts							$63,398		
Air Sparge and VES									
Treatment System Maintenance Labor (12 Months)	12.0	days	@	$500	/day	$6,000			Assumes 2 events per month, 0.5 day per event
Treatment Electricity (12 months @ 8 hp)	12.5	hp-months	@	$538	/hp-mo	$6,714			1 blower to inject 3 psi and 10 cfm into each of 9 injection wells (90 cfm) and a second blower to vacuum an equal amount of air (90 cfm) from VES lines for each 5,000 square foot site. Need two 1 hp blower for each 5,000 square foot of site. Assume pulse operation for 2 (12 hour) days per week or 4 days per month = 0.13 months.
Laboratory Analytical Sample Analysis									
GRO, RRO, VOCs, SVOCs	48.0	samples	@	$435	ea	$20,880			Assume 6 monitoring wells plus 20% QC each quarter
Organic Vapors	19.2	samples	@	$200	ea	$3,840			Assume 4 vapor samples plus 20% QC each quarter
Environmental Consultant									
Project Management	12.0	hours	@	$134	/hour	$1,608			2 hours per work day
Treatment Monitoring and Sampling (1 person)	6.0	days	@	$900	/day	$5,400			Assumes 1 event per month, 0.5 day per event
Per Diem (1) and Vehicle	6.0	days	@	$240	/day	$1,440			Assumes shared between sites
Travel to Site (1 person)	0.55	ea	@	$1,500	ea	$818			Assumes travel shared between 22 sites eligible for bioventing
Change Out Engineer/Geologist/Env. Scientist (1)	0.3	ea	@	$1,500	ea	$429			Change out crew every 21 days (assumes work at multiple sites)
Work Plan and Reporting	80.0	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites included in Tables 6.0-2 and 6.0-3
Contingency (15%)						$8,269			

TABLE C.13 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 13 - AIR SPARGING AND VAPOR EXTRACTION SYSTEM

Alternative 13 - Air Sparging and Vapor Extraction System

	AOC DAST7								
								COSTS	
Future Capital Costs (One Time at End of Treatment)								**$224,473**	
Decommissioning Efforts							$224,473		
Well Decommissioning									
Remove Chain-Link Fence (150 feet/day)	0.2	days	@	$1,750	/day	$408			580 Backhoe with Operator and 2 laborers
Tubex Drill Rig (100 feet/day)	23.3	days	@	$4,500	/day	$104,760			30 injection wells to 66 feet plus 6 monitoring wells to 58 feet
Per Diem (3)	23.3	days	@	$420	/day	$9,778			
Change Out Driller (1), Helper (1) and Laborer	1.1	ea	@	$4,500	ea	$4,989			
Environmental Consultant									
Project Management	46.6	hours	@	$134	/hour	$6,239			2 hours per work day
Decommissioning Monitoring	23.3	days	@	$900	/day	$20,952			Same hours as drill crew
Per Diem (1) and Vehicle	23.3	days	@	$240	/day	$5,587			
Travel to Site (1 person)	0.55	ea	@	$1,500	ea	$818			Assumes travel shared between 22 sites eligible for bioventing
Change Out Engineer/Geologist/Env. Scientist (1)	1.1	ea	@	$1,500	ea	$1,663			Change out crew every 21 days (assumes work at multiple sites)
Reporting	400.0	hours	@	$100	/hour	$40,000			Assumes stand alone cleanup report for each site
Contingency (15%)						$29,279			

Alternative 13 - Air Sparge/Vapor Extraction Total (DAST7): $1,170,555

PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER SQUARE FOOT*
Mobilization/Demobilization Costs	1	$0	$0	0.935	$0	-
Mobilization/Demobilization Costs	10	$0	$0	0.508	$0	-
Capital Cost	1	$882,684	$882,684	0.935	$824,938	$52
O&M Cost (Year 1)	1	$63,398	$63,398	0.935	$59,251	$4
O&M Cost (Year 2)	2	$63,398	$63,398	0.873	$55,375	$3
O&M Cost (Year 3)	3	$63,398	$63,398	0.816	$51,752	$3
O&M Cost (Year 4)	4	$63,398	$63,398	0.763	$48,366	$3
O&M Cost (Year 5)	5	$63,398	$63,398	0.713	$45,202	$3
O&M Cost (Year 6)	6	$63,398	$63,398	0.666	$42,245	$3
O&M Cost (Year 7)	7	$63,398	$63,398	0.623	$39,481	$2
O&M Cost (Year 8)	8	$63,398	$63,398	0.582	$36,898	$2
O&M Cost (Year 9)	9	$63,398	$63,398	0.544	$34,484	$2
Future Capital Cost (one time)	10	$224,473	$224,473	0.508	$114,111	$7
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)					**$1,352,104**	$85

* Average cost per square feet is for treating AOC DAST7 having a groundwater plume with an areal extent of 16,000 square feet.

TABLE C.13 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 13 - AIR SPARGING AND VAPOR EXTRACTION SYSTEM

Alternative 13 - Air Sparging and Vapor Extraction System

Item	Qty	Unit	@	Unit Cost	Per	Cost	Subtotal	COSTS	Notes
AOC L1									
Mobilization/Demobilization Costs								**$0**	
Equipment and Personnel Mobilization/Demobilization Effort							$0		
Air Sparge Well Equipment and Personnel									
Tubex Drill Rig Mob/Demob	0	lump sum	@	$32,500	ea	$0			Assumes that Alternative 6 - Bioventing will be implemented at AOC L1 to treat the impacted soil and that the Vapor Extraction System (VES) will have similar components and costs as the Alternative 6 - Bioventing. Assumes mobilization/demobilization costs for the Air Sparging component for this alternative for Year 1 (treatability study), Year 2 (system installation), and Year 10 (system decommissioning) will be paid for with the Biovent/VES alternative.
Driller (1), Helper (1) and Laborer	0	ea	@	$4,500	ea	$0			
Air Sparge and VES Manifold, Equipment and Personnel									
Excavator/Backhoe - Local	0	lump sum	@	$500	ea	$0			
Operator (1) & Laborers (2) - Local	0	lump sum	@	$300	ea	$0			
Environmental Consultant									
Engineer/Geologist/Env. Scientist (2)	0	ea	@	$3,000	ea	$0			
Contingency (15%)						$0			
Capital Costs								**$113,692**	
Treatability Study							$28,798		See Site Plan Figure AS-1(L1) for 630 sf site. L1 has 2 monitoring wells. Assumes 3 additional monitoring points for conducting VES test will be installed when Biovent alternative is installed.
(Assumes 1 injection well to 23 feet and 2 monitoring wells to 16 feet)									
Well Installation									
Tubex Drill Rig (100 ft well/day)	0.4	days	@	$4,500	/day	$1,755			1-2" well to 23 feet and 1-2" wells to 16 feet.
2-inch Well Piping Materials and Shipping	43	lin ft	@	$25	/lf	$1,075			1 well to 23 feet and 1 well to 16 feet plus 2 foot stickups
Per Diem (3)	0.4	days	@	$420	/day	$164			Same days as drill crew
Change Out Driller (1), Helper (1) and Laborer	0.02	ea	@	$4,500	ea	$84			Change out drill crew every 21 days
Laboratory Analytical Sample Analysis									
N:P:K, Het/Oil Bacteria, FOC, Grainsize, etc.	2	samples	@	$200	ea	$400			One sample per boring
Organic Vapors	2	samples	@	$200	ea	$400			Vapor samples collected at 0, 2, 4, and 8 hours after startup
GRO, DRO, VOCs, SVOCs	4	samples	@	$435	ea	$1,740			One sample per boring and one sample per monitoring well
Environmental Consultant									
Project Management	0.8	hours	@	$140	/hour	$109			2 hours per work day
Monitoring and Sampling (2 person)	4.4	days	@	$1,800	/day	$7,902			Same days as drill crew plus two days to develop wells and two days for feasibility test.
Blower Test Equipment	0.6	weeks	@	$1,800	/week	$1,129			1 AIS Blower and 1 VES Blower and 1 generator
Miscellaneous Equipment	4.4	days	@	$1,000	/day	$4,390			
Per Diem (2) and Vehicle	4.4	days	@	$380	/day	$1,668			
Change Out Engineer/Geologist/Env. Scientist (2)	0.2	ea	@	$3,000	ea	$627			
Work Plan and Reporting	40.0	hours	@	$100	/hour	$4,000			Assumes part of larger work plan and report effort for all sites included in Tables 6.0-2 and 6.0-3
Contingency (15%)						$3,355			
Air Sparging and VES System Installation Effort							$84,895		1 injection well and 3 monitoring wells needed. L1 has 2 monitoring wells and 1 monitoring well and 1 injection well will be installed for treatability study. Do not need more monitoring wells or injection
(Assumes 630 square foot groundwater plume and air injection Radius of Influence of 13 feet. Assumes no additional injection wells or monitoring wells are needed.)									
Well Installation									
Tubex Drill Rig (100 ft well/day)	0	days	@	$4,500	/day	$0			No additional injection wells or monitoring wells
2-inch Well Piping Materials and Shipping	0	lin ft	@	$25	/lf	$0			No additional injection wells or monitoring wells
Per Diem (3)	0	days	@	$420	/day	$0			
Change Out Driller (1), Helper (1) and Laborer	0.0	ea	@	$4,500	ea	$0			Change out drill crew every 21 days
Manifold Piping and Equipment Installation									
Clearing and Grubbing (10,000 square feet/day)	0	days	@	$5,000	/day	$0			Assumes vegetation removed from site for biovent alternative
1-inch Manifold Piping Materials and Shipping	30	lin ft	@	$20	/lf	$600			Piping to individual injection wells = 1 @ 30 for a 630 square foot site.
Excavate Trenches 3 feet wide by 4 feet deep	30.0	lin ft	@	$18	/lf	$540			Common Trenches for manifold piping
Blowers/Shed/Knockout Drum/Meters etc.	1	site	@	$25,000	/site	$25,000			0.5 hp air sparging blower; Assume 0.5 hp blower installed for biovent
Install Three-phase Electrical Supply	1	site	@	$25,000	/site	$25,000			1-Phase needed for 0.5 hp blowers
Chain-Link Fence for Treatment Area	35	lin ft	@	$132	/lf	$4,620			65 square foot area, 35 linear feet - assumes 100 ft of fence per day
20-mil petroleum resistant liner	1600	sf	@	$0.50	/sf	$800			40 feet x 40 feet liner for a 630 square foot site
Clean gravel cover	30	cy	@	$38	/cy	$1,126			40 feet x 40 feet liner for a 630 square foot site covered with 0.5 foot gra
Per Diem (3) and Vehicle (1)	2.3	days	@	$520	/day	$1,196			Assume 100 feet per day (excavate trench, place pipe, and backfill) and 2 days for blower/shed setup and testing
Change Out Operator (2) & Laborers (1)	0.1	ea	@	$4,500	ea	$493			
Environmental Consultant									
Project Management	4.6	hours	@	$140	/hour	$644			2 hours per work day
Excavation Monitoring and Sampling (2 person)	2.3	days	@	$1,800	/day	$4,140			Same hours as drill and excavation crew
Miscellaneous Equipment	2.3	days	@	$200	/day	$460			
Per Diem (2) and Vehicle	2.3	days	@	$380	/day	$874			
Change Out Engineer/Geologist/Env. Scientist (2)	0.1	ea	@	$3,000	ea	$329			
Work Plan and Reporting	80	hours	@	$100	/hour	$8,000			Assumes part of larger work plan and report effort for all sites included in Tables 6.0-2 and 6.0-3
Contingency (15%)						$11,073			
O&M Costs								**$23,368**	
Long-Term Treatment Efforts	80.0						$23,368		
Air Sparge and VES									
Treatment System Maintenance Labor (12 Months)	6.0	days	@	$500	/day	$3,000			Assumes 2 events per month, 0.25 day per event
Treatment Electricity (12 months @ 2 hp)	1.6	hp-months	@	$538	/hp-mo	$839			1 blower to inject 3 psi and 10 cfm into 1 injection well (10 cfm) and a second blower to vacuum an equal amount of air (10 cfm) from VES lines for a 630 square foot site. Need single-phase electricity and two 0.5 hp blowers. Assume pulse operation for 2 (12 hour) days per week or 4 days per month = 0.13 months.
Laboratory Analytical Sample Analysis									
GRO, RRO, VOCs, SVOCs	14.4	samples	@	$435	ea	$6,264			Assume 3 monitoring wells plus 20% QC each quarter
Organic Vapors	4.8	samples	@	$200	ea	$960			Assume 1 vapor sample plus 20% QC each quarter
Environmental Consultant									
Project Management	6.0	hours	@	$134	/hour	$804			2 hours per work day
Treatment Monitoring and Sampling (1 person)	3.0	days	@	$900	/day	$2,700			Assumes 1 event per month, 0.25 day per event
Per Diem (1) and Vehicle	3.0	days	@	$240	/day	$720			Assumes shared between sites
Travel to Site (1 person)	0.55	ea	@	$1,500	ea	$818			Assumes travel shared between 22 sites eligible for bioventing
Change Out Engineer/Geologist/Env. Scientist (1)	0.1	ea	@	$1,500	ea	$214			Change out crew every 21 days (assumes work at multiple sites)
Reporting	40	hours	@	$100	/hour	$4,000			Assumes part of larger work plan and report effort for all sites included in Tables 6.0-2 and 6.0-3
Contingency (15%)						$3,048			

TABLE C.13 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 13 - AIR SPARGING AND VAPOR EXTRACTION SYSTEM

Alternative 13 - Air Sparging and Vapor Extraction System

	AOC L1								
								COSTS	
Future Capital Costs (One Time at End of Treatment)								**$16,011**	
Decommissioning Efforts							$16,011		
Well Decommissioning									
Remove Chain-Link Fence (150 feet/day)	0.2	days	@	$1,750	/day	$408			580 Backhoe with Operator and 2 laborers
Tubex Drill Rig (100 feet/day)	0.7	days	@	$4,500	/day	$3,195			1 injection well to 23 feet plus 3 monitoring wells to 16 feet
Per Diem (3)	0.7	days	@	$420	/day	$298			
Change Out Driller (1), Helper (1) and Laborer	0.03	ea	@	$4,500	ea	$152			
Environmental Consultant									
Project Management	1.4	hours	@	$134	/hour	$190			2 hours per work day
Decommissioning Monitoring	0.7	days	@	$900	/day	$639			Same hours as drill crew
Per Diem (1) and Vehicle	0.7	days	@	$240	/day	$170			
Travel to Site (1 person)	0.55	ea	@	$1,500	ea	$818			Assumes travel shared between 22 sites eligible for bioventing
Change Out Engineer/Geologist/Env. Scientist (1)	0.03	ea	@	$1,500	ea	$51			Change out crew every 21 days (assumes work at multiple sites)
Reporting	80.0	hours	@	$100	/hour	$8,000			Assumes stand alone cleanup report for each site
Contingency (15%)						$2,088			
							Alternative 13 - Air Sparge/Vapor Extraction Total (L1):	**$153,070**	

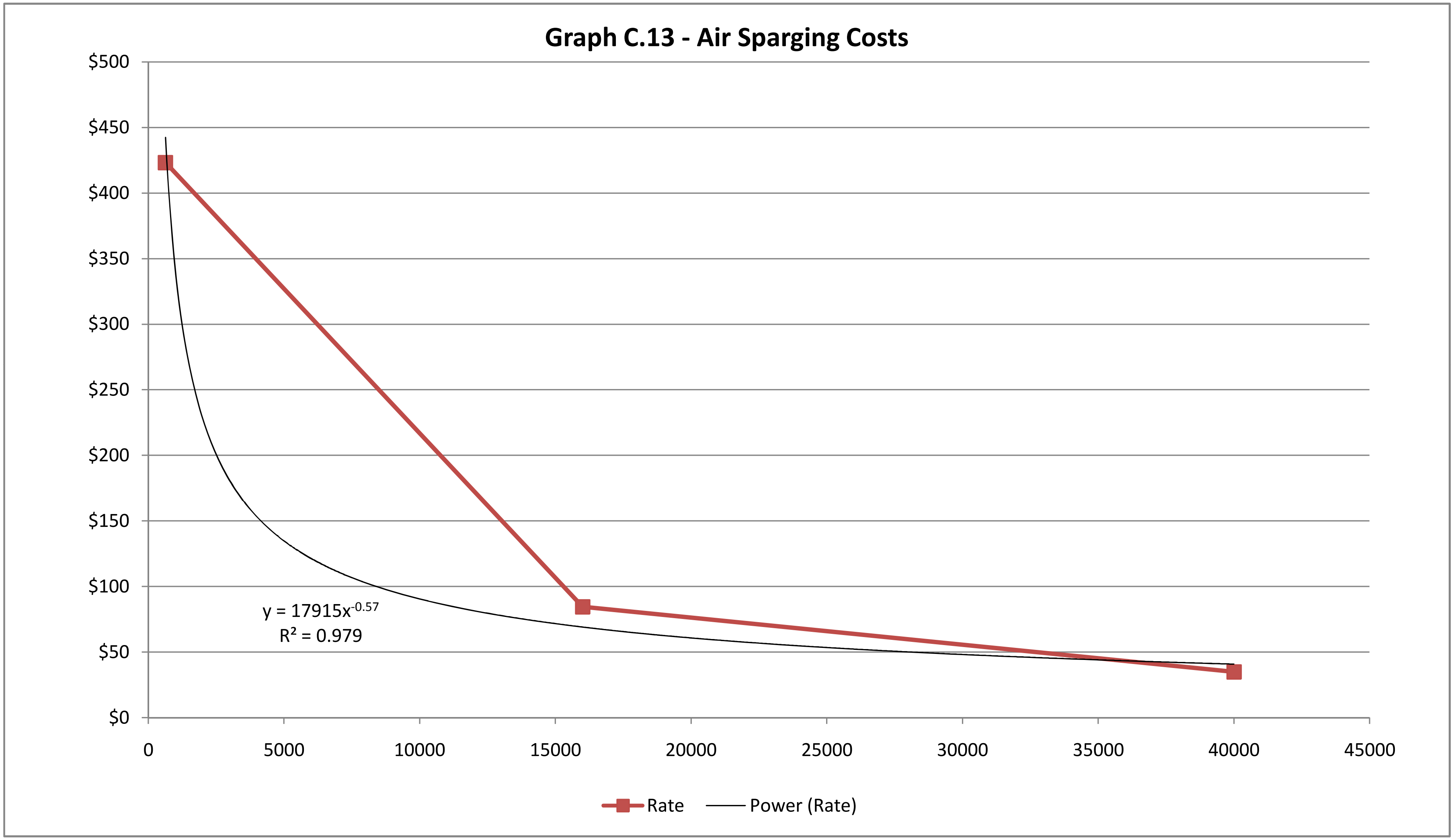
PRESENT VALUE ANALYSIS

COST TYPE	YEAR	TOTAL COST		TOTAL COST PER YEAR		DISCOUNT FACTOR (7%)	NET PRESENT VALUE	AVERAGE COST PER SQUARE FOOT*
Mobilization/Demobilization Costs	1	$0		$0		0.935	$0	-
Mobilization/Demobilization Costs	10	$0		$0		0.508	$0	-
Capital Cost	1	$113,692		$113,692		0.935	$106,254	$169
O&M Cost (Year 1)	1	$23,368		$23,368		0.935	$21,839	$35
O&M Cost (Year 2)	2	$23,368		$23,368		0.873	$20,410	$32
O&M Cost (Year 3)	3	$23,368		$23,368		0.816	$19,075	$30
O&M Cost (Year 4)	4	$23,368		$23,368		0.763	$17,827	$28
O&M Cost (Year 5)	5	$23,368		$23,368		0.713	$16,661	$26
O&M Cost (Year 6)	6	$23,368		$23,368		0.666	$15,571	$25
O&M Cost (Year 7)	7	$23,368		$23,368		0.623	$14,552	$23
O&M Cost (Year 8)	8	$23,368		$23,368		0.582	$13,600	$22
O&M Cost (Year 9)	9	$23,368		$23,368		0.544	$12,710	$20
Future Capital Cost (one time)	10	$16,011		$16,011		0.508	$8,139	$13
TOTAL NET PRESENT VALUE OF ALTERNATIVE (Mob/demob costs not included)							**$266,639**	$423

* Average cost per square feet is for treating AOC L1 having a groundwater plume with an areal extent of 630 square feet.

TABLE C.13 - ROUGH ORDER MAGNITUDE COSTS FOR ALTERNATIVE 13 - AIR SPARGING AND VAPOR EXTRACTION SYSTEM

Alternative 13 - Air Sparging and Vapor Extraction System



APPENDIX D

COMMENT RESPONSE FORMS

PROJECT: Yakutat AFB **DOCUMENT:** Remedial Screening Alternatives, December 12, 2008
REVIEW COMMENTS **LOCATION:** Yakutat, Alaska

DATE: 01/05/2008 **REVIEWER:** Carey Cossaboom **PHONE:** (907) 753-2689

Item No.	Location (page, par., sen.)	COMMENTS	Review A – Comment Accepted W – Comment Withdrawn N - Noted	Shannon & Wilson Response
1.	Table 3-1	What about Sites B2 (As), B3 (As), C1 (Cr), C7 (Metals), O1 (As)? See the Background values we came up with.	A	We will include these AOCs; however, the total number of AOCs to be considered exceeds the original scope of work.
2.	Table 3-1	Groundwater at K-1?	A	Groundwater not affected at K1 by fuel contaminants. Surface water contained metals, and will be addressed.
3.	Table 4-1 - General	You may want to consider Institutional Controls as a potential alternative.	A	IC was to be considered as an option under “no action”. We will make it clearer in the FS by including IC as a separate alternative.
4.	Table 4-1 and Table 4-4	Alternative 3 Enhanced Bioremediation - might consider Chemical Oxidation (simply say “introduce oxidizing agents” as well).	A	We will eliminate Alternative 3 Enhanced Bioremediation from Table 4.0-1 and include Chemical Oxidation using liquid hydrogen peroxide (Fenton’s Reagent oxidation) on Table 4-1 per Tom Reed’s comment.

PROJECT: Yakutat AFB **DOCUMENT:** Draft Feasibility Study , May, 2009 **REVIEW COMMENTS** **LOCATION:** Yakutat, SE Alaska				
DATE: 07/24/09		**REVIEWER:** Carey Cossaboom	**PHONE:** (907) 753-2689	
Item No.	**Location (page, par., sen.)**	**COMMENTS**	**Review** **A – Comment/Response Accepted** **W – Comment Withdrawn** **N – Noted D - Discuss**	**Shannon & Wilson Response**
1.	General	It appears that there is little consideration to site specifics as far as implementing certain remedial actions at the sites. Granted, at many sites it can be rather straightforward, but at others, the site specifics may be key to implementation. For instance:	A	Our general comment, is that there are challenges associated with developing a FS that covers about 30 sites in a single FS report. The objective of the FS is to identify preferred alternatives; thus, we had to reduce the sites to common features to develop general alternative recommendations. Without disputing the value of site-specific considerations, inclusion of unique considerations would justify site specific FS, not an area-wide FS. We will provide a discussion of site-specific constraints and assumptions for each site in Section 6.3 Site-Specific Considerations.
		Is excavation really a viable alternative at Site C2 where the drum site is essentially a swamp?	A	For Site C2, we note that the drill rig was able to access the areas surrounding Site C2 to install Borings AP-021 through AP-024 and assume that an excavator would be able to do so as well. We assume that wetland permits will need to be obtained. We also assume that excavation may need to be scheduled for mid-winter when surface and subsurface materials are frozen.
		Are there any peculiar concerns to Site D because the contamination is so close to a City Water supply.	A	In our August 2006 report, S&W recommended that a hydrogeologic investigation be conducted to evaluate the capture zones for the City Water supply wells, ARCO#1 and ARCO#2. We will provide a discussion in Section 6.3 Site-Specific Considerations indicating that a Drinking Water Well Capture Zone Study should be conducted particularly if In-Situ Chemical Oxidation is the preferred alternative.
		Should some technologies not be considered because of the potential confining layer of a deeper aquifer at Site D?	A	At Site D, we note that a confining layer was not encountered in the borings for Monitoring Wells AST5-4, AST6-3, or AST7-4 which were positioned closest to the two City Water supply wells. Monitoring Well AST5-4 was drilled to about 15 feet below the static water level. We do not anticipate that the technologies evaluated will need to be extended beyond a depth of 15 feet below the water table.
		Do you really believe that the contaminants at the K1 landfill are “hotspots”?	A	For Site K1, a “hotspot” was assumed at locations where a single surface or subsurface soil sample contained a COC. Based on further discussion with the USACE PM, the “hotspots” presented in Section 3.10 and on Figure 3.10-1 for AOC K1 will be removed. The surface material over the entire landfill will be considered impacted with COCs and the quantity of impacted soil will be revised in Tables 3.1-1 and 6.02. An additional Remedial Alternative will be introduced for capping the landfill. We will also review soil and groundwater analytical results presented on Figure 3.10-1 for accuracy. The lead in groundwater concentration shown for Well AP-045 is incorrect and should be 0.0003 mg/L. We will also provide a brief discussion in Section 3.10 noting what other analytes (especially SVOCs) have been tested for in the soil and groundwater at AOC K1. Also see Carey’s Comment No. 17.
		Does the USFS Garage at Concern M2 present any particular challenges to certain remedial alternatives? Let’s discuss adding some detail	A	We will add the USFS Garage, shown on Figures 10.1 and 10.2 of the ROST Report, to Figure 3.12-1. We will estimate the volume of impacted soil located within the footprint of the USFS Garage and provide a discussion in Section 6.3 that this impacted soil cannot be removed by excavation without disturbing the building.

PROJECT: Yakutat AFB **DOCUMENT:** Draft Feasibility Study , May, 2009 **REVIEW COMMENTS** **LOCATION:** Yakutat, SE Alaska				
DATE: 07/24/09	**REVIEWER:** Carey Cossaboom	**PHONE:** (907) 753-2689		
Item No.	**Location (page, par., sen.)**	**COMMENTS**	**Review** **A – Comment/Response Accepted** **W – Comment Withdrawn** **N – Noted D - Discuss**	**Shannon & Wilson Response**
2.	General	How comfortable are you with your cost data?	A	The rough order magnitude (ROM) cost estimates presented in Appendix C are intended to be within -30 percent and +50 percent.
		Other FS Reports we have suggest Chemical Oxidation can be much less costly than excavation.	A	We will review our cost data for Chemical Oxidation and excavation.
		The RAB (as well as I) was blown away by some of the costs. Should economies of scale be factored in for sites with much greater than 2,000 cubic yards? What about sites with much less than 2,000 cubic yards?	A	We will evaluate the costs for a site having between 2,000 cubic yards and 20,000 cubic yards as well as for a site having between 2,000 cubic yards and 20 cubic yards to see if there is an appropriate economy of scale factor that can be used.
		I'm trying to reconcile the costs in Appendix C with Table 6.0-2. I believe the Mobe/DeMobe costs are off in the Table for Alts. 5 & 6.	A	The mobe/demobe cost in Table 6.02 for Alternative No. 6 is off. There is an error in the formula in the spreadsheet for Alternative No. 6 that will be corrected. It should be the same as for Alternative No. 5.
		Why does bioventing O&M go up in cost after year one where other technologies go down?	A	Bioventing O&M costs should increase slightly after Year 1 as a result of the "Screening for Cleanup" that is planned. The Year 2 costs for O&M should be the same as Year 1.
3.	TOC	Tables and Figures should have page numbers.	A	We will leave some "Pages intentionally left blank" in the text and replace them with numbered Tables and Figures.
4.	Pg. 5, 1st par., middle	<u>Yakutat</u> Tlingit Tribe	A	We will revise to "Yakutat Tlingit Tribe."
5.	Pg. 5, 1st par., end	It's a 130,000-gallon tank. What evidence is there that the Kwann requested these structures remain? We are aware of only a vague E&E (?) reference.	A	We will revise to "130,000" and remove "as requested by Yak Tat-Kwann, Inc."
6.	Pg. 13, 1st par., end	<u>38</u> ppt TEQ	A	During the 2004 RI, ADEC accepted a screening level of 39 ppt. We will revise each occurrence of "39 ppt TEQ", where it refers to the current ARAR, to "38 ppt TEQ".
7.	Pg. 14	I believe your values are incorrect for Toluene, and Penta (sediment). There are new SQuiRT tables.	A	Yes, we did use the NOAA 1999 SQuiRT tables and are now aware that 2008 SQuiRT tables are available. We will revise the FS using the 2008 SQuiRT table values.
8.	Pg. 31, last sentence	And Table C GW Cleanup Levels	A	We will add "and Table C groundwater cleanup levels."

PROJECT: Yakutat AFB **DOCUMENT:** Draft Feasibility Study , May, 2009 **REVIEW COMMENTS** **LOCATION:** Yakutat, SE Alaska				
DATE: 07/24/09	**REVIEWER:** Carey Cossaboom	**PHONE:** (907) 753-2689		
Item No.	**Location (page, par., sen.)**	**COMMENTS**	**Review** **A – Comment/Response Accepted** **W – Comment Withdrawn** **N – Noted D - Discuss**	**Shannon & Wilson Response**

9.	Pg. 39, 3rd par.	The second sentence about sampling the city wells seems out of place here. What were the results? Move the 2nd sentence to before the last sentence.	N A	The Yakutat City water wells, ARCO #1 and #2, are located approximately 75 feet northwest and immediately south of former Tank AST8. At the end of the same paragraph, the text indicates that DRO or other target analytes were not detected in water samples collected from ARCO Wells #1 and #2. We will move the 2nd sentence to before the last sentence.
10.	Pg. 42, 3rd par.	Please check penta SQuiRT value.	A	We will revise.
11.	Pg. 44, 2nd par	ENSR, not ENR	A	We will revise.
12.	Pg. 47, 2nd par.	It's a 130,000-gallon tank. Without direct evidence, we should leave out "… ~~as requested by Yak-Tat Kwaan, Inc~~."	A	We will revise to "130,000" and remove "as requested by Yak Tat-Kwann, Inc."
13.	Pg. 48, Sec. 3.9.2, 2nd par.	"The sediment sample was not analyzed for dioxins" is repeated twice. Eliminate the first instance.	A	We will revise.
14.	Pg. 48, Sec. 3.9.2, 3rd par.	Next to last sen. = misplaced period. Grammar error; one period only.	N A	We presently have periods after both the sentence and the following reference. The source of the information in the preceding paragraph was obtained from the reference cited. We will remove the period after the sentence and retain the period after the reference.
15.	Pg. 49, 1st par.	H2 is not considered in the FS because there are no COCs, not because the Tribe plans to conduct further investigations.	A	We will remove "We understand that the Yakutat Tlingit Tribe Native Association plans to conduct further evaluation of dioxins at AOC H2 and, therefore," Also see BGES comment No. 33.
16.	Pg. 49, Sec. 3.10, 3rd par.	The second and third sentences should be moved so that the soil and water sample statements are not disjointed.	A	The second and third sentences will be cut and pasted as the fourth and fifth sentences in the same paragraph.

PROJECT: Yakutat AFB **DOCUMENT:** Draft Feasibility Study , May, 2009
REVIEW COMMENTS **LOCATION:** Yakutat, SE Alaska

DATE: 07/24/09 **REVIEWER:** Carey Cossaboom **PHONE:** (907) 753-2689

Item No.	Location (page, par., sen.)	COMMENTS	Review A – Comment/Response Accepted W – Comment Withdrawn N – Noted D - Discuss	Shannon & Wilson Response
17.	Pg. 50, In summary	The idea of hotspots in a landfill is illogical. There are bound to be many more "hotspots" within the landfill. The emphasis of a discussion on the landfill should be that the Corps is primarily concerned if the landfill is leaching contaminants to the environment. Landfills can be assumed to contain COCs. Landfill removal is typically not conducted unless there is pressing reason for such.	A	The landfill was covered with 2 feet of gravelly sand during the 1984 cleanup efforts. Most of the "hotspots" were detected within the cover in surface soil from 0 to 2 feet bgs. Two subsurface soil hotspots, ranging from 2 to 4 feet deep, are included in this FS. Based on further discussion with the USACE PM, the "hotspots" presented in Section 3.10 and on Figure 3.10-1 for AOC K1 will be removed. The surface material over the entire landfill will be considered impacted with COCs. An additional Remedial Alternative will be introduced for capping the landfill. Also see Carey's Comment No. 1.
18.	Pg. 56, Sec 3.11.4, last sen.	The wording is off.	A	We will clarify.
19.	Pg. 58, last par., 1st sen.	"As and Cr were the only ~~other~~ analytes detected …."	A	We will clarify that arsenic and chromium were the only analytes detected.
20.	Pg. 60, last par. of AOC M2	It should be mentioned that the SW end of the contamination trails under a Forest Service garage building. Does your estimated volume of 1,441 cy include the portion under the garage?	A A	We will add the USFS Garage, shown on Figures 10.1 and 10.2 of the ROST Report, to Figure 3.12-1. Also see Carey's Comment No. 1. We will estimate the volume of impacted soil located within the footprint of the USFS Garage and provide a discussion in Section 6.3 that this impacted soil cannot be removed by excavation without disturbing the building.
21.	P.62, N1 summary par.	Please change second and third sentences as follows: USACE was not successful in obtaining a Right of Entry to further investigate the contaminants at Site N1. USACE hopes to investigate this site further in the near future.	A	The second and third sentences will be revised accordingly.
22.	Pg. 63, O1 summary par.	Lead in GW should not be a concern.	A	The maximum lead concentration detected was 0.0452 mg/L in Monitoring Well AP-101 which exceeds the ARAR. No additional sampling of Monitoring Well AP-101 was conducted. Monitoring Well AP-101 was not available for sampling. We will add a sentence to the end of the fourth paragraph in Section 3.14 stating "According to the USACE PM, the non-detectable lead concentrations in groundwater at the locations of Monitoring Wells AP-99 and AP-100 are considered representative of the groundwater conditions at Monitoring Well AP-101." Lead in groundwater will not be considered a COC in the last paragraph of Section 3.14.
23.	Pg. 63, Sec. 3.15	It's Kardy Lake not Kandy Lake.	A	We will revise.

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DATE: 07/24/09		**REVIEWER:** Carey Cossaboom	**PHONE:** (907) 753-2689	
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24.	Table 3.1-1	Please alternate shading of lines for easier reading.	A	We will shade alternate lines for easier reading.
25.	Fig. 3.5-9	I'm curious why the Area for Remedial Action bulges out to the NE at the east side of the AST7 foundation. All the samples around it are "clean".	A	ROST LIF Boring YAK D 021 was interpreted as containing DRO concentrations exceeding cleanup criteria from 0 to 2 feet within the bulge. The ROST LF probe locations will be shown on the site plans. We will also check the volume of contaminated soil for D-AST7.
26.	Fig. 3.12-1	Where is the USFS Garage?	A	We will add the USFS Garage, shown on Figures 10.1 and 10.2 of the ROST Report, to Figure 3.12-1. Also see Carey's Comment No. 1.
27.	Table 5.2-1	Alternative 4 is indicated as a Remedial Alternative for the L Concern, but it is not costed in Table 6.0-2	A	The costs for Alternative 4 for the L Concern need to be provided in Table 6.0-2.
28.	Pg. 89, 1st par.	I'm not following how mobilization at Concern C6 for LTTD costs $350K. Table 6.0-2 indicates it would be $289K plus $6K ($295K).	A	Mobilization costs at Concern C6 for Excavation and LTTD (Table 6.0-2) plus monitored natural attenuation of soil (Table 6.0-2) and groundwater (Table 6.0-3) are $290K + $6K + $52K ~ $350K. Further clarification will be provided.
29.	Table 6.0-2	Title is messed up. Rows 2 and 3 verbiage has improper justification (truncated words). Note 3 has "to" misspelled. Please provide alternate shading for easier reading. Double print	A A A	The electronic version (pdf) has truncated words in Rows 2 and 3 and Note 3. We will revise. We will shade alternate lines in the tables for easier reading. The double printing error and other printing errors on Table 6.0-2 have been corrected for the Final version. Also, certain sections of the report, such as Appendix B, will be double-sided.
30.	Table 6.0-2	This table suggests that the costs for Alternative 9 are the same no matter what the COC. Is this so?	N	Yes. We obtained a price to dispose of the soil at Waste Management in Arlington, Oregon as "non-regulated contaminated soil." We assume that the soil will not have sufficiently elevated metals or volatiles to be characterized as RCRA waste.
31.	Pg. 131	This letter seems out of place. PCBs? Sampling you conducted? Your tests?	A	Yes, it is out of place. Section 7.0 needs to be revised.
32.	Pg. 39 , last par.	The water tank and well have a footprint that will not be amenable to excavation. Shouldn't this be reflected in the amount of soil that could be considered for remediation?	A	Yes, we will estimate the volume of impacted soil located within the footprint of the water tank and provide a discussion in Section 6.3 that this impacted soil cannot be removed by excavation without disturbing the tank.

PROJECT: Yakutat AFB **DOCUMENT:** Draft Feasibility Study , May, 2009
REVIEW COMMENTS **LOCATION:** Yakutat, SE Alaska

DATE: 07/24/09 **REVIEWER:** Carey Cossaboom **PHONE:** (907) 753-2689

Item No.	Location (page, par., sen.)	COMMENTS	Review A – Comment/Response Accepted W – Comment Withdrawn N – Noted D - Discuss	Shannon & Wilson Response
33.	Pg. 47, last par. of Sec. 3.8	I don't believe that 4,210 sf is a realistic area for the impact of this single drum. The slough here can be no more than 10 feet wide.	A N	The area shown on Figure 4-2 of the BC-J report was 4,210 based on the scale shown on this site plan. It is noted that the site plan appears to exaggerate the size of the drum and aerial extent of excavation. We assume the drum and estimated 150 gallons of sediment were removed from an area measuring approximately 5 feet by 5 feet. The lateral extent of impacted sediment is assumed to extend 10 feet beyond the area of excavation for an estimated area of 625 sf. The impacted sediment is assumed to extend vertically from the sediment surface (located beneath water in the slough) to 3 feet bgs (top of the clay layer). The estimated volume of impacted sediment is approximately 80 cy. Please note that the concentration of barium in surface water at AOC G4 should be investigated further to determine if barium is still present.
34.	Pg. 89, Sec 6.1, or Site-Specific Considerations	This may be best addressed as a Site-Specific Consideration for certain sites (e.g., Sites C6, D1-D4). No action is a viable alternative where there are no likely receptors (wells or potential wells) for contaminated groundwater. If there is no potential for groundwater use, the cleanup level for diesel in soil, for instance, would go from 230 mg/Kg to 8250 mg/Kg.	A	The potential for groundwater use at Concern D was addressed in S&W 2006b. In accordance with ADEC guidance evaluation of this exposure pathway must consider groundwater as a potential future drinking water source, regardless of the presence or absence of a current drinking water well in the vicinity. We will indicate in Section 6.3 Site-Specific Considerations that a groundwater use determination in accordance with 18 AAC 75.350 should be conducted for the Concern D sites. If there is no potential for groundwater use, the cleanup level for diesel in soil would be 8250 mg/Kg.

PROJECT: Yakutat AFB **DOCUMENT:** Final Feasibility Study , July, 2010
REVIEW COMMENTS **LOCATION:** Yakutat, SE Alaska

DATE: 12/03/10 **REVIEWER:** Carey Cossaboom **PHONE:** (907) 753-2689

Item No.	Location (page, par., sen.)	COMMENTS	Review A – Comment/Response Accepted W – Comment Withdrawn N – Noted D - Discuss	Shannon & Wilson Response

A	Original Comment #10. Pg. 42, 3rd par.	Please check penta SQuiRT value. On page 43, last par., 2nd sen. – you now state that the penta sediment samples exceed ADEC Cleanup Levels. The ADEC does not have sediment cleanup levels. Should you be using the 0.01 mg/kg Squirt value? Or did the ADEC ok their soil cleanup level for sediment?	A	We will revise. We will use the 0.01 mg/kg Squirt value for Dutch Sediment. The Squirt value will be changed on Table 3.1-1. We will change the 2nd sentence in last paragraph on page 43 to state "These concentrations exceed the SQuiRT value of 0.01 mg/kg."
1.	Original Comment #22. Pg. 63, O1 summary par.	Lead in GW should not be a concern. Your indicated response does not show up in the Final FS (Pg. 65). *Feb 2011: I would make the following change: "Monitoring Well AP-101 was not available for sampling (S&W 2006a)."*		The maximum lead concentration detected was 0.0452 mg/L in Monitoring Well AP-101 which exceeds the ARAR. No additional sampling of Monitoring Well AP-101 was conducted. Monitoring Well AP-101 was not available for sampling. We will add a sentence to the end of the fourth paragraph in Section 3.14 stating "According to the USACE PM, the non-detectable lead concentrations in groundwater at the locations of Monitoring Wells AP-99 and AP-100 are considered representative of the groundwater conditions at Monitoring Well AP-101." Lead in groundwater will not be considered a COC in the last paragraph of Section 3.14. The indicated response is in the 1st sentence on Pg. 65. *Feb 2011: We will remove "sampled for lead" at the top of Page 65 and replace with "available for sampling".*
2.	Original Comment #25. Fig. 3.5-9	I'm curious why the Area for Remedial Action bulges out to the NE at the east side of the AST7 foundation. All the samples around it are "clean". I don't see the ROST LF probe locations on the AST7 Site Plan. *Feb 2011: I now understand why you drew the bulge – it's the surface expression of the subsurface modeled plume in cross sections G-G' and F-F' in the ROST Report. BUT I STILL THINK IT LOOKS GOOFY! The ROST cross sections are modeled to fill in data gaps. Based on the available data and the slope of the ground, I think the ROST cross sections are wrong. I would draw the surface contour per the attached scan It's still a guess, but it looks more believable considering this map.*		ROST LIF Boring YAK D 021 was interpreted as containing DRO concentrations exceeding cleanup criteria from 0 to 2 feet within the bulge. The ROST LF probe locations will be shown on the site plans. We will also check the volume of contaminated soil for D-AST7. The ROST LF probe locations are shown on Fig. 3.5-9 (the hexagonal symbols). We will add ROST LF probe YAK D 020 location to the site plan. The Area of Remedial Action bulges out to the NE based on the fluorescence cross sections (Figure 7-14) in the ROST report. Cross sections G-G' and F-F' indicate fluorescence extending from probe YAK D 021a towards YAK D 020, thus creating the "bulge" in the Area of Remedial Action. A copy of Figure 7-14 is attached. *Feb 2011: We will revise Figure 3.5-9 to remove the bulge in the Area for Remedial Action extending from probe YAK D 021a towards YAK D 020. We will add the following statement after the fourth sentence in the last paragraph of Section 3.5.7, Page 40: "Note that the area for remedial action has not been extended to the northeast of Probe YAK D 021a towards YAK D 020 as suggested in the 2005 ROST/LIF report."*

REVIEW COMMENT

PROJECT: Yakutat FS

DOCUMENT: Remedial Alternative Tables **LOCATION:** Yakutat, AK

U.S. ARMY CORPS OF ENGINEERS CEPOA-EN-EE-	**DATE: 8 January 2009** **REVIEWER:** Tom Reed **PHONE:** 907-753-5642	**Action taken on comment by:** Nicholas Protos

Item No.	Drawing Sht. No., Spec. Para.	COMMENTS	REVIEW CONFERENCE A - comment accepted W - comment withdrawn (if neither, explain)	DESIGN OFFICE C - correction made (If not, explain)	Back check by: (Initials)
1.	Table 3-1	Recommend removing “Alternative 3 Enhanced Bioremediation” from Fuel Derived COPCs for soil. Recommend removing “Alternative 3 Nutrient Amendment” from Fuel Derived COPCs for groundwater. Recommend removing “Alternative 2 Dehalogenation” from Pentachlorophenol. I don’t believe that these technologies could be implemented.	A A A A	C – Corrections will be made to both Table 3.0-1 and the appropriate Section 4 Tables. C - Removed C - Removed C – All Removed	
2.	Table 3-1	Please add to Fuel Derived COPCs for soil at C,M and L concerns: 1. insitu soil heating (electrical IR or heating elements) 2. insitu chemical treatment (Fenton reaction- hydrogen peroxide)	A A	C - Insitu soil heating has been added to Tables 4-1, 3-2, and 4.0-1. C - Fenton reaction - hydrogen peroxide chemical treatment has been added to Tables 3-1, 3-2, and 4.0-1.	
3.	Table 3-1	Soil metals Alternative 2 soil washing- Recommend adding particle size separation (grizzly) before soil washing	A	C - Particle separation already included in text description of technology. We will add to Table description.	
4.	Table 3-1	G4 Seaplane Slough- Remove alternatives 3,4,5 for this site	A	C - Removed	

REVIEW COMMENT

PROJECT: Yakutat AFB

DOCUMENT: Draft FS

LOCATION: Yakutat AK

U.S. ARMY CORPS OF ENGINEERS CEPOA-EN-EE-	DATE: 14 July 2009 REVIEWER: Tom Reed PHONE: 753-5642	Action taken on comment by: Shannon & Wilson, Inc.

Item No.	Drawing Sht. No., Spec. Para.	COMMENTS	REVIEW CONFERENCE A - comment accepted W - comment withdrawn (if neither, explain)	DESIGN OFFICE C - correction made (If not, explain)	Reviewer Acceptance
1.	Page ii 1st para	Bis 2 ethylhexyl phthalate is a not a petroleum component but is instead a plasticizer and a common lab contaminant. It is released from plastics, especially when overheated in the lab. Don't remove from COC list, but move it from list of petroleum hydrocarbon constituents. The legal petroleum exclusion does not include any additives. So the lead and leaded gas and phthalates would not be excluded. I don't believe that phthalates were commonly used during the WWII era.	N A	We agree that Bis 2 ethylhexyl phthalate is a plasticizer and a common lab contaminant. Note that its molecular formula is C24H38O4 and that it is used widely in munitions and industrial and lubricating oils. We will remove Bis 2 ethylhexyl phthalate from the sentence of this paragraph listing the petroleum hydrocarbon COCs. We will add a statement to the end of this paragraph indicating that Bis 2 ethylhexyl phthalate is a COC but is also a common laboratory contaminant generated by overheating lab ware.	
2.	Page ii 3rd para	RAOs are primarily based on ADEC method 2 cleanup levels Comment withdrawn	W	For this FS, RAOs are medium-specific goals for protecting the human health and the environment through use of engineering and/or institutional controls, reducing the concentrations of COCs to levels below ARARs, and/or eliminating non-viable exposure pathways.	
3.	Page ii last para, bullets	The Pb at the rifle range should be considered its own medium Recommend creating a new medium just for the lead at the rifle range and grouping the remaining metals together, because the lead was deposited in a unique way, is likely still in elementary form, and the cleanup alternatives are different than remaining metals	N A	We understand that an abandoned Rifle Range may not be a waste site until the lead and lead-impacted soil is disturbed. The DOD is currently developing a DOD Range Rule which may identify when a discharged munition on a range becomes a solid waste under RCRA. The EPA munitions rule may currently be applicable. We will add an additional remedial alternative to the FS to address removal of lead bullets at the rifle range. (Soil Washing)	
4.	Figure 1.0-1, legend	Trouble with fonts	A	We will revise and use same font.	
5.	Page 9 1st para	Brown bears are also common in Yakutat	A	We will add brown bears too.	
6.	Section 3.1.2 last sentence	Better to say the drum is not of DOD origin and therefore removal not FUDS eligible	A	We will revise to indicate that the drum is not of DOD origin and, therefore, removal is not FUDS eligible.	
7.	Page 14	Table does not have label	A	The Table will be removed from the text to an excel spreadsheet and be labeled Table 3.1-1 – COPCs and ARARs for Former Yakutat AFB AOCs	
8.	Page 22 last para and general discussion of Cr	ADEC Cr total cleanup levels are based on Cr+6. The trivalent Cr cleanup levels are 124000 mg/kg. All the sites with elevated Cr should be first sampled for Cr+6. We are planning to provide for Cr+6 sampling before remedial action	A	We will add a statement to the end of the last paragraph that the USACE plans to collect more samples from all the sites with elevated chromium and analyze for Cr+6 before remedial action. The results of the Cr+6 analyses will not be included in this FS.	

REVIEW COMMENT

PROJECT: Yakutat AFB
DOCUMENT: Draft FS
LOCATION: Yakutat AK

U.S. ARMY CORPS OF ENGINEERS CEPOA-EN-EE-	DATE: 14 July 2009 REVIEWER: Tom Reed PHONE: 753-5642	Action taken on comment by: Shannon & Wilson, Inc.

Item No.	Drawing Sht. No., Spec. Para.	COMMENTS	REVIEW CONFERENCE A - comment accepted W - comment withdrawn (if neither, explain)	DESIGN OFFICE C - correction made (If not, explain)	Reviewer Acceptance
9.	Page 23 1st para	Cr discussion. Should discuss that Cr contamination assumes Cr+6; if CR is actually Cr+3, there is no COC.	A	We will revise as follows: In summary, the chromium concentration in surface soil exceeds the current background concentration of 37 mg/kg and is the only COC identified at AOC C1. Note that the chromium concentration in surface soil is assumed to be hexavalent chromium (Cr6+), a known carcinogen. All the sites with elevated chromium are recommended to be retested to determine if the chromium concentration is due to hexavalent chromium or trivalent chromium (Cr3+). The cleanup level for trivalent chromium is 124,000 mg/kg. If it is determined that the chromium concentration in surface soil is actually trivalent chromium, then there are no COCs at AOC C1. We will also provide a discussion in Section 6.3 Site-Specific Considerations indicating that all the sites with elevated chromium are recommended to be retested to determine if the chromium concentration is due to hexavalent chromium or trivalent chromium (Cr3+).	
10.	Page 23, 3rd para	"Army disposed.." If this was from WWII activity it would have been Army, if it was related to Ocean Cape Radio Relay it would have been the Airforce. May better to say DOD disposed	A	The sentence with be revised to: A former RCA worker interviewed by AGRA reported that the DOD disposed …	
11.	Page 33 top para, last sentence	Better to say that there was clear evidence that the drums were of non-DOD origin	A	The sentence with be revised to According to the USACE project manager, there was clear evidence that these drums were of non-DOD origin.	
12.	Page 42, 3rd para	Cr and As- Comparing sediment values to soil background	A	We propose to use 37 mg/Kg for chromium and 11.6 mg/Kg for arsenic which are the background concentrations established by the USACE. The SQuiRT document encourages the use of established background concentrations for screening sediment and soil.	
13.	Sect 3.9.2 1st para	Need to add that cultural camp land was also part of the OCRR	A	The second sentence with be revised to: The Cultural Camp site was a World War II military site in the 1940s and part of the OCRR Station.	
14.	Page 51 top para last sentence	Better to say that the surface water should be carefully resampled for Cd and Pb. "The concentration of cadmium and lead in surface water on the downgradient (south) side of the dump should be appropriately re-sampled to determine if cadmium and lead are still present. Care should be taken to not disturb the sediment."	A	We will revise as follows: The concentration of cadmium and lead in surface water on the downgradient (south) side of the dump should be appropriately re-sampled to determine if cadmium and lead are still present. Care should be taken to not disturb the sediment."	
15.	Sect 3.11, 2nd to last sentence	This sentence is inaccurate - Alaska was not a state until 1959	A	The sentence with be revised to The 15 aboveground fuel storage tanks were removed shortly before the tank farm site was relinquished to the Territory of Alaska in 1948.	

REVIEW COMMENT

PROJECT: Yakutat AFB

DOCUMENT: Draft FS

LOCATION: Yakutat AK

U.S. ARMY CORPS OF ENGINEERS CEPOA-EN-EE-	DATE: 14 July 2009 REVIEWER: Tom Reed PHONE: 753-5642	Action taken on comment by: Shannon & Wilson, Inc.		

Item No.	Drawing Sht. No., Spec. Para.	COMMENTS	REVIEW CONFERENCE A - comment accepted W - comment withdrawn (if neither, explain)	DESIGN OFFICE C - correction made (If not, explain)	Reviewer Acceptance
16.	Section 3.17	Include the backstop berm in this FS that even though it has not been sampled. Assume approximately same volume contamination as target berm	A	We will add a sentence to the last paragraph of Section 3.17 to indicate that: Although the backstop berm has not been sampled, it will be included in this FS. The impacted soil at the backstop berm is assumed to extend vertically from the ground surface to a depth of 2 feet bgs and laterally over an area of 2,702 sf. The estimated volume of impacted soil at the backstop berm is assumed to be approximately 230 cy for a total of about 460 cubic yards.	
17.	Section 3.17	Propose using method 3 industrial/commercial lead levels of 800 ppm for the rifle range. It is part of the DOT airport, it already has restricted access (ICs) in place. Future use -will always be part of airport. We should get ADEC buy in.	A	We will revise the ARAR for lead at the Rifle Range. ADEC has indicated 800 ppm is an acceptable level because the current and anticipated future land use is industrial/commercial and access to the property as the small arms range is located within the restricted area controlled by the airport.	
18.	Sect 4.1	Phthalate not POL See comment above	A	We will remove Bis 2 ethylhexyl phthalate from the sentence listing the petroleum hydrocarbon COCs. We will add a statement to the end of this paragraph indicating that Bis 2 ethylhexyl phthalate is a COC but is also a common laboratory contaminant generated by overheating lab ware.	
19.	Sect 4.3.1	IC discussion. 1. By definition FUDS properties are not owned by DOD and therefore DOD has no legal ability to impose deed restrictions or any restrictions on land use. It has no legal authority to enforce any controls. Any attempt to place controls on land would be considered a taking by the government. The most that FUDs program can do is put a deed notice on the property explaining any remaining contamination and request that the land owner manage property so human health and environment protected 2. EPA and ADEC have different definitions of ICs. If there is non-CERCLA contamination(POL) then only ADEC ICs would be considered 3. USACE and ADEC will have to develop IC language	A	We will revise the second paragraph in Section 4.3.1 as follows: Institutional Controls are a limited-action option that may comprise a discrete response alternative, but may also be incorporated into other integrated remedial alternatives to prevent or limit exposure to COCs. A description of Institutional Controls is provided in 18 AAC 75.375. In accordance with the ADEC guidance document, institutional controls may consist of fences, signs, liners, caps, easements, restrictive covenants, deed restrictions, deed notices, and/or zoning ordinances. Institutional controls may need to be implemented to increase the probability that exposure to human and environmental receptors is within protective levels and/or provide safeguards to preventing specific exposure scenarios. Institutional controls should be designed/selected to be effective in preventing human or environmental exposure to hazardous substances that remain on site above levels which allow unrestricted use. The responsible party or owner of the property must demonstrate that certain procedures are in place, or will be put in place, that will provide sufficient basis for determining that the institutional controls will perform as expected in the future. It is expected, for this FUDS project, that USACE, ADEC and the land owner will work together to develop the appropriate ICs.	

REVIEW COMMENT

PROJECT: Yakutat AFB

DOCUMENT: Draft FS

LOCATION: Yakutat AK

U.S. ARMY CORPS OF ENGINEERS CEPOA-EN-EE-	DATE: 14 July 2009 REVIEWER: Tom Reed PHONE: 753-5642	Action taken on comment by: Shannon & Wilson, Inc.

Item No.	Drawing Sht. No., Spec. Para.	COMMENTS	REVIEW CONFERENCE A - comment accepted W - comment withdrawn (if neither, explain)	DESIGN OFFICE C - correction made (If not, explain)	Reviewer Acceptance
20.	Sect 4.5.1 1st para	Enhanced bioremediation can work in subsurface soils as long as there is oxygen in the soil voids.	A	Section 4.5.1 will be revised as follows: Due to lack of oxygen supply to the subsurface soil and submerged sediments, enhanced bioremediation should be considered a surface soil treatment alternative. Enhanced bioremediation, however, can work in subsurface soil as long as there is oxygen in the soil voids.	
21.	Sect 4.5.2 1st para	Passive ventilation has been used successfully in Alaska to remediate DRO contaminated soil. This is a good option for remote access sites	A	Section 4.5.2 will be revised as follows: Forced air movement through either extraction or injection of air is used to supply oxygen. Passive ventilation may be a cost effective option particularly for remote access sites.	
22.	Sect 4.5.9 1st para	Technology doesn't work well with fine grain soils	A	We will add a sentence to indicate that: Soil washing can be effective with soil grain sizes ranging from fine to coarse sand (about 0.24 to 2 millimeters) but does not work well with finer grained soil such as silt and clay.	
23.	Sect. 4.5.11	Soil heating technology chosen is 6 phase. Please change to technology to conductive heating (Terratherm for example). Can be used for both surface contamination and at depth. In some situations may not require SVE wells	A	We will use the conductive heating technology and have developed costs based on conversations with a representative from TerraTherm.	
24.	Sect 4.7.1	Average Yak annual temp about 40 deg F. Groundwater likely to be about this temperature. There should be little to no hindrance to biological activity due to temperature. Back in the 90's USACE did a number of treatability studies (Ft Rich and Ft Wain) and found in general there were plenty of subsurface bacteria that had adapted to the colder soil. Please retain Nutrient Amendment and remove "Due to Yakutat's climate and cold temperatures that may hinder effectiveness of this technology,"?	N A	In our opinion, warmer temperatures are more conducive to biological breakdown of petroleum contaminants. We will revise the first sentence in the last paragraph in Section 4.7.1 as follows: Based on the USACE's experience, nutrient amendment has not contributed to the successful treatment of petroleum-impacted groundwater and will not be retained as a discrete remediation alternative for detailed analysis.	
25.	Table 4.0.1	ICs—see discussion above Awaiting direction	A	See also Response to Tom's Comment No. 19.	
26.	Table 4.0.1	ICs for groundwater. One option is to work with the city to insure no drinking water wells in contaminated areas. Awaiting direction	A	See also Response to Tom's Comment No. 19.	

REVIEW COMMENT

PROJECT: Yakutat AFB

DOCUMENT: Draft FS

LOCATION: Yakutat AK

U.S. ARMY CORPS OF ENGINEERS CEPOA-EN-EE-	DATE: 14 July 2009 REVIEWER: Tom Reed PHONE: 753-5642	Action taken on comment by: Shannon & Wilson, Inc.

Item No.	Drawing Sht. No., Spec. Para.	COMMENTS	REVIEW CONFERENCE A - comment accepted W - comment withdrawn (if neither, explain)	DESIGN OFFICE C - correction made (If not, explain)	Reviewer Acceptance
27.	Table 4.0.1 Treatment of groundwater	Any treatment (disturbance) of the groundwater at Concern D could inadvertently cause a release into the drinking water wells. Please add a statement equivalent to "Any treatment (disturbance) of the groundwater at Concern D could inadvertently cause a release into the drinking water wells"	A A	We will add a statement that: Treatment (disturbance) of the groundwater at Concern D could inadvertently cause a release into the drinking water wells We will also provide a discussion in Section 6.3 Site-Specific Considerations indicating that a Drinking Water Well Capture Zone Study should be conducted particularly if In-Situ Chemical Oxidation is the preferred alternative.	
28.	Table 4.0.1	Phthalate- please include footnote that phthalate is common lab contaminant.	A	We will add a footnote indicating that Bis 2 ethylhexyl phthalate is a common lab contaminant. See also Response to Tom's Comment No. 1.	
29.	Sect 5.7	Please include discussion between +3 and +6 Cr.	A	We will add a sentence indicating that the chromium concentration in surface soil is assumed to be hexavalent chromium (Cr6+), a known carcinogen. All the sites with elevated chromium should be retested to determine if the chromium concentration is due to hexavalent chromium or trivalent chromium (Cr3+). The cleanup level for trivalent chromium is 124,000 mg/kg. If it is determined that the chromium concentration in surface soil is actually trivalent chromium, then some sites, for example AOC C1, have no COCs.	
30.	Sect 6.1 throughout section	Typically with no action alternative one assumes there would be no change in contamination and therefore they would be no reduction in POLs. I agree that there seems to be a contradiction and POL is likely to degrade over time, but from EPA RI/FS guidance document "Alternative 1 - No Action The no-action alternative provides a baseline for comparing other alternatives. Because no remedial activities would be implemented with the no-action alternative, long-term human health and environmental risks for the site essentially would be the same as those identified in the baseline risk assessment." I interpret this to mean for the purpose of a baseline comparison one assumes that there is no change in contamination and risk over time. Otherwise one would have to say the risk will be reduced over time at some unknown rate.	N A	We assume that biodegradation of petroleum COCs has been on-going and will continue even with the "No Action" alternative. It seems contradictory to say that Alternative 3 – Monitored Natural Attenuation will rely on reduction of petroleum COCs but not allow reduction with Alternatives 1 and 2. We will state that although natural attenuation processes should reduce petroleum COC concentrations and non-petroleum COCs in surface water, over time, for the purposes of this FS we assume that concentrations will not change for Alternatives 1 and 2. We will also revise the other portions of the report to indicate that we assume that concentrations will not change for Alternatives 1 and 2.	
31.	Sect 6.2 ICs	See IC discussion above and also comment #31. Awaiting direction	A	See also Response to Tom's Comment No. 19.	

REVIEW COMMENT

PROJECT: Yakutat AFB

DOCUMENT: Draft FS

LOCATION: Yakutat AK

U.S. ARMY CORPS OF ENGINEERS CEPOA-EN-EE-	DATE: 14 July 2009 REVIEWER: Tom Reed PHONE: 753-5642	Action taken on comment by: Shannon & Wilson, Inc.

Item No.	Drawing Sht. No., Spec. Para.	COMMENTS	REVIEW CONFERENCE A - comment accepted W - comment withdrawn (if neither, explain)	DESIGN OFFICE C - correction made (If not, explain)	Reviewer Acceptance
32.	Sect 6.2	ICs – Physical access is restricted by a gate and signs. Must obtain permission from DOT to access land. EPA and ADEC have different definitions of ICs	A	See also Response to Tom's Comment No. 19.	
33.	Sec 6.3 1st para	5 years- The interval of sampling will be negotiated between ADEC and USACE	A	5-years is referenced in the Guide to Developing Costs document. We will add a sentence stating: The interval for collection and analyses of samples will be negotiated between ADEC and USACE.	
34.	Sect 6.3 1st para last sentence	Please replace "will" with "may"	A	We will revise.	
35.	Page 93 1st para last sentence	"dilution and volatilization"- metals and PCBs are unlikely to volatilize. Suggest replacing with "dilution and dispersion"	A	We will revise to: dilution and dispersion.	
36.	Page 93 1st para 3rd sentence	Replace "would be" with "may be"	A	We will revise.	
37.	Page 93 1st para 1st sentence	Natural attenuation may very well work for the POL hot spots	A	We will add a sentence indicating that: Natural attenuation may achieve ARARs for petroleum-impacted hot spots.	
38.	Sect 6.4	A concentrated hydrogen peroxide solution would likely kill off all biological activity and bioremediation should be discounted	A	We will say that: oil degrading bacteria may need to be re-introduced.	
39.	Sect 6.4 2nd para	Why would three phase power be required? A chain link fence would not be necessary if treatment would be short term. The Fenton reaction is rather quick and confirmation samples could be taken immediately after or even while treatment is occurring	A N N	Three phase power is not needed for this alternative and will be removed. An electrical supply would be required to pressure-inject hydrogen peroxide and ferrous iron. "Gravity-feed" in the first paragraph will be deleted as the plan is to use pressure-injection. A chain-link fence was included to protect the public from direct contact with the concentrated hydrogen peroxide solution. We assumed that 100 percent coverage would not be obtained and that those areas not affected by the chemical oxidation process be allowed to bioremediate over the following three years.	
40.	Page 95 4th para	A concentrated hydrogen peroxide solution would likely kill off all biological activity and bioremediation should be discounted	N A	We assumed that 100 percent coverage would not be obtained and that those areas not affected by the chemical oxidation process will be allowed to bioremediate over the following three years. We will say that "oil degrading bacteria may need to be re-introduced."	

REVIEW COMMENT

PROJECT: Yakutat AFB

DOCUMENT: Draft FS

LOCATION: Yakutat AK

U.S. ARMY CORPS OF ENGINEERS CEPOA-EN-EE-	DATE: 14 July 2009 REVIEWER: Tom Reed PHONE: 753-5642	Action taken on comment by: Shannon & Wilson, Inc.		

Item No.	Drawing Sht. No., Spec. Para.	COMMENTS	REVIEW CONFERENCE A - comment accepted W - comment withdrawn (if neither, explain)	DESIGN OFFICE C - correction made (If not, explain)	Reviewer Acceptance
41.	Page 95 last para	A concentrated H2O2 may also be a fire risk if O2 was released	A	We will add a sentence indicating that a concentrated H2O2 may also be a fire risk if O2 was released.	
42.	Sect 6.5	See comment 24	A	In our opinion, warmer temperatures are more conducive to biological breakdown of petroleum contaminants.	
43.	Sect 6.5	Soil heating treatment should be sufficient; any components left would be heavy and unlikely to breakdown with bioremediation. Confirmation samples could be collected immediately after treatment.	A	We will emphasize that cleanup to ARARs will be obtained by the soil heating process during the first year. Residual heavy ends may remain.	
44.	Sect 6.6	Passive bioventing should also be considered	A	We will add "Passive Bioventing" as a remedial alternative. We can also provide a discussion in Section 6.3 Site-Specific Considerations indicating that Passive Bioventing may be the preferred alternative at AOCs C2, C4, and C6 due to the presence of wetlands.	
45.	Page 100 1st para	It should be noted the length of treatment is dependant on type of fuel to be treated. GRO may very well be reach cleanup in 1-2 years, DRO longer and RRO may never reach cleanup goals	A	We will include a sentence indicating that the length of treatment is dependant on type of fuel to be treated. GRO-impacted soil typically reaches cleanup quicker than DRO which typically reaches cleanup quicker than RRO. It should also be noted that the COCs at the sites to be treated with Bioventing are DRO and a little GRO and that RRO was not identified as a COC.	
46.	Page 103 top para "Costs"	Can it be assumed that all these costs include clean backfill and the decommission of soil piles and soil removal when completed?	A	The costs on Table C.7 include decommissioning the biopiles and re-using the treated soil as backfill material. On Table C.7 and C.9, we show that the excavation will be backfilled with imported gravel and with the treated soil. We will remove "Backfill Excavation with Imported Gravel" from the cost estimate.	
47.	Sect 6.8 1st para	Need to subdivide excavation in approach and costs, Recommend 0-5 ft, 5-15 ft an 15 to 30 ft. The decision then can be made to which depth would be appropriate for each site.	A	We will adjust the quantities and cost estimates to breakout contaminated soil from 1 to 15 feet and greater than 15 feet instead of 1 to 30 feet and greater than 30 feet currently shown in Draft FS. We will revise the first sentence in Section 6.8 to "Excavation and LTTD applies to AOCs with surface soil, subsurface soil, and sediment impacted by petroleum COCs up to depths of about 15 feet bgs or to groundwater, whichever occurs first." We will also revise the other portions of the report which indicate that excavation can be accomplished to 30 feet bgs and change to 15 feet bgs.	
		Also need note that excavation would only go to groundwater table. Sites c2, c4, c6 appear to have shallow groundwater	A	We will provide a discussion in Section 6.3 Site-Specific Considerations indicating which sites have a groundwater level less than 15 feet bgs.	

REVIEW COMMENT

PROJECT: Yakutat AFB

DOCUMENT: Draft FS

LOCATION: Yakutat AK

U.S. ARMY CORPS OF ENGINEERS CEPOA-EN-EE-	DATE: 14 July 2009 REVIEWER: Tom Reed PHONE: 753-5642	Action taken on comment by: Shannon & Wilson, Inc.

Item No.	Drawing Sht. No., Spec. Para.	COMMENTS	REVIEW CONFERENCE A - comment accepted W - comment withdrawn (if neither, explain)	DESIGN OFFICE C - correction made (If not, explain)	Reviewer Acceptance
48.	Sect 6.9	Very specific in how excavation would be accomplished. There are other equally valid methods to excavate and dispose. i.e. using open top connexes. Please note the specific method mentioned is for costing purposes only and other methods may be employed.	A	We will include a sentence indicating that the disposal method chosen is for cost estimating purposes only and that other excavation methods may be employed.	
49.	Sect 6.11	Please mention that any treatment of the groundwater could cause a disturbance or release in the public drinking water wells	A	We will provide a discussion in Section 6.3 Site-Specific Considerations indicating that a Drinking Water Well Capture Zone Study should be conducted particularly if In-Situ Chemical Oxidation is the preferred alternative at Concern D.	
50.	Page 111 top paragraph	It would not be feasible to install horizontal pipe at concern D. Concern D has deep contamination. How deep can a horizontal pipe be installed? It seems impractical to install horizontal pipe below 15-20 ft.	N A	Oxygen-rich air can be drawn through the near surface petroleum-impacted soil using horizontal piping and short-circuiting can be reduced using an impermeable cover. Horizontal manifold piping would also be needed to tie the vertical wells to the environmental shed. The third sentence at the top of Page 111 under Implementability will be revised to: Excavating equipment, available in Yakutat, would be needed for installing horizontal pipes.	
51.	Sect 6.12.1	Please include surface soil conductive heating. I believe there is technology to treat surface contamination conductive heating. TerraTherm thermal blanket.	N A	Soil Heating was not considered feasible for AOCs with surface soil only due to the limited radius of influence in shallow soils. We will add Alternative 5 – In-Situ Soil Heating and incorporate the use of a thermal blanket for treating surface soil into Section 6.12.1. We received a verbal estimate of costs from TerraTherm for in-situ Soil Heating and will incorporate these into the soil heating cost estimate.	
52.	Page 112 1st para	Alt. 2 may reduce risk of direct contact with soil	A	We will revise this paragraph to indicate that Alternative 2 – Institutional Controls may also reduce risk of direct contact with soil.	
53.	Page 112 2nd para	"Compliance with ARARs" alternative 4 removes COCs from the environment by destruction and treatment is typically stops when ARARs are met. Alternatives 1 and 2 do assume ARARs are achieved. There is no information about the rate of degradation. If it would take hundreds or thousands of years to achieve ARARs it would can assumed for FS they would not be achieved.	A A A	We will revise the sentence to: COCs are not removed from the environment with Alternative 4 but are destroyed and/or reduced to ARARs by implementing medium-term in-situ treatment. We will revise this paragraph to indicate that, for this FS, we assume that ARARs are not achieved with Alternatives 1 and 2. See above response and Response to Tom's Comment No. 30.	

REVIEW COMMENT

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54.	Page 112 3rd para	Alt #1 (No Action) would not be effective	A	We will revise this paragraph to indicate that, for this FS, we assume that ARARs are not achieved with Alternative 1.	
55.	Sect 6.12.2	Excavation should be considered to 5, 15 and 30 ft or to the groundwater. For example for Concern D it may be reasonable to only remove replace the top 5 feet of soil or depth utilities	A A	The section header will be revised to: Petroleum COCs in Subsurface Soil (<15 feet bgs). The depth of excavation will depend on the depth to the bottom of the petroleum-impacted soil zone or to groundwater but not greater than 15 feet bgs. See Response to Tom's Comment No. 47.	
56.	Page 116 last para 1 & 2nd sentence	1st sentence says no risk and 2nd says less risk	A	The first sentence discusses risk during implementation. The second sentence discusses risk until ARARs are met. We will improve the wording.	
57.	Page 122 "Implement abilty"	A removal action of sediment at the C concerns may be rather difficult to implement due to much of the area is wetlands that would not support equipment. The excavation would need permit for any backfilling . Environmental harm in excavation may be damaging then leaving contamination in place. Anadromous fish occupy the ditch at E1	A A	We will add more discussion for alternatives that disturb wetlands and/or sediment about the need for wetland permits to work in wetlands and stream beds. We will include the sentence: A nationwide permit to disturb surface soil in a wetland or drainage channel may be required but can typically be obtained within about 30 days. Obtaining wetland permits may make Alternatives 7, 8, and 9 even more complex than Alternatives 1, 2, and 3. For the C Concerns, we note that the drill rig was able to access the areas to install borings and assume that an excavator would be able to do so as well. We assume that excavation may need to be scheduled for mid-winter when surface and subsurface materials are frozen. AOC E1 is discussed in Section 6.12.5. A similar sentence about obtaining a nationwide permit will be added to Section 6.12.5.	
58.	Page 126	"Reduction…" Alt 1 and 2 assume no biodegradation	A	See Response to Tom's Comment No. 30.	
59.	Sect 6.12.7 1st para	Suggest resampling water making sure sediment not disturbed Recommend resample AOC C2, AOC K1 and AOC O1.	A	We will add a statement to this paragraph indicating that the USACE plans to resample surface water and sediment from AOCs C2, K1, and O1. The results of the analyses, however, will not be included in this FS.	
60.	Page 127 last para	Non of the chemicals listed would likely volatilize	A	We will revise to "dilution and dispersion."	
61.	Page 130 "Implement ability"	Difficult to implement Alt. #11 at Concern D due to cobbles and boulders impeding drilling to depth.	A	We assume that Tubex drilling tools, which were very successful in 2005 at Concern D, would be used to advance borings/monitoring wells. We will indicate in this paragraph, as well as in Section 6.3 Site-Specific Considerations, that there are boulders and erratics at Concern D that may affect the implementability of Alternative 11.	

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62.	General	Liquid hydrogen peroxide- suggest using term "hydrogen peroxide solution" instead	A	We will revise to "hydrogen peroxide solution."	
63.	Table 6.0-1 alternatives 8 and 9	Need to note somewhere in FS alt 8 need a minimum amount (?) of soil before it can be considered feasible and alt 9 typical is typically advantages with small volumes of soil.	A	We agree that for several of the alternatives, a minimum amount of soil or square footage is necessary to make the alternative feasible. We will provide a brief discussion in Section 6.0.	
64.	Table 6.0-1 alternatives 10	Typically needs a minimum amount (?) of soil before being considered	A	We agree. We assumed that the Rifle Range with about 230 cubic yards, now about 460 cubic yards based on Tom's Comment No. 16, would provide the minimum amount of metal-impacted soil to make Alternative No. 10 feasible.	
65.	Table 6.0-2 title	Font problem	A	We will check the fonts.	
66.	Table 6.0-2	C concern soil- costs should be 1-2 ft below groundwater	A	Please see Response to Tom's Comment No. 47.	
67.	Table 6.0-2	D concern – should include costs to 0-5 ft, 5-15 ft, 15-30 ft	A	Please see Response to Tom's Comment No. 47.	
68.	Table 6.0-2	D-AST1 and D-AST downslope- please add <30 ft and >30 ft to AOCs	A	Would you like us to show the names as "D-AST1 > 30 ft" and "D-AST downslope < 30 ft"?	
69.	Table 6.0-2	Alt 4 costs vs Alt 9 costs. At NE cape the costs of Alt 4 was approximately 1/3 the cost of Alt 9	A	We will review our costs for Alternatives 4 and 9.	
70.	Page 131	PCB cleanup? -Page does not apply	A	We will revise.	
71.	Append B	Please include conductive soil heating	A	We will use the conductive heating technology and have developed costs based on conversations with a representative from TerraTherm.	
72.	Append C	LTTD –costs per CY should go down substantially as total volume of soil increases. May need to also look at costs for 5K, 10K, 20K CY	A	The costs will decrease as the volume of soil increases. We will evaluate the costs for a site having between 2,000 cubic yards and 20,000 cubic yards as well as for a site having between 2,000 cubic yards and 20 cubic yards to see if there is an appropriate economy of scale factor that can be used. Also, see Response to Carey's Comment No. 2.	
73.	Append E	May want to include different page, much does not apply to FS	A	This is a standard document. We will consider revising.	

PROJECT: Yakutat AFB **REVIEW COMMENTS**	**DOCUMENT:** Draft TAPP Review of Draft Feasibility Study - S&W **LOCATION:** Yakutat, Alaska			
DATE: 8/5/09	**REVIEWER:** Robert Braunstein	**PHONE:** (907) 644-2900		

Item No.	**Location (page, par., sen.)**	**COMMENTS**	**Review** **A – Comment/Response Accepted** **W – Comment Withdrawn** **N – Noted D - Discuss**	**Shannon & Wilson Response**
1.	General note:	BGES did not review any of the reports referenced in this document	N	
2.	Executive Summary - Page ii, Bullet List at bottom:	30 feet is used as the maximum depth for feasibly removing soils from the ground for ex-situ treatment. However, a depth of 15 feet may also be important when evaluating soil contamination, since most construction excavations do not go any deeper than this.	A	We understand that if contamination was removed to a depth of 15 feet, the ADEC cleanup levels for the inhalation exposure pathway would no longer be applicable as ARARs. The “migration to groundwater” cleanup criteria, however, would still be the appropriate cleanup criteria unless we demonstrate to the ADEC that groundwater is not a potential drinking water source. We also understand that a depth of 15 feet is important because excavation for buildings and utilities do not typically extend beyond 15 feet. If contamination remains below a depth of 15 feet, however, an Institutional Control would likely be required in the form of a deed restriction. Also, see Response to Tom’s Comment No. 47.
3.	Acronym List – Page ix:	Please change “Civil Aeronautic Association” to “Civil Aeronautic Administration” Please Change “Code of Federal Register” to “Code of Federal Regulations”	A	We will revise.
4.	Section 1.3, Page 2, last sentence (and throughout the document):	Please change medium to media	A	We will revise globally and change to media, where plural.
5.	Section 2.3, Page 5, first sentence:	Please change 691 (certified 2002) to 590 (certified 2007)	A	We will revise.
6.	Section 2.3, Page 5, second paragraph:	Please update; water is now piped to all 191 homes in the community and to the schools	A	We will revise.
7.	Section 2.3, Page 5, second paragraph:	Some of this information could be verified on the Alaska Community Development Database, but other information could not. Adding a reference for this demographic information would be helpful.	A	We will revise.
8.	Section 2.4, Page 6, second paragraph, first sentence:	According to the Alaska Office of Economic Development, the Bering Glacier is the largest glacier (may be due to recent melting)	A	We will revise to say that it is one of the largest.
9.	Section 2.6, Page 9, first paragraph, eighth sentence:	Please add “Service” after “U.S. Fish and Wildlife”	A	We will revise.

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10.	Section 2.6, Page 9, first paragraph, ninth sentence:	The Alaska Department of Fish and Game lists 13 species as endangered, not 5.	A	We will review and revise accordingly.
11.	Section 2.6, Page 9, first paragraph, tenth sentence:	Additional species appear to inhabit the Yakutat area including Stellar sea lions, blue whales, fin whales, sperm whales, and possibly the northern right whale	A	We will review and revise accordingly.
12.	Section 3.0, Page 10, first sentence:	This is the first reference to the 18 sites (they are not discussed in the Executive Summary, thus, this was a little confusing. It would be helpful if they were briefly discussed in the Executive Summary.	A	We will add to Executive Summary.
13.	Section 3.0, Page 10, first sentence:	WW II should be spelled out for the first time here and added to the acronym list	A	We will add to list.
14.	Section 3.1.1, Page 10, first bullet:	Please add this to list of references at end of report	A	We will add to list.
15.	Section 3.1.1, Page 11, second to last sentence:	GFM is already defined as being plural; please delete the "s"	A	We will review and revise accordingly.
16.	Section 3.1.2, Page 11, first paragraph, last sentence:	Please add "GOCO" to the acronym list	A	We will add to list.
17.	Section 3.1.2, Page 11, second paragraph, third sentence:	Tank AST2 is listed as an eligible site in the report text and Table 3.0-1. Are the drums a small portion of this site that is not eligible? Please clarify.	A	We will review and clarify.
18.	Section 3.1.3, Page 12, first paragraph, third sentence:	Please add 18 AAC 70 to the list of references at end of report. Please also add SQuiRT to acronym list. Please also add NOAA 1999 to list of references at end of report.	A	We will add 18 AAC 70 to list. NOAA 2008 will be added to the list.
19.	Section 3.1.3, Page 12, second paragraph, first sentence:	2,3,7,8-tetrachlorodibenzo-p-dioxin is listed in 18 AAC 75 Table B-1. Please clarify that other dioxins are not listed. The reference to ADEC 2008a should be 2008b. Add the word "and" before "Guidance for Cleanup…" In addition, this title does not match title in references.	A	We will revise.
20.	Section 3.1.3, Page 12, second paragraph, last sentence:	It would be clearer if the word "those" was changed to "the cleanup criteria"	A	We will revise.
21.	Section 3.1.3, Page 12, second complete paragraph, first sentence:	It is not clear why dioxins are singled out? Why would dioxins that exceed the cleanup standards not be considered COCs?	A	Dioxins were an exception in the cited paragraph because they were discussed on Page 13. We will clarify.

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22.	Section 3.1.3, Page 12, last paragraph:	Please spell out milligrams per kilogram for the first time here	A	We will revise.
23.	Section 3.1.3, Page 13, first paragraph, second to last sentence:	Current regulations in 18 AAC 75.341 list a TEQ of 38 parts per trillion, not 39. Please also spell out ppt for first time here.	A	In 2004, ADEC accepted 39 ppt but realize the current level is 38 ppt. We will clarify. ppt is spelled out previously.
24.	Section 3.1.3, Page 13, second paragraph, second sentence:	There are some USTs associated with the Seaplane Base in AOC G.	A	We will revise.
25.	ARARs Table, Page 14:	General: Some of the proposed ARARS are more conservative (lower cleanup values) than may be warranted. Especially considering the magnitude of the estimated costs to complete the remedial work at these sites, a less restrictive approach to selecting ARARs may be beneficial. For example, it may be more appropriate to utilize human health and ecological risk-based screening criteria for surface water ARARs, which in some cases are higher than the maximum contaminant levels that are proposed, if the surface water is not to be used for drinking water. In some cases, this advantage may be off-set somewhat or be undesirable because of the increased need for institutional controls.	N	We agree that ARARS are potentially more conservative (lower cleanup values) than may be warranted. We do not feel that we can use higher cleanup values than the most stringent without input from USACE and ADEC. See Response to Tom's Comment No. 17.
		The toluene ARARs listed as 4.8 mg/Kg should be 6.5 mg/Kg.	A	We will revise.
		Footnote b: The background concentrations are only used for surface soils and subsurface soils.	A	We will revise.
		The chromium ARAR for sediments (37.3) is not discussed anywhere in the text. The lowest effective level (LEL) for chromium which is the level of sediment contamination that can be tolerated by most benthic organisms is 26.0.	A	We used the 1999 SQuiRT threshold effects level (TEL) value for chromium in freshwater sediment of 37.3 mg/Kg. Note that 2008 SQuiRT threshold effects level (TEL) value for chromium in freshwater sediment is also 37.3 mg/Kg. We see that the 2008 SQuiRT has a lowest effective level (LEL) value for chromium in freshwater sediment of 26 mg/Kg. We propose to use 37 mg/Kg for sediment, surface soil, and subsurface soil which is the background concentration for chromium established by the USACE. The SQuiRT document encourages the use of established background concentrations.
		The dioxins ARAR should be 38 ppt.	A	We will revise.

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25.	Continued	It is not clear where the pentachlorophenol ARAR for sediments (0.009 mg/Kg) was obtained. The ADEC cleanup criterion is 0.047 mg/Kg (from the ADEC cleanup criterion, except where the sediments are of marine origin, in which case the ARAR is 0.017 mg/Kg); a more appropriate ARAR would be the SQuiRT TEC value of 0.15 mg/Kg.	A	Prior to October 9, 2008, the ADEC cleanup criterion was 0.009 mg/Kg and there was not a SQuiRT value in the NOAA 1999 document. Now we are aware that new SQuiRT values were published in November 2008. We agree we need to use the most stringent SQuiRT value. We cannot find the SQuiRT TEC value for pentachlorophenol of 0.15 mg/Kg. Based on discussions with the USACE PM, we will use the ADEC soil cleanup criterion for pentachlorophenol of 0.047 mg/Kg as the ARAR for freshwater sediments.
		The chronic freshwater screening value in the SQuiRT table for benzo(a)anthracene is 0.000027 mg/L which is considerably lower than the groundwater cleanup level of 0.0012 mg/L. Footnote e states that the most stringent value will be used.	A	We will revise.
		It is not apparent where the ARAR for 2-methylnaphthalene of 0.00078 mg/L in surface water was obtained? The most stringent concentration for this substance appears to be the ADEC drinking water standard of 0.15 mg/L.	A	The ADEC Technical Memorandum 01-007 (November 2003) shows a 0.78 mg/L groundwater cleanup level for 2-methylnaphthalene. We misinterpreted this number as 0.78 ug/L. The ADEC drinking water standard of 0.15 mg/L, the most stringent concentration for this substance, will be used.
		The DDD sediment ARAR should be 0.00354 mg/Kg (SQuiRT TEL) not 7.2 mg/Kg	A	We will revise.

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25.	Continued	The DDD surface water SQuiRT value for fresh surface water and chronic effects is 0.000011 mg/L which is more stringent than the 0.0035 mg/L value provided in the table	A	We will revise.
		The DDT SQuiRT sediment TEL value is 0.00119 mg/Kg, which is more stringent than 7.3 mg/Kg	A	We will revise.
		The DDT surface water ARAR should be 0.0000005 mg/L (SQuiRT Chronic value), not 0.0025 mg/L	A	We will revise.
		The cadmium SQuiRT sediment TEL is 0.583 mg/Kg, not 0.598 mg/Kg	A	We will revise.
		The cadmium surface water ARAR should be 0.00025 (SQuiRT TEL) mg/Kg, not 0.005 mg/Kg	A	We will revise.
		The mercury surface water ARAR should be 0.00077 mg/L (SQuiRT Chronic value), not 0.002 mg/L	A	We will revise.
		The silver sediment TEC is 1.6 mg/Kg (previous SQuiRT tables), which is more stringent than 19 mg/Kg	A	Based on discussions with the USACE PM, the 2008 SQuiRT LEL value for silver of 0.500 mg/Kg, the most stringent concentration for this metal, will be used as the ARAR for freshwater sediments.
		The silver surface water ARAR should be 0.00036 mg/L (SQuiRT Chronic value – temperature dependent) not 0.00012 mg/L.	A	We will revise.
26.	Section 3.3.1, Page 17, second paragraph, third sentence:	It is assumed that the non-detectable concentration is less than the cleanup criterion, but this should be stated for clarity	A	We will review and clarify that the non-detectable result had a practical quantitation limit (PQL) less than the ARAR.
27.	Section 3.3.1, Page 17, fourth paragraph, third from last sentence:	This is a reasonable assumption if the samples were not filtered in the field	N	According to the USACE PM, the samples were not filtered in the field.
28.	Section 3.3.1, Page 18, first full paragraph:	These results indicated a lead concentration that was an order of magnitude less than what ENSR detected. It is presumed that this is due to using a more appropriate low-flow sampling technique, or that the sample was filtered in the field. Please clarify.	A	We will delete "appropriate" and clarify that low-flow sampling procedures were used in 2004 by S&W.
29.	Section 3.3.2, Page 18, second paragraph, last sentence:	Please clarify that the non-detectable concentration(s) was below the cleanup criterion	A	We will clarify.

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30.	Section 3.3.2, Page 19, second paragraph, second sentence and last paragraph, last sentence:	The ADEC cleanup criterion for arsenic is 0.10 mg/L, not 0.05 mg/L.	A	We will revise and use the current ADEC groundwater cleanup criterion of 0.01 mg/L for arsenic.
31.	Section 3.3.3, Page 20, second paragraph, first sentence:	It is assumed that the date should be 2001, based on Figure 3.3.1 and the reference ENSR 2003b	A	We will revise.
32.	Section 3.4.1, Page 22, first paragraph, first sentence:	AGRA is not listed in references	A	We will add to list.
33.	Section 3.4.1, Page 22, first paragraph, second to last sentence:	According to EPA Region 3 RBC Table published in April of 2009, the soil TCDD equivalent RBC should be 4.5 ppt, not 4.0 and the water RBC should be 0.03 ppt, therefore, the water TCDD concentration of 0.038 ppt does represent a risk at this site.	A	The 0.038 ppt 2,3,7,8-TCDDconcentration in water does exceed the ARAR of 0.03 ppt and, therefore, should be included as a COC for AOC C1.
34.	Section 3.4.1, Page 22, second paragraph, fourth sentence:	Was APO-13 not sampled? Please clarify.	A	We will review and clarify.
35.	Section 3.4.1, Page 23, first full paragraph, first sentence:	Please add dioxins in water as a COC (see comment 33 above)	A	We will add.
36.	Figure 3.4-1:	Please add units to the chromium concentration	A	We will add.
37.	Section 3.4.2, Page 23, second paragraph, fourth sentence:	Please add AGRA 1997 to references	A	We will add.
38.	Section 3.4.2, Page 24, first paragraph, second to last sentence:	Please add E&E to acronym list	A	We will add.
39.	Section 3.4.2, Page 25, first full sentence:	The ADEC migration to groundwater cleanup criterion for RRO (as also listed in the ARAR table on Page 14) is 9,700 mg/Kg, not 2,000 mg/Kg.	A	We will revise.
40.	Section 3.4.2, Page 25, third full paragraph, third sentence:	Elevated DRO concentrations were also detected in C3 and C4 areas	A	We will revise.
41.	Section 3.4.2, Page 26, third sentence:	According to Figure 3.4-2, the value for cadmium should be 3.4 mg/Kg, not 3.5 mg/Kg	A	We will review and make the appropriate correction.

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42.	Section 3.4.4, Page 28, third full paragraph, second sentence:	Should reverse east and south to match concentrations	A	We will revise.
43.	Section 3.4.4, Page 28, third full paragraph, fourth sentence:	According to the figure, AP062 is about 80 feet, not 400 feet east of the tank foundation	A	We will revise.
44.	Section 3.4.4, Page 28, last sentence and first sentence on Page 29:	Unless DRO was sampled in the groundwater, as recommended by ENSR, how can the potential for contamination to reach the slough be ruled out? Furthermore, the concluding paragraph to this section indicates that DRO contamination in soils is assumed to extend from the ground surface. In this case, the contamination is shallow enough to affect human and ecological receptors.	A	We will revise the sentence to: The results did show that the contamination in soil does not extend to Ankau Slough.
45.	Section 3.4.4, Page 29, second full paragraph, last sentence:	Based on the area of impact listed, the DRO contamination could reach Ankau Slough.	A	We will revise the text to indicate that 6 ROST/LIF probes were positioned between Ankau Slough and the soil contaminant plume originating at the tank. These 6 probes were advanced to the depth of groundwater. The ROST/LIF results for these 6 probes did not indicate that DRO contamination was present. We will also show these ROST/LIF probe locations on Figure 3.4-3. Although these results indicate that DRO contamination does not extend to Ankau Slough, groundwater sampling was not conducted and, therefore, the lateral extent of DRO-impacted groundwater is not known.
46.	Section 3.4.5, Page 29, first paragraph, second to last sentence and throughout this section:	ENSR 2001 b is not in reference list	A	Should be 2003b. We will revise.
47.	Section 3.4.5, Page 29, last paragraph, last sentence:	A sentence could be added here to describe the arsenic in surface soil as a COPC like the discussion below for chromium	A	We will revise.
48.	Section 3.5.1, Page 32, fourth paragraph:	It is not clear where the probes were advanced. It would be helpful to show their locations on one of the figures.	A	We will add the ROST boring/probe locations to the figures.
49.	Section 3.5.4, Page 35, second paragraph, sixth sentence:	Does upgradient refer to upslope as discussed below, or upgradient with respect to groundwater flow direction? It may help to clarify by providing a compass direction.	A	We will review and revise.

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50.	Section 3.5.5, Page 35, first paragraph, third to last sentence:	The locations of ARCO 2 and ARCO 1 appear to be more wsw and ssw than west and south	A	We will revise.
51.	Section 3.5.5, Page 36, last sentence:	Please clarify this sentence, the two depth ranges do not match	A	We will review and revise.
52.	Section 3.5.6, Page 37, third full paragraph, second sentence:	Please clarify as to lower than what?	A	We will review and revise.
53.	Section 3.5.7, Page 38, first full paragraph, fourth sentence:	The DRO concentration of 7,100 mg/Kg is not shown on Figure 3.5-9	A	We will review the surface sample results shown on Figure 3.5-9 and make the appropriate revisions to show the DRO concentration of 7,100 mg/Kg.
54.	Section 3.5.7, Page 38, first full paragraph, sixth sentence:	"A subsurface soil sample also contained 56 mg/Kg…" Figure 3.5-9 only shows one sample with 20 mg/Kg	A	We will add to the figure.
55.	Section 3.5.7, Page 38, first full paragraph, seventh sentence:	It is not clear where concentrations listed on Figure 3.5-9 above AST 7 and below AST 7-4 should be attributed	A	We will revise the figure.
56.	Section 3.5.7, Page 38, second full paragraph, second sentence:	The concentration of benzene (0.021 mg/Kg) appears to have been measured in 2004, not 2005, based on tables on Figure 3.5-9	A	We will revise the text and figure to remove benzene since the concentration is below ARAR.
57.	Section 3.5.7, Page 38, second full paragraph, second to last sentence:	The 3,200 mg/L value is not shown on Figure 3.5-9 while the figure implies that all exceedances are shown	A	We will revise the figure.
58.	Section 3.5.7, Page 39, first paragraph:	2-methylnaphthalene is listed on Table 3.0-1 but not on Table 5.2-1	A	We will verify which table is correct and revise.
59.	Figure 3.5-9:	Benzene is shown on this figure, although it is below the ADEC cleanup criterion and the footnote on the table says only exceedances are shown	A	We will revise the figure to remove benzene
60.	Section 3.5.10, Page 40, second paragraph:	Surface stains from the 1940s would not be expected to be seen any more. It is recommended that hand borings be advanced in this area.	A	We will add the following statement to the end of the first paragraph: Based on discussions with the USACE PM, since no visual indication of contamination was found along the alignment of the former aboveground pipeline, additional investigation is not warranted.
61.	Section 3.6.1, Page 41, first sentence:	E&E 1994 is not included in list of references	A	We will add.
62.	3.6.1, Page 41, third sentence:	A DRO concentration of 145 does not exceed the ADEC cleanup criterion	A	We will revise the wording.

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63.	Section 3.6.1, Page 41, third paragraph, last sentence:	E&E 1998 is not included in the list of references	A	We will add.
64.	Section 3.6.1, Page 42, second full sentence:	It is presumed that the twelve surface samples are soils; please clarify.	A	We will revise.
65.	Section 3.6.1, Page 42, third full sentence:	Same comment as above. In addition, if just two samples were collected (primary and duplicate), please say "and" instead of ranging from. Furthermore, Figure 3.6-1 shows just one sample at a concentration of 510 or 610 (it is hard to read)	A	We will revise the text and Figure.
66.	Section 3.6.1, Page 42, first paragraph, last sentence:	The background chromium concentration has been established at 37 mg/Kg.	A	We will revise.
67.	Section 3.6.1, Page 42, second full paragraph, third from last sentence:	Is the value of 37.3 correct for the chromium SQuiRT (see comment 25)?	A	We propose to use 37 mg/Kg for sediment, surface soil, and subsurface soil which is the background concentration for chromium established by the USACE.
68.	Section 3.6.1, Page 42, last paragraph, last sentence:	No further remedial action does not make sense for this site, given the detected concentrations. In addition, this conflicts with the conclusion in the summary section below. If the previous report is being quoted here, please clarify.	A	The statement is from the ROST report and does not state "no further remedial action." It states that no further remedial investigation is necessary at this site. We will clarify.-yes
69.	Section 3.6.2, Page 43, first paragraph, last sentence:	USACE 1985 is not included in the list of references	A	We will add.
70.	Section 3.6.2, Page 44, first full paragraph, last sentence:	This statement conflicts with statement above that says no further Department of Defense action is indicated	A	We will clarify.
71.	Section 3.6.2, Page 44, second full paragraph:	It should be noted that additional characterization may be warranted. Two soil samples collected down-slope of a dump area, where the extent of buried drums is unknown, is not likely to be sufficient to characterize this area.	A	We will add a statement to indicate that some additional investigation is warranted based on review of the GFMs and discussions with the USACE PM. The results, however, will not be included in this FS.
72.	Section 3.8.1, Page 45, first paragraph, last sentence:	These references are unclear	A	We will clarify.
73.	Section 3.8.2, Page 46, first full paragraph, second to last sentence:	Is this SQuiRT value of 37.3 correct (see comment 25)?	A	We propose to use 37 mg/Kg for sediment, surface soil, and subsurface soil which is the background concentration for chromium established by the USACE.

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74.	Section 3.8.2, Page 46, first full paragraph, last sentence:	The SQuiRT value for barium is not listed in the ARAR table on Page 14	A	The SQuiRT value for barium, 0.0039 mg/L, will be listed on Page 14. Please note that the concentration of barium in surface water at AOC G4 was measured at 0.007 mg/L. Surface water at AOC G4 should be investigated further to determine if barium is still present.
75.	Section 3.9.1, Page 48, first paragraph:	It is not clear why no additional characterization is recommended, considering the 500 drums that were removed between 1984 and 1995. Was appropriate sampling performed at that time?	A	We will add a statement to indicate that some additional investigation is warranted based on review of the GFMs and discussions with the USACE PM. The results, however, will not be included in this FS.
76.	Section 3.9.2, Page 48, first paragraph, second to last and last sentences:	It should be noted that the camp is no longer used because of dioxins measured in shellfish in the area. Furthermore, cabins were not apparent during a recent site visit. Wall tent frames were set up.	A	We will revise the last sentence to: Wall tent frames are all that remain of the Cultural Camp.
77.	Section 3.9.2, Page 48, second paragraph, fourth sentence:	It should be stated that this does not exceed the TEQ screening value.	A	We will revise the text to indicate that this concentration does not exceed the TEQ screening value for 2,3,7,8-TCDD of 38 ppt.
78.	Section 3.9.2, Page 48, second paragraph, sixth sentence:	Please spell out TCDF here for the first time and add to acronym list	A	We will spell out TCDF here and add it to the acronym list.
79.	Section 3.9.2, Page 48, second paragraph, last sentence:	ADEC-accepted screening level should be 38 ppt	A	We will revise.
80.	Section 3.9.2, Page 48, third paragraph, third sentence:	Regarding the TEQ concentration of 0.0034 ppt; is this the same sample shown on Figure 3.9-2 as 0.003 ppt?	A	We will review and clarify.
81.	Section 3.9.2, Page 48, third paragraph, fourth sentence:	Value should be 38 ppt	A	We will revise.
82.	Section 3.9.2, Page 48, fourth paragraph, last sentence:	Value should be 38 ppt	A	We will revise.
83.	Section 3.9.2, Page 49, first paragraph, first sentence:	Value should be 38 ppt	A	We will revise.
84.	Section 3.10, Page 49, second paragraph, first sentence:	Please spell out DERP for the first time here and add to acronym list	A	We will spell out DERP here and add it to the acronym list.

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85.	Section 3.10, Page 50, first full paragraph, second sentence:	Based on the data listed in Figure 3.10-1, the lower end of the range should be 5.4 mg/Kg Unsatisfactory response	A	We will revise to: Arsenic was detected in three surface and three subsurface samples at concentrations ranging from 5.4 to 32 mg/kg which exceed the ADEC Method Two soil cleanup level of 3.7 mg/kg. Some of these arsenic concentrations also exceed the established background concentration of 11.6 mg/kg.
86.	Section 3.10, Page 50, first full paragraph, fourth sentence:	Based on the data listed in Figure 3.10-1, the lower end of the range should be 28 mg/Kg. Unsatisfactory response 3rd sen	A	Analytical results that do not exceed ARARs have been removed from Figure 3.10-1. The sentence referred to now matches the revised Figure 3.10-1 and will state: Chromium was detected in one surface soil and one soil boring sample at concentrations of 39 and 59 mg/kg which exceed the ADEC Method Two soil cleanup level of 25 mg/kg and the established background concentration of 37 mg/kg (ENSR 2003a).
87.	Section 3.10, Page 50, last paragraph, first sentence:	Cadmium and lead are not included in Table 3.1-1. In addition, Table 5.2-1 shows cadmium in surface soils and subsurface soils, but Table 3.0-1 shows cadmium only in surface soils. Furthermore, Table 3.0-1 does not show cadmium and lead as FUDS-eligible or requiring further action (there is no entry).	A	Cadmium and lead are included in Table 3.1-2 because they exceeded ARARs in surface water. We will review the cadmium concentrations in surface and subsurface soil and revise Tables 3.0-1 and 5.2-1 to make sure they are consistent with the text. We will review the cadmium and lead concentrations in surface water and revise Table 3.0-1.
88.	Section 3.10, Page 51, seventh line down:	Should be arsenic and chromium according to Table 3.1-1	A	We will review the arsenic and chromium concentrations in surface and subsurface soil and revise Table 3.1-1, the text, and/or Figure 3.10-1.
89.	Section 3.11.1, Page 51, first paragraph, third sentence:	It would be helpful if the drum locations were discussed in the same context as in Table 3.1-1, i.e. north and south drum dumps	A	We will clarify.
90.	Section 3.11.1, Page 51, second paragraph, first sentence:	Please add "…samples were collected west AND NORTHWEST…"	A	We will revise to: and four samples were collected west and northwest of Tank 8.
91.	Section 3.11.1, Page 51, second paragraph, second sentence:	Please add "…two soil borings (AP-077 and AP-078) were advanced NORTHwest"	A	We will revise to "and two soil borings (AP-077 and AP-078) were advanced northwest of Tank 8."
92.	Section 3.11.1, Page 52, first full paragraph, first sentence:	Please add "At the drum dump NORTHwest…"	A	We will revise to: At the drum dump northwest of Tank 8.
93.	Section 3.11.1, Page 52, second full paragraph, third sentence:	Exceedances are not shown for AP-076 on Figure 3.11-1 Did this well get resampled?	A	We will revise Figure 3.11-1 and remove the 2001 data showing exceedances for groundwater at Wells AP-076, AP-077, and AP-078. We will clarify in the text that the 2001 data is considered invalid since ENSR attributed the elevated metals concentrations in groundwater at Wells AP-076, AP-077, and AP-078 to suspended solids in the samples. In 2004, S&W sampled Wells AP-076 and AP-078 (AP-077 was dry) and in 2006, BC-J sampled Wells AP-077 and AP-078. Based on the 2004 and 2006 data, the metals concentrations in groundwater at Wells AP-076, AP-077, and AP-078 have been shown to be less than ADEC groundwater cleanup criteria.

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94.	Section 3.11.1, Page 52, second full paragraph, third to last sentence:	Should also discuss lead which exceeded the ADEC groundwater cleanup criterion according to Figure 3.11-1 Did this well get resampled?	A	We will revise Figure 3.11-1 and remove the 2001 data showing exceedances for groundwater at Wells AP-076, AP-077, and AP-078.
95.	Section 3.11.1, Page 52, second full paragraph, last sentence:	Why is AP-078 and not AP-077 potentially attributed to a fuel release?	A	This was a quote of a statement by ENSR. We will review and clarify.
96.	Section 3.11.1, Page 52, fourth full paragraph, first sentence:	Please add “north” in front of “west” in two places in this sentence	A	We will revise.
97.	Section 3.11.1, Page 53, first paragraph, first sentence:	Please add “by” between “sampled” and “BC-J”	A	We will revise.
98.	Section 3.11.1, Page 53, second paragraph, third sentence:	It would be prudent to resample AP-077 and AP-078 once more before ruling out lead as a COC	A	The USACE PM has indicated that based on the 2006 data, the lead concentrations in groundwater at Wells AP-077 and AP-078 have been shown to be less than ADEC groundwater cleanup criteria. No additional sampling of these wells is warranted.
99.	Section 3.11.1, Page 53, second paragraph:	Should discuss the fact that the area to the west of Drum Dump 1 (North Drum Dump) is not included in the Feasibility Study	A	We will revise to indicate that no COCs were identified at the North Drum Dump located west of Tank 1 and, therefore, the North Drum Dump is not included in the detailed FS.
100.	Section 3.11.3, Page 55, third full paragraph, last sentence:	The ARAR for selenium is not included in the ARARs table on Page 14. In addition, the silver ADEC cleanup criterion is 0.10 mg/L, not 0.18 mg/L	A A	We will revise the ARARs table on Page 14 to include selenium, barium, and others. We will revise the text to show that the silver ARAR is 0.1 mg/L.
101.	Section 3.11.4, Page 55, first paragraph, first sentence:	Does the distance refer to Ophir Creek Road and not Ophir Creek? Pg 56	A	We will clarify that the Field Revisions, A.C Tactical Gas System plan, dated April 17, 1943, and provided in Appendix A, shows the location of Truck Fill Stand No. 4 approximately 1,200 feet southeast of Ophir Creek, in the Temporary A.C. Gas Storage Area.
102.	Section 3.12.1, Page 58, last paragraph, first sentence:	What does the term “other” mean here? Other than what? Please clarify	A	We will review and clarify by removing “other” if appropriate.
103.	Section 3.14, Page 62, third paragraph, first sentence:	The arsenic concentration should be 13.4 mg/Kg not 13.5, according to Figure 13.4-1	A	We will review and correct.
104.	Section 3.15, Page 64, first partial paragraph, last sentence:	The screening level should be 38 ppt not 39 ppt	A	We will revise.
105.	Section 3.15, Page 64, first full paragraph, first sentence:	The “J” qualifier should be explained or omitted	A	We will revise the sentence to: The surface water sample and associated replicates contained an <u>estimated concentration of 0.00681 up</u> to 0.015 mg/L bis(2-ethylhexyl)phthalate <u>and</u> up to 0.00771 mg/L lead.

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106.	Section 3.16, Page 64:	Should include a statement that additional assessment may be warranted, such that it is not inferred that this AOC is not contaminated.	A	We will add a statement to indicate that additional investigation is warranted based on review of the GFMs and discussions with the USACE PM. The results, however, will not be included in this FS. See Response to Jonathan's Comment No. 2.
107.	Section 3.17, Page 65, first paragraph, first sentence:	How can a rifle range be contained within a single berm? Do you mean "contained a berm"	A	We will review the E&E report and clarify.
108.	Section 3.18, Page 66, last paragraph, first sentence:	Should include a statement that additional assessment may be warranted, such that it is not inferred that this AOC is not contaminatedpg 67	A	We will add a statement to indicate that additional investigation is warranted based on review of the GFMs and discussions with the USACE PM. The results, however, will not be included in this FS.
109.	Table 4.0-1, 4th column:	Remedial Action Objective No. 2 should probably discuss inhalation of vapors from the soil. Inhalation of soil (presumably dust particles), would be the same as ingestion. In addition, why would inhalation of carcinogenic COCs be the only concern? Inhalation of non-carcinogenic COCs can also adversely impact ecological and human health.	A	Remedial Action Objective No. 1 for soil in Table 4.0-1 will be revised to: Prevent ingestion and/or direct contact with soil containing COCs. Remedial Action Objective No. 2 in Table 4.0-1 will be revised to: Prevent inhalation of COCs in soil.
110.	Table 4.0-1	It is agreed that land-farming would have a reduced effectiveness in such a wet climate. It should also be pointed out that the shallow water table at some AOCs would render land-farming impractical because of the potential for migration of contaminants, unless a liner was utilized.	A	We will add: and shallow water table, where present, may render this technology impractical.
111.	Table 4.0-1	The excavation and disposal option should also include VOCs	A	We will revise.
112.	Table 4.0-1	For groundwater cleanup, the introduction of oxygen releasing compounds is not mentioned. Is this part of nutrient amendment, or has this been deemed impractical?	A	Oxygen releasing compound (ORC) has been deemed impractical by the USACE.
113.	Table 4.0-1	Capping – this technology is not suitable for sediments as listed	A	Sediments will be removed from "Capping".
114.	Table 4.0-1	For groundwater Remedial Action Objectives –preventing inhalation of volatiles should be added which would address this potential if the groundwater was to be used as a water supply.	A	Remedial Action Objective No. 1 for groundwater in Table 4.0-1 will be revised to: Prevent ingestion and/or direct contact with groundwater containing COCs. Remedial Action Objective No. 2 for groundwater in Table 4.0-1 will be revised to: Prevent inhalation of COCs in groundwater.
115.	Section 4.2, Page 69, first bullet:	Why is inhalation of non-carcinogenic vapors not a concern?	A	The first two bullets on Page 69 will be revised to: ingestion and/or direct contact with soil containing COCs" and "inhalation of COCs in soil. The bullet on Page 69 for surface water and groundwater will be revised. For surface water, the bullet will state: ingestion and/or direct contact with surface water containing COCs. For groundwater, the first bullet will state: ingestion and/or direct contact with groundwater containing COCs and the second bullet will state: inhalation of COCs in groundwater.

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116.	Section 4.4, Page 70, second line:	Please add "on" after "based"	A	We will add "on" after "based" in the second to last line on Page 70.
117.	Section 4.5.14, Page 77, fifth sentence:	Some portion of contaminants may be destroyed. Better to say that this method is not designed to destroy contaminants.	A	We will revise to: This method is not designed to destroy contaminants, ...
118.	Section 5.1, Page 83, first bullet in second bullet list:	Why not include sediments in monitored natural attenuation?	A	We will revise to include sediments.
119.	Section 5.1, Page 83, fourth bullet in second bullet list:	Should include sediments in biopile as indicated as being applicable in section 6.7	A	We will revise to include sediments.
120.	Section 5.1, Page 83, seventh bullet in second bullet list:	Should include sediments in soil washing as indicated as being applicable in Section 6.10	A	We will revise to include sediments.
121.	Section 5.1, Page 83, tenth bullet in second bullet list:	Should include sediments in low temperature thermal desorption as indicated as being applicable in Section 6.8	A	We will revise to include sediments.
122.	Section 5.1, Page 83, last bullet in second bullet list:	Should include sediments in excavation and off-site disposal as indicated as being applicable in Section 6.9	A	We will revise to include sediments.
123.	Section 5.1, Page 84, third and fourth bullet:	Should include sediments in no action and institutional controls options	A	We will revise to include sediments.
124.	Section 5.2, Page 84, seventh sentence:	Nutrient amendment can be integrated into the biopiles technology as well. Why is application of ORC not considered?	A	See Response to Comment No. 112.
125.	Section 5.10, Page 87, bullet list:	Why not included application of ORC?	A	See Response to Comment No. 112.
126.	General:	BGES did not evaluate the cost estimates for reasonableness	N	
127.	Section 6.4, Page 96, Costs; second sentence:	Table C.4 estimates the capital costs at $405, not $430 per cubic yard ? pg 3 of 3 (C.4)	A	We will clarify the text to indicate that the capital costs are the sum of the Capital Cost ($405) and the Future Capital Cost ($30) shown on Page 3 of 3 in Table C.4.
128.	Section 6.5, Page 98, Costs; second sentence:	Table C.5 estimates the capital costs at $518, not $560 per cubic yard	A	We rounded in the text. We will clarify the text to indicate that the capital costs are the sum of the Capital Cost ($518) and the Future Capital Cost ($40) shown on Page 3 of 3 in Table C.5.
129.	Section 6.6, Page 100, Costs; second sentence:	Table C.6 estimates the capital costs at $176, not $220 per cubic yard	A	We rounded in the text. We will clarify the text to indicate that the capital costs are the sum of the Capital Cost ($176) and the Future Capital Cost ($41) shown on Page 3 of 3 in Table C.6.

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130.	Section 6.7, Page 101; first partial paragraph, second to last sentence:	The values given apparently assume a slope of the sides of the biopile, which is a reasonable assumption; or that the dimensions provided are the actual size of the liner, such that the average length and width of soil placement is somewhat less. This should be stated so that any readers who do calculations will understand this.	A	We estimated that the usable area of a 50 feet by 100 feet liner, inside the perimeter berm, would be about 90 feet by 40 feet and that the sides of the biopile would slope at a 1.5 to 1. At <u>an average</u> height of <u>about</u> 10 feet, the biopile would hold about 1,300 cubic yards. The text will be revised accordingly.
131.	Section 6.7, Page 101; first full paragraph, third sentence:	This statement is misleading unless a blower or a passive wind turbine is anticipated to be connected to the PVC. The cost table includes a blower; please add a brief description here.	A	We will add the blower into the description.
132.	Section 6.7, Page 101; first full paragraph, last sentence:	For clarification, please add "be sloped to" between the "biopile would" and "drain". Please add "back" between "would be pumped" and into; please add "in the biocell" after "into the soil" and before "through"	A	We will revise to: The bottom of the Biopile would be sloped to drain to a leachate collection system at one corner and water that accumulates would be pumped back into the soil in the Biopile through the aeration piping.
133.	Section 6.7, Page 101; second full paragraph, last sentence:	Confirmation borings are not included in the cost estimate. In addition, the use of a hand auger may be more cost effective for collecting samples in the biopiles. The hand auger might penetrate 7 or 8 feet into the disturbed soils in the piles under ideal conditions. Furthermore, the use of multi-incremental soil sampling would greatly reduce the characterization cost.	A	We had planned to use a local backhoe to advance test pits. We prefer to state that: confirmation test pits or hand auger borings would be advanced and multi-incremental soil sampling may be conducted at 5 years …
134.	Section 6.7, Page 101; third full paragraph:	Are these samples included with the 48 confirmation samples? There are no provisions associated with confirmation sampling in the decommissioning effort in the cost table.	A	No. Confirmation samples within the Biopile footprint will be added to Table C.7.
135.	Section 6.7, Page 103, costs; second sentence:	Table C.7 estimates the capital costs at $398, not $420 per cubic yard	A	We rounded in the text. We will clarify the text to indicate that the capital costs are the sum of the Capital Cost ($398) and the Future Capital Cost ($28) shown on Page 3 of 3 in Table C.7.
136.	Section 6.8, Page 105, implementability; first partial paragraph, first full sentence:	Please add "up" between "petroleum-impacted soil" and "to depths of" since not all sites would be excavated to 30 feet below grade	A	We will revise to "Excavating equipment and trucks, potentially available in Yakutat, would be needed to remove the petroleum-impacted soil up to depths of 30 feet and transport the impacted soil to the Treatment Area."
137.	Section 6.9, Page 106, short-term effectiveness; fifth sentence:	Please add "and/or off-site" after "to the containment area."	A	We will add "and/or off-site" after "to the Containment Area."
138.	Section 6.9, Page 107, implementability; first line:	Please add "up" between "petroleum-impacted soil" and "to depths of" since not all sites would be excavated to 30 feet below grade	A	We will revise to: Excavating equipment and trucks, potentially available in Yakutat, would be needed to remove the petroleum-impacted soil up to depths of 30 feet and transport the impacted soil to the Containment Area.
139.	Section 6.9, Page 107, costs; first sentence:	Please delete one of the redundant "for treating the petroleum AOCs"	A	We will revise.

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140.	Section 6.10, Page 108, short-term effectiveness, fourth sentence:	It is suggested that the following be added to the end of this sentence "…to the treatment area AND THE WATER/LIQUID RESIDUE OFF SITE"	A	We will revise to: Additional risks to the community may result from transporting impacted soil and/or sediment to the Treatment Area and the water/liquid residue off site.
141.	Section 6.11, Page 110, short-term effectiveness, :	It is recommended that a sentence or two be added to discuss the need to exercise care in some cases such that contaminated groundwater is not "pushed" off site	A	We will add a brief discussion.
142.	Section 6.11, Page 111, costs; last line:	The value given ($230 per square foot) is for the total O&M not the annual O&M.	A	We will revise to: The total O&M cost is for monitoring and is estimated to be $230 per square foot of impacted groundwater plume.
143.	Section 6.12.1, Page 112, overall protection of Human Health and Environment; fourth sentence:	Engineering controls (at least temporary) may also be required for alternatives 4, 7, and 8.	A	We will add that temporary engineering controls, such as a chain-link fence, may be required for alternatives 4, 7, and 8 to limit exposure while COCs are reduced.
144.	Section 6.12.2, Page 114, first paragraph, first line:	Please double check the number of AOCs – seems to be 11.	A	We double-checked and we count 11.
145.	Section 6.12.2, Page 114, third sentence:	Why isn't DAST-1 included in the list of AOCs as indicated on Table 5.2-1?	A	We will revise the third sentence of Section 12.2.2 as follows: The AOCs include C2, C4, C6, DAST-1 (downslope), D-AST3, D-AST4 (north and south), D-AST5, D-AST6, D-AST8, L1-South Dump, and M2 (tank and Quonset hut).
146.	Table 6.12-2	Should add DAST-1 (downslope) as indicated in Table 5.2-1	A	DAST-1 (downslope) will be included in Section 12.2.2 and Table 6.12-2.
147.	Section 6.12.2, Page 114, last sentence:	Should be 11 AOCs if DAST-1 is added as suggested above 6.12.2 Table 5.2-1	A	D-AST1 is included in Section 12.2.3 but DAST-1 (downslope) needs to be included in Section 12.2.2 and Table 6.12-2.
148.	Section 6.12.2, Page 117, first complete paragraph, third sentence:	Please add "which" between "alternative 6" and "may"	A	We will revise to: Alternative 7 may require about 5 years to achieve ARARs which is more effective than Alternative 6 which may require about 10 years.
149.	Section 6.12.2, Page 117, cost, third sentence:	Monitored natural attenuation is probably better referred to as a passive, not active remedial strategy	A	We will revise "active" to "remaining".
150.	Section 6.12.3, Page 120, cost, third sentence:	Monitored natural attenuation is probably better referred to as a passive, not active remedial strategy	A	We will revise "active" to "remaining".
151.	Section 6.12.4, Page 122, cost, third sentence:	Monitored natural attenuation is probably better referred to as a passive, not active remedial strategy	A	We will revise "active" to "remaining".

PROJECT: Yakutat AFB **REVIEW COMMENTS**	**DOCUMENT:** Draft TAPP Review of Draft Feasibility Study - S&W **LOCATION:** Yakutat, Alaska			
DATE: 8/5/09	**REVIEWER:** Robert Braunstein **PHONE:** (907) 644-2900			
Item No.	**Location (page, par., sen.)**	**COMMENTS**	**Review** A – Comment/Response Accepted W – Comment Withdrawn N – Noted D - Discuss	**Shannon & Wilson Response**
152.	Section 6.12.5, Page 123, overall protection of human health and the environment, first sentence:	Why would the overlying soil or sediment have to be impacted?	A	The first sentence under "Overall Protection Of Human Health And The Environment" will be removed.
153.	Section 6.12.5, Page 123, short-term effectiveness, first paragraph, last sentence:	This sentence does not seem to make sense.	A	We will revise this sentence.
154.	Section 6.12.6, Page 125, overall protection of human health and the environment, first sentence:	Why would the overlying soil or sediment have to be impacted?	A	The first sentence under "Overall Protection Of Human Health And The Environment" will be removed.
155.	Section 6.12.6, Page 126, short-term effectiveness, first sentence:	Please remove "have"	A	We will revise.
156.	Section 6.12.6, Page 126, short-term effectiveness, first paragraph, last sentence:	Please add "s" after "pose"	A	We will revise.
157.	Section 6.12.6, Page 126, short-term effectiveness, second paragraph, first sentence:	Please replace "are" with "is"	A	We will revise.
158.	Section 6.12.7, Page 127, overall protection of human health and the environment, first sentence:	With institutional controls, alternative 3 may protect human health, but would not likely protect other biota	A	We will revise to "Alternative 3 is the only remedial alternative that provides adequate protection of human health but would not likely protect other biota."

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Item No.	**Location (page, par., sen.)**	**COMMENTS**	**Review** **A – Comment/Response Accepted** **W – Comment Withdrawn** **N – Noted D - Discuss**	**Shannon & Wilson Response**
159.	*Section 6.12.8, Page 129, overall protection of human health and the environment, first sentence:*	Alternative 3 would not necessarily protect biota other than humans in the case of shallow groundwater	A	We will revise to: Risks to humans through potential ingestion of impacted groundwater are addressed with Alternative 3 through long-term monitoring. Alternative 3, however, would not necessarily protect biota in the case of shallow groundwater.
160.	Section 6.12.8, Page 130, short-term effectiveness, third sentence:	Please remove "the" after "poses"	A	We will revise.
161.	Section 7.0, second sentence	The report name is incorrect	A	We will revise.
162.	Appendix C, second paragraph, second to last sentence	5,000 square feet for the groundwater plume may be light, considering Table 3.1-2 indicates the average area of groundwater impact per site to be 18,877 square feet	A	We will address each of the three groundwater-impacted sites, AOC C6, D-AST7 (D2), and L1-South Dump, separately instead of using an average area of groundwater impact.
163.	Appendix C, general	The net present value analysis includes a discount rate of 7 percent. This value was recommended in EPA's guide to developing and documenting cost estimates during a feasibility study, and was adopted from the OMB Circular A-94, dated October 29, 1992. This rate is very high for today's economic climate and may distort the present value to an artificially low number. A sensitivity analysis could be performed using a lower discount rate if desired.	A	The USACE PM requests that we continue to use a discount rate of 7 percent as recommended by EPA.

PROJECT: Yakutat AFB **DOCUMENT:** Feasibility Study, May 2009
REVIEW COMMENTS **LOCATION:** Yakutat, Alaska

DATE: June 24, 2009 **REVIEWER:** Jonathan Schick **PHONE:** (907) 269-3077

Item No.	Location (page, par., sen.)	COMMENTS	Review A – Comment Accepted W – Comment Withdrawn N - Noted	Shannon & Wilson Response
1	General	This report succinctly summarizes all of the concerns at the majority of the sites in Yakutat in a way that is easy to understand.	N	
2	Section 3.16, Page 64 and Table 3.0-1	The State is concerned about the AACS Transmitter Station Power house. The site has not been assessed and therefore no COPCs were identified. Additional investigation was recommended by ENSR and no follow on work has been performed. Power house sites are of specific concern because they often have PCB contamination in the vicinity of the site as well as fuel contamination. This site needs to be located and properly investigated.	A	The AACS Transmitter Station Power house warrants additional investigation based on review of the GFMs and discussions with the USACE PM and not based on our personal knowledge. The AACS Transmitter Station Power house will be addressed in a separate SI. The AACS Transmitter Station Power house will not be one of the 28 AOCs included in this FS.
3	Table 6.12-1 through Table 6.12-8.	The Tables that compare the remedial alternatives does a good job of capturing all of the applicable alternatives and the criteria, however there are a few issues with the comparisons. For instance many times the scores are the same for different alternatives. If this system is a comparison of alternatives, then it should be determined that one alternative is better than another and the score should reflect that.	A	The scores need to be the same for different alternatives that address the specific criteria equally. For instance, excavation and on-site LTTD and excavation and off-site disposal, shown in Table 6.12-1, equally address "Overall Protection of Human Health and the Environment", "Compliance with ARARs", "Long-Term Effectiveness and Permanence", and "Reduction of Toxicity, Mobility, or Volume Through Treatment."
4	Table 6.12-1 through Table 6.12-8.	Compliance with ARARs is a yes or no question and is a Threshold Criteria according to the CERCLA process. It is difficult to interpretona1-9 scale if a score in the middle is compliant with the ARARs. The numbers in this column should be changed to a yes or no, perhapsa1 or a zero. The stake holders should discus show this will impact the scoring system involved in this analysis of alternatives.	A	Based on discussions during the comment-response resolution meeting, the scores will remain as they are. For this FS, we assume that the "No Action" and "Institutional Control" alternatives will not comply with ARARs. We will foot note the score for these two alternatives under "Compliance with ARARs" with a comment indicating that "For this FS, we assume that this alternative will not comply with ARARs."
5	Table 6.12-1 through Table 6.12-8.	Over all protection of Human Health and the Environment is also a Threshold Criteria. While there is more room to interpret the level of protectiveness, it is also a yes or no question and therefore alternatives that do not comply with the ARARs and do not adequately protect human health and the environment should not be considered viable alternatives and thus eliminated from further evaluation. The numerical scale provided in the comparative analysis of alternatives does not indicate if these Threshold Criteria have been met by the alternative. This needs to be amended.	A	We will footnote the "Overall Score" for the "No Action" and "Institutional Control" alternatives with a comment that "This alternative does not comply with the ARARs, does not adequately protect human health and the environment, and is not considered a viable alternative by ADEC."
6	Table 6.12-1 through Table 6.12-8.	Another issue within these tables is regarding implementability. The land owners for each site must be in concurrence with the selected alternative in order to implement it. There is no mention within this report about the acceptance of any of these alternatives by the respective landowners, nor any mention of who the various land owners are for the sites in question. This is an important issue that should be settled before an implementability score can be assigned. Please include a section or table that details the landowner for each of the sites in question.	A	We will add a column to Table 3.0-1 indicating who the landowner is (Private, State of Alaska, Federal, Native, etc.) for each of the AOCs. The landowners will not be contacted.

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Item No.	Location (page, par., sen.)	COMMENTS	Review A – Comment Accepted W – Comment Withdrawn N - Noted	Shannon & Wilson Response
7	Section 6.12.3, Pages 119 and 120, and Table 6.12-1 through Table 6.12-8.	Please include additional discussion about the implementability and effectiveness of the three enhanced remediation systems proposed to treat petroleum COCs in subsurface soils (>30 feet bgs). It is stated that the contamination at depths up to and greater than 50 feet below ground surface at the sites in question (at Concern D). The comparison of alternatives does not include any indication of which technology would be the most effective to treat impacted soil at such depths.	A	We will add a discussion to Section 6.12.3 "Long-Term Effectiveness and Permanence" and "Implementability" regarding the three enhanced remediation systems proposed to treat petroleum COCs.
8	Section 4.15.14, Page 77, and Table 6.12-1 through Table 6.12-8.	The text in the comparison of alternatives states that the sediment will have to be dewatered in order to implement the low temperature thermal desorption technology. According to Table 6.12-4 its over all score is the lowest, thus possibly the preferred alternative. Was dewatering considered in the cost calculations for this alternative? Would dewatering be necessary for all of the ex-situ treatment alternatives?	A	We assume that soil or sediment excavated from a wetland or stream would be placed on plastic membrane adjacent to the excavation and allowed to drain excess water. Best management practices would be used to filter particulates and contaminants from the leachate prior to allowing discharge back into the excavation. Dewatering would be needed prior to transporting soil or the excess water, potentially containing COCs, would drain onto Yakutat roads.
9	Table 6.12-4	Also on Table 6.12-4 why is excavation and off-site disposal not considered to be effective in the short term? Also, how is monitored natural attenuation considered less effective in the short term than no action? Additional explanation regarding the scoring system and the way that the numbers are assigned should be included as a preface to the tables.	A	We will make three columns for Short-term Effectiveness. The first column score will address risks to the community, workers, etc. as result of implementation of the proposed remedial action, such as dust from excavation, transportation of hazardous materials, or air-quality impacts from a stripping tower operation that may affect human health. The second column score will be based on the time required to meet ARARs. The third column will show the average of the first and second column scores and will be the value used to represent the Short-term Effectiveness for the Overall Score.
10	Table 6.12-4	The key beneath the table explains that for the evaluation of short term effectiveness, separate scores are given to each alternative and the average of the scores is shown. Are the scores then rounded up? It seems odd that only whole numbers are shown when it is supposed to be an average. Please elaborate the explanation of how the scoring system is designed to work. Additional discussion needs to be included to explain how No Action can be as effective in the short term, and in one case, more effective in the short term, than one of the other remedial alternatives.	A	Two scores are given to the alternative for short term effectiveness, summed and then divided by two. The result is rounded up to the nearest whole number by the excel program. Please see 6.2.3.5 Short-term Effectiveness in the document *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA.*