FINAL REPORT:

FEASIBILITY STUDY FOR REMEDIAL ACTIONS AT CAMP LONELY LANDFILL, ALASKA

JUNE 2007

Hoefler
CONSULTING GROUP

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Prepared for:

The Camp Lonely Landfill Potentially Responsible Parties

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List of Acronyms and Abbreviations

%	Percent
µg/L	Micrograms per liter
AAC	Alaska Administrative Code
ADEC	Alaska Department of Environmental Conservation
AWQS	Alaska Water Quality Standards
BLM	Bureau of Land Management
bgs	Below Ground Surface
BTEX	Benzene, Toluene, Ethylbenzene, and Total Xylenes
°C	Degrees Celsius
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CIRI	Cook Inlet Region, Inc.
COC	Contaminant of Concern
DRO	Diesel Range Organics
°F	Degrees Fahrenheit
FNSB	Fairbanks North Star Borough
FS	Feasibility Study
GRO	Gasoline Range Organics
HCG	Hoefler Consulting Group
HI	Hazard Index
ICs	Institutional Controls
LNAPL	Light Non-Aqueous Phase Liquid
mg/Kg	Milligram(s) per Kilogram
NOAA	National Oceanic and Atmospheric Administration
NPRA	National Petroleum Reserve - Alaska
NSB	North Slope Borough
PAH	Polynuclear Aromatic Hydrocarbon
PRG	Preliminary Remediation Goal
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RoD	Record of Decision

RRO	Residual Range Organics
SQuiRT	Screening Quick Reference Table (NOAA)
SRRS	Short Range Radar Station
TAH	Total Aromatic Hydrocarbons
TAqH	Total Aqueous Hydrocarbons
TCLP	Toxic Characteristic Leaching Procedure
TSCA	Toxic Substances Control Act
TSD	Treatment, Storage, and Disposal
USAF	U.S. Air Force
USEPA	U.S. Environmental Protection Agency
yd^3	Cubic Yard

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1.0 INTRODUCTION

This Feasibility Study (FS) identifies and evaluates alternatives for the environmental remediation (cleanup) of the Camp Lonely Landfill and associated pad. The Camp Lonely Landfill is located on the Arctic coastline of Alaska. The cleanup will be performed with the objective of obtaining site closure under State of Alaska Oil and other Hazardous Substances Pollution Control regulations (18 AAC 75).

Camp Lonely is situated near Pitt Point between Smith and Harrison Bays, on the Beaufort Sea (Figure 1-1). It is approximately 1.5 miles northwest of the Point Lonely Short Range Radar Station (SRRS), which is managed by the U.S. Air Force (USAF). The Point Lonely SRRS was closed in the summer of 2005 and is scheduled for demolition in 2008.

Camp Lonely is not connected to the Alaska road system. Overland access is possible in the winter, and sea access can occur during the summer. The nearest airstrip is located at the Point Lonely SRRS. The road between Camp Lonely and Point Lonely SRRS is only drivable by All-Terrain Vehicle (ATV) or rollagon due to coastal erosion. Figure 1-2 contains an aerial photograph of Camp Lonely and the USAF installation. The structures and debris on the Camp Lonely pad were demolished and removed during the summer of 2005.

The Camp Lonely site included a permitted landfill that operated between approximately 1976 and 1986, and received waste from multiple parties. The site is located on a gravel pad adjacent to vegetated tundra. Small freshwater (thermokarst) ponds and brackish lagoons are present in the vicinity of the Beaufort Sea. There have been several environmental investigations conducted at the landfill. The most detailed work was a site characterization of the landfill performed in July and August 2005 (HCG 2006a). This was followed by a supplemental site characterization in August 2006 (HCG 2006c).

A geophysical survey of the pad indicated there are four primary areas where metallic debris was buried (HCG 2006a). Test pits and site observations indicated these areas generally correlated with landfill boundaries. Three of the four burial areas are located on the western half of the pad. For practical purposes, this area is considered one landfill because intermittent debris was present between the three areas. This area is collectively referred to as the "Western Landfill" or simply the "landfill" in this report. Cleanup of this landfill is the primary focus of the FS. However, the study also addresses to a more limited extent petroleum-contaminated soil and another suspected debris burial area on the pad. This latter area is referred to as the Northeast Dumpsite. Figure 1-3 depicts the location of the landfill and other areas of concern on the pad.

1.1 Purpose and Approach of Study

The purpose of this FS is to:

- Identify and evaluate remedial alternatives; and
- Select a preferred remedial action alternative.

Several approaches were used to expedite the identification and evaluation of remedial alternatives:

- The FS focuses on remedial alternatives suitable for the remote arctic conditions. Remedial alternatives at Camp Lonely are limited by several factors, including the following:
  - The remote location (not road accessible);
  - The arctic climate (limited time period when temperatures are above freezing); and
  - The limited infrastructure (resources and facilities).
- The evaluation of treatment alternatives relied on the knowledge gained from previous studies and remedial actions conducted on the arctic coast of Alaska. Remedial alternatives that were unproven in these site conditions or considered difficult to implement were not considered appropriate for this remote arctic site due to the inherent risk.
- The FS focuses on contaminated media instead of individual locations, when appropriate.
- Repetition of information presented in the site characterization reports (HCG 2006a and 2006c) was minimized. The FS references previous reports when applicable.

In addition, an objective of the FS was to develop an approach and schedule that could be integrated with cleanup actions at the nearby Point Lonely radar station. This facility is scheduled for demolition and environmental remediation in 2008 by the USAF. It may be efficient to perform environmental remediation at Point Lonely and Camp Lonely during the same period due to their remote locations. It is very likely that some fixed costs such as mobilization, demobilization and infrastructure (e.g., camp operations) can be shared. The degree of cost savings will depend upon the timing of projects, contracting approaches, and degree of coordination among the responsible parties. The FS does not quantify the potential cost savings of integrating the two projects. However, for cost estimating purposes the FS assumed that remedial activities at Camp Lonely would start in 2008 to coincide with the Point Lonely cleanup activities. However, the greatest cost saving may come for staggering the start date for the cleanup operations at the two sites by a year so equipment can be mobilized for one project to another. The lack of a road between Point Lonely and Camp Lonely hinders frequent travel between the two locations by conventionally wheeled equipment (e.g., tucks, end dumps and loaders).

1.2 Summary of the Site

The background information used as the basis for the FS was derived from several principal sources. Information on the landfill areas was obtained from the 2005 site characterization report (HCG 2006a) and supplemental site characterization report (HCG 2006c). Information regarding contamination of the pad other than the landfill areas was derived from a 2005 environmental assessment (ENSR 2005). See Appendix G, pages 1-4, for select photographs of the test pits from the 2005 investigation.

As discussed previously, a geophysical survey of the pad indicated there are four primary areas on the pad where metallic debris was buried (HCG 2006a). The site characterization focused on the landfill area on the southwest corner of the pad, which was the original focus of the study, but additional areas were also characterized. The sampling indicated that contaminants associated with petroleum hydrocarbons were migrating from the landfill areas into adjacent surface water bodies. Benzene, toluene, ethylbenzene, and xylenes (BTEX) compounds were identified as contaminants of concern (COCs) in the water based on the combined 2005 and 2006 site characterization results (HCG 2006a and 2006c). Elevated BTEX compounds in one small pond adjacent to the landfill resulted in exceedances of Alaska Water Quality Standards (AWQS) contained in 18 AAC 70 for total aromatic hydrocarbons (TAH) and total aqueous hydrocarbons (TAqH). The concentrations of BTEX and polynuclear aromatic hydrocarbon (PAH) compounds in the water did not exceed the National Oceanic and Atmospheric Administration (NOAA) Screening Quick Reference Table (SQuiRT) aquatic life criteria. In addition, the small pond where the AWQS exceedances occurred offers limited aquatic habitat. Therefore, the ecological risk posed by these compounds in the water may be low despite the regulatory exceedances.

Other surface water bodies next to the landfill have not contained water with concentrations exceeding AWQS. The TAH and TAqH concentrations were very low or non detectable. Therefore, the exceedances within the single pond are likely the result of a localized source within the landfill (e.g., a product leak from a drum). If this source is eliminated, it is likely that TAH or TAqH concentrations would drop below AWQS. No petroleum sheens were evident on any of the water bodies adjacent to the landfill in 2005 or 2006.

The soil sample results from the test pits and other sample locations within the landfill and pad contained a consistent list of compounds exceeding risk based or regulatory criteria with minor variation. Most soil COCs are associated with diesel fuel, motor oil or other petroleum products. Diesel range organics (DRO) was the most widespread contaminant to exceed screening criteria (Alaska Department of Environmental Conservation [ADEC] Method One cleanup levels). The highest residual range organics (RRO) and chromium concentrations were detected in areas with surface staining, and therefore reflect relatively localized impacts. Overall, soil within the landfill areas is best categorized as having low to moderate DRO contamination with isolated hotspots of RRO and to a lesser extent chromium. These hotspots are typically associated with releases from localized sources (e.g., a leaking drum). The contaminated areas are located within the interior of the pad and are not immediately threatened by erosion. Ecological receptors are unlikely to have significant exposure to the COCs in the landfill soils under the current site conditions because the gravel pad constitutes poor ecological habitat. A conceptual cross section though the south portion of the landfill based on the 2005 and 2006 investigations is contained on Figure 1-4. Test pits indicated the landfill contained a variety of domestic and industrial waste. The latter was the most prevalent and included wire, cable, piping, landing mats, and drums (HCG 2006a).

Cumulative risk calculations indicate the human health risk from hazardous substances does not exceed ADEC's risk management standards for carcinogenic risk (1×10^{-5}) and noncarcinogenic risk (HI =1) under an industrial exposure scenario but exceeded those standards for a residential exposure scenario (HCG 2005a). An industrial exposure scenario is more appropriate for the site than a residential exposure scenario. Residential land use is not occurring at Camp Lonely, and is unlikely given its remote location and the susceptibility of the pad to erosion. Based on the interim remedial actions and site characterization, there does not appear to be any immediate threat to human health or the environment based on the current site uses and conditions, with the possible exception of aquatic organisms in the pond immediately adjacent to the landfill.

The future risk of potential environmental impacts from landfill material is considered greater than the current risk. The landfill is located near an eroding coastline. Erosion of landfill areas closest to the coast is projected to occur within 40 years if the current rate of erosion continues. This would release debris and any remaining contamination into the marine environment. The release of debris and contaminated soil into the ocean could result in exceedances of state and federal regulations and statutes, including the Clean Water Act, ADEC Solid Waste regulations (18 AAC 60), and ADEC water quality regulations (18 AAC 70). For example, erosion of soil with petroleum hydrocarbons could potentially cause surface water sheening (most likely limited and of short duration). Debris scattered in the ocean could interfere with navigation, especially for small motor boats operating close to the shoreline. In addition, ecological receptors could become exposed to contaminants in the eroding waste or soils. move

Based on the investigations conducted to date (HCG 2006a and c), the soil and water COCs for the Camp Lonely Western Landfill and pad are summarized in Table 1-1. The estimated volumes of contaminated soil and debris for the Camp Lonely landfills and pad are listed in Table 1-2. The estimated volumes of contaminated soil and debris located at the Western Landfill are listed in Table 1-3. The site-specific calculations and assumptions used to quantify the estimated volumes of contaminated soil for each area are contained in Appendix A. In these summary tables, the contaminated soil volumes represent the volume of DRO contaminated soil above 500 milligrams per kilogram (mg/Kg), the Method One cleanup level for gravel pads in the Arctic Zone. As stated previously, DRO is the most widespread COC in the soil. The other COCs are either commingled with the DRO contaminated soil volume and/or represent a minor component. Therefore, DRO soil volumes are used as the basis for evaluating cleanup alternatives and cost. In the summary Tables 1-3 and 1-4, the volumes of petroleum-contaminated soil within several DRO concentration ranges are listed (500, 1,000, and 2,000 mg/Kg). These distinctions were made to evaluate the cost and effectiveness of various cleanup levels.

The estimated volumes of soil and waste contain a moderate to high degree of uncertainty depending upon the area. This uncertainty results from the limited historical information regarding spills, the limited sample points, and difficulty in accurately characterizing a historic landfill (dump) without disposal records. Dump sites may be highly heterogeneous in terms of their contents and contamination. It is possible that small hot spots of contamination or hazardous materials were missed during the previous investigation. These estimates are presented for the purposes of the FS only.

1.3 Remedial Action Objectives and Preliminary Remediation Goals

The remedial action objectives for Camp Lonely Landfill are to:

- Protect human health and the environment; and
- Comply with applicable Federal, State, and local laws and regulations.
- Obtain site closure under 18 AAC 75 (either conditional or full closure).

To meet these remedial objectives, preliminary remediation goals (PRGs) were developed. PRGs are target cleanup levels which should enable the remedial objectives to be achieved. The PRGs are used to evaluate the remedial alternatives in the FS. Final site-specific cleanup levels will be established through a decision document, approved corrective action plan, or similar process. The COCs and PRGs used for the FS are listed in Table 1-1.

The soil PRGs used in the FS are ADEC Method Two cleanup levels for the Arctic Zone (18 AAC 75.341, Tables B1 and B2), with modifications made to protect surface water. Method Two cleanup levels meet the ADEC human health risk management standards of 1 in 100,000 (1×10^{-5}) for excess cancer risk and a noncarcinogenic hazard index (HI) of 1.0. Site-specific risk assessments may support higher alternative cleanup levels than Method Two; however, these risk assessments have not been conducted or approved by the necessary parties.

The approval of Method Two cleanup levels in the Arctic Zone for petroleum hydrocarbons requires the responsible party to demonstrate that levels will be protective of migration to surface water (18 AAC 75.340 [c]). Method Two soil cleanup levels for petroleum hydrocarbons may not be sufficient to prevent exceedances of 18 AAC 70 AWQS at the Camp Lonely Landfill. Exceedances of AWQS for TAH and TAqH were detected in sample results in the adjacent water bodies, although the majority of the soil results were well below Method Two cleanup levels.

In addition, there is potential for the landfill soil to erode, exposing contaminated soil to surface water, and creating surface water sheens. Sheen tests indicated that the soils with a DRO concentration of around 500 mg/Kg may generate a sheen when exposed to surface water (HCG 2006c). Although these sheens are unlikely to pose significant human health or ecological risk (see HCG 2006a, Section 7; and ENSR 2001), they may result in an exceedance of AWQS. As written in 18 AAC 70.020, the standard for petroleum hydrocarbons, oil and grease for marine water uses is:

> *Surface water and adjoining shorelines must be virtually free from floating oil, film, sheen, or discoloration.*

For freshwater uses, the water quality standards include the requirement that there "may not be a visible sheen upon the surface water." These standards are subject to interpretation because the regulations do not define the size or duration of a sheen that will result in a water quality exceedance. Nonetheless, a cleanup objective is to prevent surface water sheening exceeding 18 AAC 70 criteria. This objective includes preventing soil that may cause sheen in excess of 18 AAC 70 criteria from coming into contact with surface water. The DRO soil concentration that may cause a sheen has been conservatively estimated to be 500 mg/Kg.

Alternatively, the soil could be cleaned up to a higher concentration than 500 mg/Kg, provided the DRO will naturally attenuate to a concentration that will not generate a sheen before the site erodes in an estimated 40 years (Section 1.2). Furthermore, it is possible that with natural attenuation (weathering) over the next 40 years, the DRO concentration at which the soil sheens will increase above 500 mg/Kg.

A recent study modeled the natural attenuation of petroleum hydrocarbons in the vadose zone of North Slope gravel pads (Geosphere 2004). The study indicated that gasoline range organics (GRO) and BTEX concentrations were primarily reduced through volatilization. Volatilization and biodegradation contributed approximately equally to reduce DRO concentrations. The model indicated that soil containing an arctic diesel fuel with an initial total petroleum hydrocarbon concentration of 10,000 mg/Kg would have approximately 86% GRO and 60% DRO mass reduction in 22 years (Geosphere 2004). It would also be devoid of benzene and toluene. The reduction in the non-vadose (saturated) zone was less. Based on this generic modeling, soil in the vadose zone with a current DRO concentration on the order of 1,000 to 2,000 mg/Kg should be capable of naturally attenuating to 500 mg/Kg prior to erosion of the soils. The potential cost savings and risks of a cleanup level higher than 500 mg/Kg for DRO are evaluated in Section 4.0

A 500 mg/Kg DRO cleanup level is equivalent to the highest permitted ADEC Method One cleanup level for petroleum hydrocarbons in the Arctic Zone for man-made gravel pads and roads (18 AAC 75.341, Table A2). Under Method One, the DRO cleanup level for GRO, DRO, and RRO are 100, 200, and 2,000 mg/Kg, respectively. However, if the contamination is due to a diesel spill, the regulations permit a DRO cleanup level of 500 mg/Kg, provided certain conditions are met (i.e., BTEX is less than [<] 15 mg/Kg; benzene is <0.5 mg/Kg; and other site conditions are favorable).

The overall site conditions of the Camp Lonely Landfill pad fit the criteria for the 500 mg/Kg DRO cleanup level, if the Method One cleanup levels are applied. The majority of the petroleum contamination within the landfill and on the pad is due to releases of diesel fuel based on the soil sample results. In addition, the majority of samples collected from the pad contained highly weathered fuel, which does not contain BTEX in excess of 15 mg/Kg. This is illustrated on Figure 1-5 which contains a plot of DRO versus BTEX concentrations in the landfill soils. In over 97% of the samples where BTEX exceeded 15 mg/Kg, the DRO level was over 900 mg/Kg. Therefore, cleanup of the soils to a DRO concentration of 500 or even 1,000 mg/Kg will effectively eliminate soils with BTEX in excess of 15 mg/Kg (Figure 1-4).

The PRGs for surface water are the AWQS in 18 AAC 70. These standards will be met by cleaning up the soil to proposed cleanup levels and removing any containers (e.g., drums) in the landfill that contain hazardous substances. As discussed in the preceding paragraph, cleanup of the soils to a DRO concentration of 1,000 mg/Kg or less will effectively eliminate soils with BTEX in excess of 15 mg/Kg. In turn, this should eliminate the elevated BTEX in the surface water if the soils are the source. If the elevated BTEX is due to leaking drums, removal of the residual fuels in these containers will eliminate the AWQS exceedances.

The proposed cleanup levels pertain to the gravel pad only. The ADEC determines cleanup levels for tundra on a site-specific basis, depending upon whether a cleanup action will cause more severe or long-term damage than the discharge or release. Less stringent cleanup criteria are recommended for the native soils compared to those for the landfill soils (gravel fill) to minimize the removal of native soils and facilitate revegetation. Avoiding excessive removal of the native soil and promoting revegetation will help protect the permafrost and make the area less vulnerable to erosion. For purposes of the FS, it is assumed that no native soils below the pad or beyond its perimeter will be removed. It is recommended that native soils are only removed if they are grossly saturated with fuels and likely to result in offsite migration or AWQS exceedances.

1.4 Evaluation Criteria

The potential remedial alternatives were evaluated using three primary criteria: effectiveness, implementability, and cost. These criteria are described briefly below

1. **Effectiveness:** How well does the alternative as a whole protect the health and safety of human health and the environment? Does the alternative meet applicable state and federal laws? Does it provide long-term effectiveness and permanence? What is the long-term risk at the site after the remedial action is complete? Could human, animal, or plant health and safety be impacted during the construction and implementation of the alternative?
2. **Implementability:** Is the alternative available and able to be constructed, maintained and/or enforced? What is the technical and administrative feasibility of this alternative and availability of the required goods and services?
3. **Cost:** Is the alternative cost-effective in terms of both capital and operation and maintenance costs?

These evaluation criteria are the same primary criteria used to evaluate remedial alternatives following U.S. Environmental Protection Agency (USEPA) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) guidance (USEPA 1988). The cleanup of the Camp Lonely Landfill is being conducted under the regulations contained in 18 AAC 75. While not required, the CERCLA evaluation criteria provide a standardized approach to the evaluation process.

1.5 Cost Estimating Procedures

Cost estimates for the various alternatives evaluated are provided in Appendices A-F. Cost estimates were developed for viable alternatives on a consistent basis that included labor rates, transportation costs, waste disposal costs, and material pricing. Initial cost estimates are based on conducting work to remove all debris and remediate soil to a 500 mg/Kg DRO cleanup level at the Western Landfill. It was assumed that remediation of the DRO to 500 mg/Kg would reduce the other COCs associated with petroleum contamination (BTEX, GRO and RRO) to the PRGs because the contamination is commingled. Costs for addressing the other sites with contaminated soil on the pad were calculated using a unit cost and assumed a single mobilization effort. The professional labor rates used were based on rates considered typical of Alaska based on professional judgment. The most recent Davis Bacon rates from the U.S. Department of Labor were used for craft labor (see Appendix E). Davis Bacon rates may not be applicable depending upon how the project is contracted. For estimating purposes, it was assumed the work would be performed in 2008. Appropriate escalation factors and project-specific modifications were applied.

Quotes for trucking and barging were obtained from local vendors to confirm the capacity and availability of a given service. Barging of materials and equipment introduces a large uncertainty into the pricing because of the limited barge season and capacity during the season. Ice on the Arctic Ocean generally prohibits barge traffic from late September through the end of June.

Pricing for waste disposal was based on quotes specific to Camp Lonely and costs from similar projects. These costs were adjusted as needed based on professional judgment to account for uncertainties and future cost escalation. Treatment of petroleum-contaminated soil was based on current market rates with a minor (2%) escalation. Petroleum-contaminated soil treatment facilities are currently available in the Alaskan communities of Deadhorse, Fairbanks, and Anchorage. However, the same soil treatment facilities may not be available at the time the project is undertaken for a variety of reasons.

The areas and volumes of contamination identified in this report are best estimated based on the sample results and site conditions. However, they contain a degree of uncertainty, especially in areas with limited sample results, which includes the majority of the pad. To convert the volumes to weights, it was assumed that the excavated soil would typically consist of damp sandy gravel, with a bulk density of 3,240 pounds per cubic yard (yd^3) or 1.6 tons per yd^3. In addition, the in-place soil volumes (bank volumes) would increase by 25% upon excavation (fluff factor). These conversion factors should be representative of the typical site conditions; however, there could be localized variations.

The cost estimates provided in this FS are an estimate of the level of effort to perform a given alternative with the services available today and the assumed waste quantities and categories. The accuracies are within the USEPA-recommended standard of plus 50% to minus 30% for an FS (USEPA 1988). The pricing is valid for comparative purposes but is not intended for final budget development or programming. Costs for project management and remedial documentation (plans and reports) were determined using USEPA-recommended methodology with modification if considered appropriate (USEPA 2000). Project management and documentation costs were generated based on a sliding percentage dependent on the total value of the project costs. The pricing can be refined once a corrective action plan for the project is approved which will better define cleanup levels and details regarding the approach and schedule.

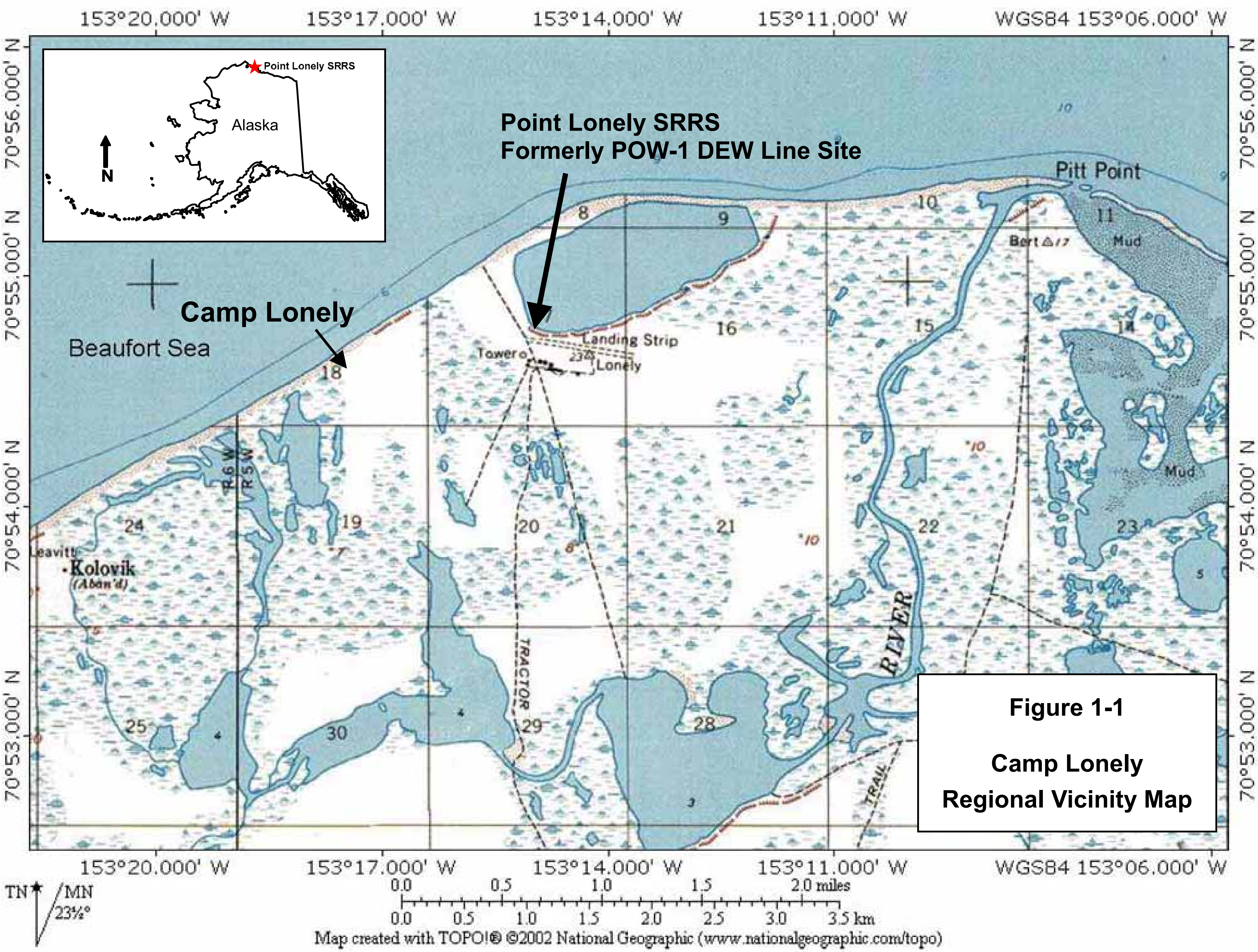

Figure 1-1

Camp Lonely
Regional Vicinity Map

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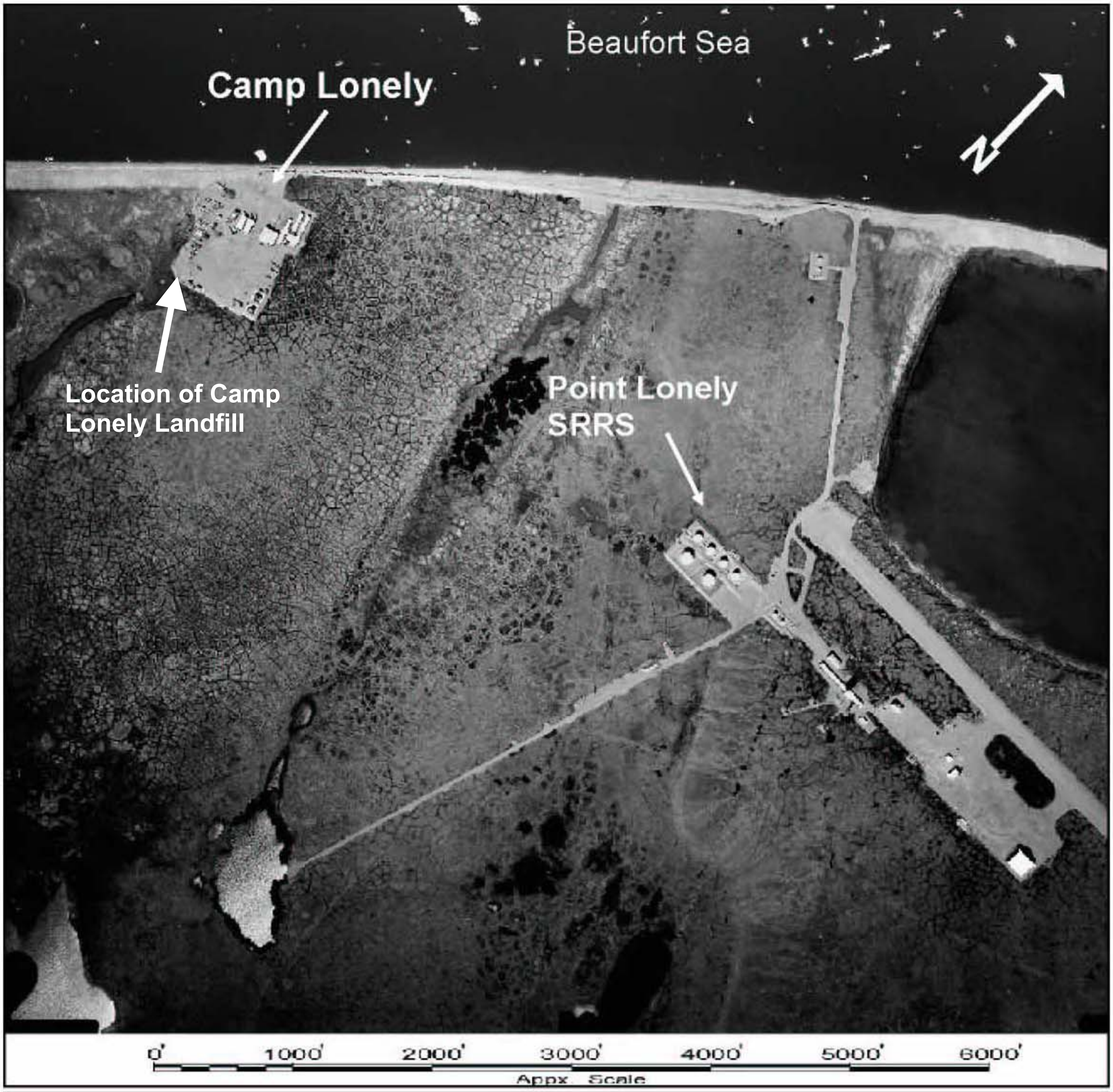

Figure 1-2

Camp Lonely with Respect to Point Lonely SRRS

Photo Date: 1992

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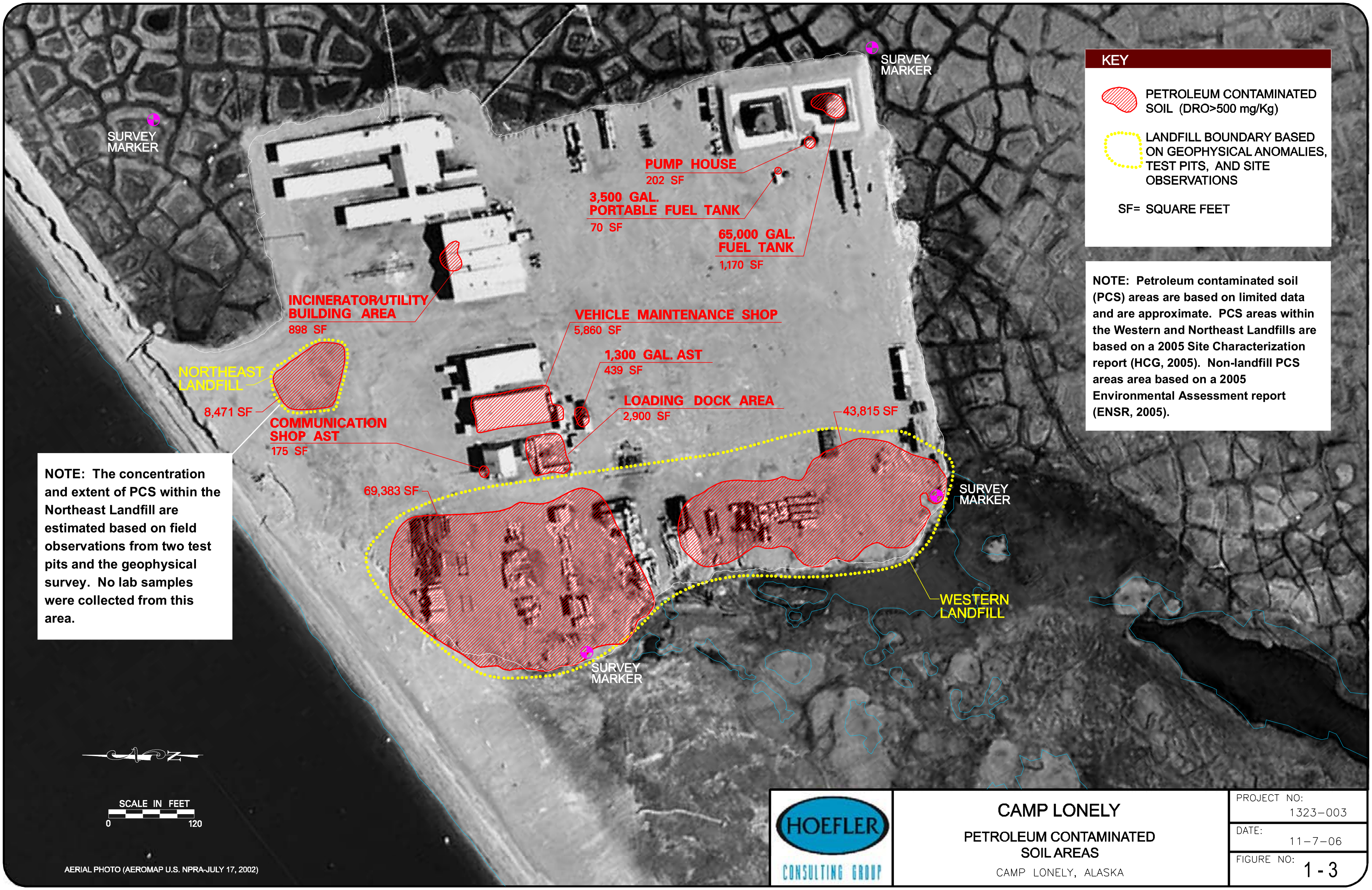

HOEFLER CONSULTING GROUP

CAMP LONELY

PETROLEUM CONTAMINATED SOIL AREAS

CAMP LONELY, ALASKA

PROJECT NO:	1323-003
DATE:	11-7-06
FIGURE NO:	1-3

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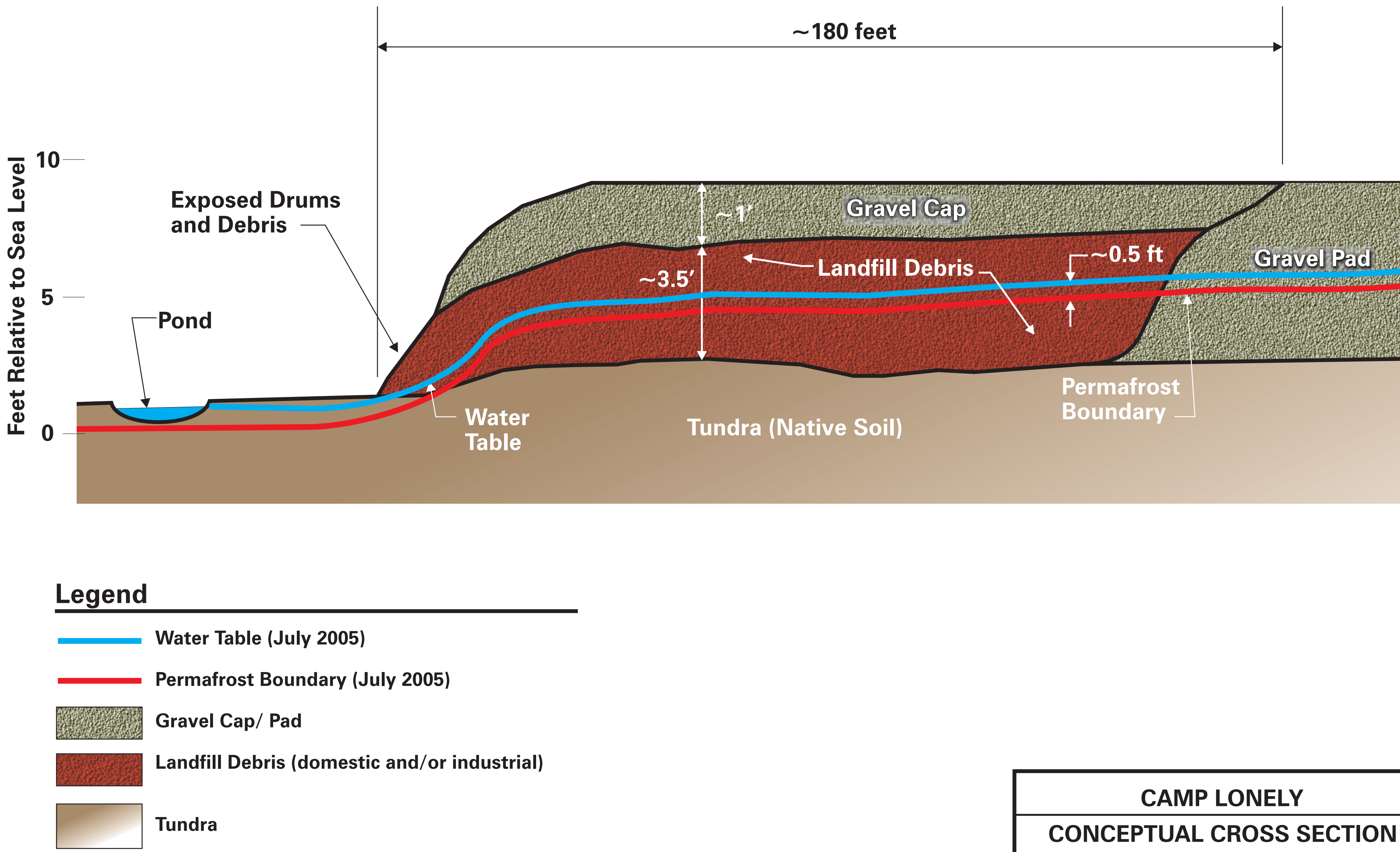

Note:
Depth and dimensions are approximate.

CAMP LONELY

CONCEPTUAL CROSS SECTION THROUGH SOUTH PORTION OF WESTERN LANDFILL

FIGURE 1-4

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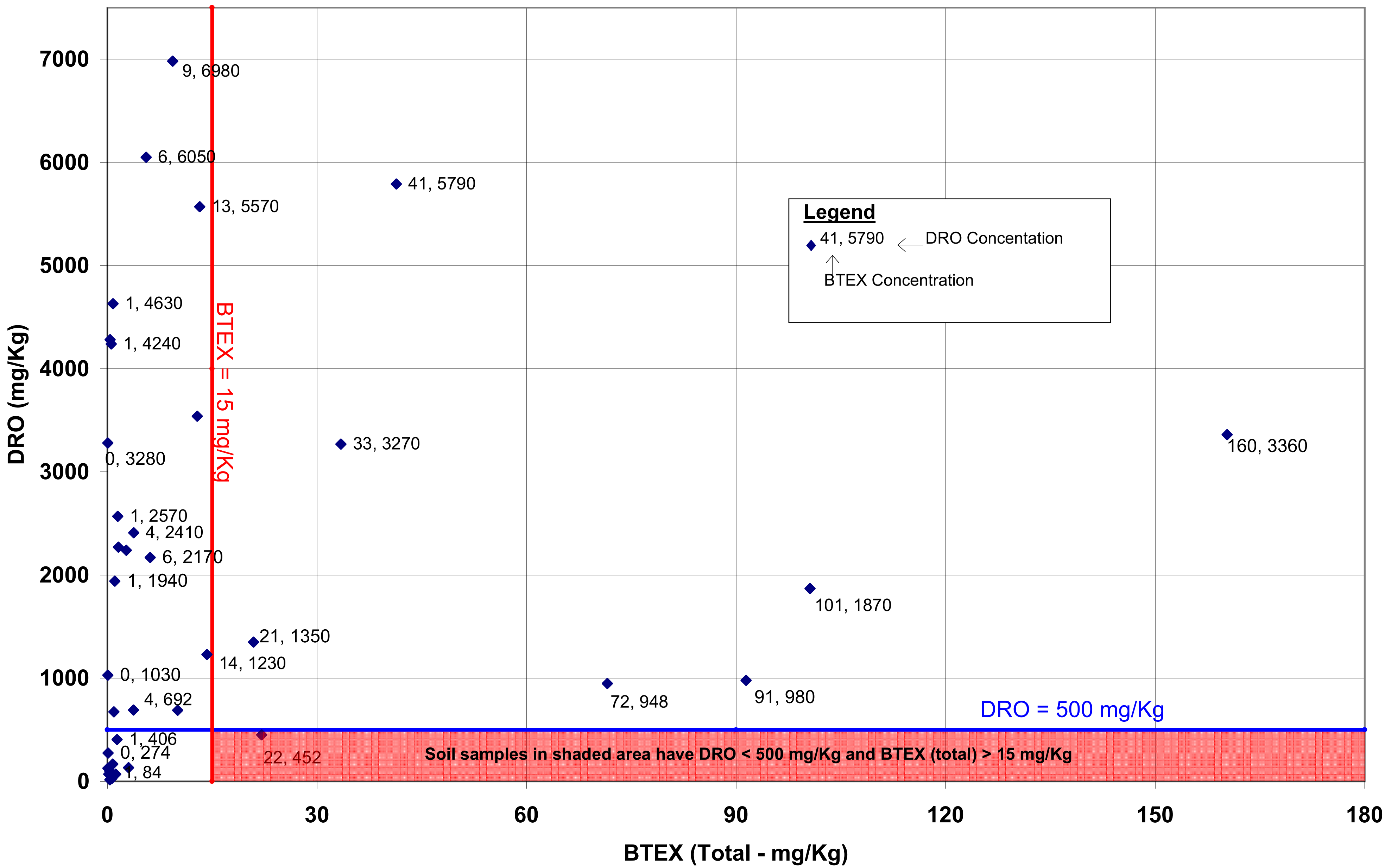
Figure 1-5: DRO Versus BTEX Concentrations in Landfill Soils



Notes: BTEX exceeded 15 mg/Kg in 8 out of 33 samples. Only one sample with DRO < 500 mg/Kg had BTEX > 15 mg/Kg. As illustrated above, BTEX above 15 mg/Kg tends to be associated with DRO concentrations > 1000 mg/Kg. **Source of Data**: 2005 Site Characterization (HCG 2005)

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Table 1-1 Summary of Current COCs and Preliminary Remediation Goals (PRGs) for the Camp Lonely Western Landfill

Location (Area)	Matrix	COCs (note 1)	2005-2006 Maximum Concentration	Basis for Concern (or Exceedance)			Preliminary Remediation Goals (PRGs) used for FS (note 5)
				Regulatory Standard and/or Screening Criteria	Citation	Frequency of Exceedance of Screening Criteria out of Total Samples	
Camp Lonely Landfill[4]	Soil (mg/Kg)	GRO[2]	930	100	18 AAC 75.341, Table A2	9/30	100
		DRO[2]	6,980	500 (200)[4]	18 AAC 75.341, Table A2	27/39	500, 1,000 and 2,000 (note 4 and 6)
		RRO	5,120[3]	2,000	18 AAC 75.341, Table A2	6/39	2,000
		Total xylenes	134.1	81	18 AAC 75.341, Table B1 (AZ)	1/30	81[7]
		Chromium	6,010	410	18 AAC 75.341, Table B1 (AZ)	3/17	410[7]
	Water (ug/L)	Benzene	8.15	5	18 AAC 70	2/5	5
		Toluene[8]	5.96	1,000	18 AAC 70	0/5	1,000
		Ethylbenzene[8]	2.86	700	18 AAC 70	0/5	700
		Total xylenes[8]	17.11	10,000	18 AAC 70	0/5	10,000
		TAH	34.08	10	18 AAC 70	2/5	10

Definitions
COC – Contaminant of concern mg/Kg – milligrams per kilogram ug/L – micrograms per liter TAH – Total aromatic hydrocarbons (sum of BTEX compounds)
AZ – Arctic Zone

Notes
1 - COCs and information listed refers to the Western Landfill only and does not include the pad area.
2 - No samples exceeded ADEC Method Two cleanup levels for the Arctic Zone (18 AAC 75.341, Table B2) for GRO and DRO of 1,400 mg/Kg and 12,500 mg/Kg, respectively.
3 - The maximum RRO value does not include values from three surface stains sampled at the site. The values from these surface stains ranged from 20,900 to 31,200 mg/Kg and their combined estimated volume is less than 1 cubic yard.
4 - The Method One cleanup level for DRO can be raised from 200 mg/Kg to 500 mg/Kg for diesel spills on gravel pads if the total BTEX concentration is < 15 mg/Kg and benzene is < 0.5 mg/Kg. The frequency of exceedances is listed for the 500 mg/Kg level. Three samples were between 200 and 500 mg/Kg DRO.
5 - Cleanup of the soils to the PRGs and removal of the landfill debris containing hazardous substances should eliminate the COCs in the water. No direct cleanup actions for water are evaluated in the FS.
6 - The FS evaluates cleaning up DRO in to soil to the three values listed. The initial evaluation is performed at 500 mg/Kg. A DRO cleanup level greater than 200 mg/Kg may result in conditional closure. The conditions (regulatory restrictions) increasing with increasing cleanup levels.
7 – Per 18 AAC 75.325(g), the cumulative risk of the hazardous substances at a site must meet ADEC risk management standards for human health ($1X10^{-5}$ for cancer risk and a hazard index of 1.0). Per 18 AC 75.340(k), a chemical that is detected at one-tenth or more of the Method Two cleanup level must be included when calculating cumulative risk. Therefore, the cleanup levels for these substances can vary so long as the ADEC risk management standards are not exceeded.
8 – Toluene, ethylbenzene, and total xylenes are considered water COCs because they significantly contribute to the TAH exceedance.

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Table 1-2 Estimated Volumes of Contaminated Media at the Camp Lonely Landfills and Pad Listed by Waste Stream

Item	Waste Stream Description[1]	Most Viable Treatment or Disposal Alternatives	Total In-Place Volume[2] (yd^3)	Total Excavated Volume[2] (yd^3)	Total Weight[4] (tons)
2	Petroleum-Contaminated Soil (DRO>500 mg/Kg), and no debris[1]	Thermal Treatment, Landfarming, or Disposal	**11,943**	**14,929**	**19,348**
3	Solid Debris	Dispose in offsite landfill (Oxbow) or MSWL in Alaska (Fairbanks)	**6,027**	**7,534**	**4,521**
		TOTALS	**17,971**	**22,463**	**23,868**

Definitions:
Clean Soil = Less than 18 AAC 75 Method One (DRO < 500 mg/Kg)

Notes:
[1] Primary component of petroleum-contaminated soil is DRO. This represents the total petroleum-contaminated soil volume in the pad and landfills evaluated for treatment in the FS.
[2] See Appendix C and Tables A-3, A-7, and A-11 for derivation of these site-specific volumes. Excavated volume contains 25% fluff factor.
[3] Landfill volumes contain a high degree of uncertainty and are subject to change.
[4] Density used for contaminated soil (gravel with sand) was 3,240 lb/yd^3 and for industrial garbage (mixed scrap metal in landfill) was 1,500 lb/yd^3. Weight was calculated from the in-place soil volume.

Acronyms and Abbreviations:
DRO – Diesel Range Organics
RRO – Residual Range Organics
mg/Kg - Milligrams per Kilogram
TSD – Treatment, Storage, and Disposal
MSWL - Municipal Solid Waste Landfill
RCRA – Resource Conservation and Recovery Act
yd^3 – cubic yards

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Table 1-3 Classification of Landfill Material in Camp Lonely Western Landfill (Depth Interval Ranging from 1 to 4.5 ft bgs)

Item	Description (Notes 1 and 2)	In-place (Bank) Volume (yd^3) (from Table A-2)	Material Composition (Note 2)	Percent by Material (Note 3)	In-place (Bank) Volume (yd^3) by Material	Density (lb/yd^3) (Note 4)	Weight (lbs) (Note 5)	Excavated Volume (yd^3) (Note 6)	Weight (Tons) (Note 5)
2a	Clean Soil (DRO <500mg/Kg) and Debris	7,078	Soil	80%	5,662	3,240	18,345,600	7,078	9,173
			Debris	20%	1,416	1,500	2,123,333	1,769	1,062
2b	Petroleum-Contaminated Soil (DRO ≥ 500 and <1000mg/Kg) and Debris	5,313	Soil	70%	3,719	3,240	12,049,590	4,649	6,025
			Debris	30%	1,594	1,500	2,390,792	1,992	1,195
2c	Petroleum-Contaminated Soil (DRO ≥ 1000 and <2000mg/Kg) and Debris	4,428	Soil	70%	3,100	3,240	10,042,746	3,875	5,021
			Debris	30%	1,328	1,500	1,992,608	1,661	996
2d	Petroleum-Contaminated Soil (DRO ≥ 2000 mg/Kg) and Debris	4,933	Soil	70%	3,453	3,240	11,187,876	4,316	5,594
			Debris	30%	1,480	1,500	2,219,817	1,850	1,110
	Total	**21,752**			**21,752**		**60,352,362**	**27,189**	**30,176**
		Total Debris (solid waste)			**5,818**		**8,726,550**	**7,272**	**4,363**
		Total Soil (excluding cap)			**15,934**		**51,625,812**	**19,917**	**25,813**

Notes and Assumptions:

1 The clean soil, with DRO concentrations less than 500 mg/Kg, is still acceptable for disposal in a Class I Landfill.

2 Clean debris is considered material acceptable for landfilling in a Class I Landfill.

3 Soil is estimated to account for 70% of the total landfill volume in geophysical anomaly areas and 80% in the landfill area outside of the geophysical anomaly areas based on 2005 test pits. These percentages are approximate and there may be localized variability.

4 The soil density is assumed to be 3,240 lbs/yd^3, which is the standard density for gravel with sand (Glover, 1996). The industrial garbage (metal debris in landfill) is assumed to be 1,500 lb/yd^3.

5 Weight was calculated from the in-place soil volume.
Soil comprises an average of 79% of the excavated landfill material volume, which equates to about 2,566 pounds per cubic yard. Debris comprises an average of 21% of the excavated landfill material volume, which equates to about 312 pounds per cubic yard. The combined soil and debris average weight is about 2,878 pounds per cubic yard or 1.44 tons per cubic yard.

6 Excavated volume includes 25% fluff factor.

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Table 1-4 Estimated Volume of Petroleum-Contaminated Soil at the Camp Lonely Landfills and Pad

Soil Classification (Contamination Concentrations)	Approximate Total In-Place Soil Volumes Based on Specified DRO Concentration Ranges (yd^3) (Notes 1 and 2)			TOTAL In-place (Bank) Volume (yd^3) (Note 2)	Percent of Total Volume	Excavated Volume (yd^3) (Note 3)	Weight (Tons) (Note 4)
	Petroleum-Contaminated Soil (DRO ≥ 500 and <1,000mg/Kg)	Petroleum-Contaminated Soil (DRO ≥ 1,000 and <2,000mg/Kg)	Petroleum-Contaminated Soil (DRO ≥ 2,000mg/Kg)				
Western Landfill	3,719	3,100	3,453	10,272	86.0%	12,840	16,640
Northeast Landfill	134	112	125	370	3.1%	463	600
Pad (Non-Landfill Areas)	895	382	24	1,301	10.9%	1,626	2,108
Total	**4,748**	**3,593**	**3,602**	**11,943**	**100.0%**	**14,929**	**19,348**
Percent of Total (in-place volume)	**40%**	**30%**	**30%**				

Total (excavated volume yd^3)	**5,935**	**4,492**	**4,502**	**14,929**

Notes and Assumptions:

1 Based on the limited amount of analytical data available, estimates of total volumes at any given soil concentration could be off by 50%.

2 The thickness is assumed to be the same for all contour intervals because there is insufficient data to vertically segregate the soils (generally one sample depth per location). The volumes of contaminated soil estimated for any concentration range from available data could vary significantly from actual.

3 Excavated volume includes 25% fluff factor.

4 The soil density is based on the standard density for gravel with sand (Glover 1996), which is 3,240 lbs/yd^3. Weight was calculated from the in-place soil volume.

5 Maximum detected level of DRO in Camp Lonely soil was 6,980 mg/Kg from Test Pit 15.

Acronyms and Abbreviations:

bgs – Below ground surface
DRO – Diesel Range Organics
ft – feet
yd^3 – cubic yards
ft^2 – square feet

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2.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

This section introduces the processes involved in identifying and screening appropriate technology options for completing the remedial action objectives. The remedial action objectives are to protect human health and the environment under both current and future conditions and to comply with applicable state and federal laws and regulations. These objectives include the reduction of COCs to a level at which the human health risk does not exceed the cancer risk management standard of 1 in 100,000 (1×10^{-5}) and a noncarcinogenic risk standard or HI of 1.0, set forth in 18 AAC 75.325(h). The overall risk may be reduced by lowering the contaminant levels and/or the exposure routes. The remedial objectives include meeting PRGs listed in Table 1-1, unless the exposure routes are eliminated through such alternatives as land use controls, containment, or stabilization.

In addition to protecting human heath and the environment from contaminants, another remedial objective is to prevent the solid waste (debris) from entering surface water bodies or navigable waterways. If debris were to erode from the landfill it could pose physical risks, and result in exceedances of state and federal regulatory standards, including the Clean Water Act. In addition, the eroding debris may contain hazardous substances that could be released to the environment.

2.1 General Response Actions

General response actions are general approaches to remedial actions and include active and passive measures to reduce site concentrations or exposure. Active measures may include removal, treatment, or isolation of the contaminated media. Passive measures rely on natural processes to reduce the toxicity, mobility, or volume of the source of contamination. Screening the general response actions streamlines the FS process by focusing on a set of viable alternatives for detailed evaluation. As part of the screening process, the “No Action” alternative was evaluated to provide a baseline reflecting current site conditions and is used for comparison with other alternatives.

Potential general response actions for the Camp Lonely Landfill are:

1. No Action (passive);
2. Institutional Controls (passive);
3. Containment (active); and
4. Removal Followed by Treatment and/or Disposal of Waste (active).

Based on similar feasibility studies addressing eroding landfills in the arctic (HCG 2004, 2005a, and 2006b), and the general preference for achieving a permanent solution, only the fourth option (landfill removal) was considered viable for detailed evaluation. Table 2-1 provides an evaluation of the prospective technologies and process options associated with each general response action for addressing the risk and concerns posed by the Camp Lonely landfill. The evaluation screened the alternatives against three primary screening criteria (effectiveness, implementability, and cost).

The No Action alternative assumes that no action is taken to address remediation of the landfill. This option provides a baseline for comparison with other alternatives. Active zone water will continue to migrate into the adjacent surface water bodies, potentially carrying dissolved petroleum hydrocarbons (e.g., BTEX) and resulting in AWQS exceedances. The existing shoreline along the Beaufort Sea is likely to move inland and eventually erode the landfill. This would result in a release of landfill debris, and contaminated soil into adjacent surface waters. The No Action alternative is not considered sufficient to meet the remedial action objectives. Therefore, this option was rejected.

Institutional controls would consist of measures to control site access (e.g., cap the soil, erect fencing, and post signs) and to reduce exposure to the contaminated soils. This option was rejected as a stand-alone response action because it would require long term monitoring and maintenance of the controls, which would be logistically difficult. In addition, the institutional controls would not prevent contaminant migration or limit exposure to ecological receptors so it does not meet the remedial objectives.

Containment would consist of shoreline stabilization. This option was rejected because the shoreline stabilization would have to be maintained indefinitely, which is cost prohibitive over the long term. In addition, conventional shoreline stabilization techniques would not prevent the offsite migration of contaminants dissolved in the active zone water. Therefore, it would not eliminate the current concentrations of BTEX in the adjacent surface water bodies that are causing AWQS exceedances.

The removal of the landfill causes two main waste streams (media) to be generated: debris (inert, nonhazardous solid waste), and petroleum-contaminated soil, as depicted on Figure 2-1. The only viable alternative for addressing the solid waste is offsite disposal (Table 2-1). This alternative is discussed further in Section 3.0. Disposal at an onsite landfill (Point Lonely SRRS) was considered; however, the land manager (owner) of the Point Lonely installation (Bureau of Land Management) is opposed to construction of the new landfill. Therefore, this option is currently not implementable, and was rejected as an alternative.

Potential general response actions for the petroleum-contaminated soil are:

1. No Action (passive);
2. Monitored Natural Attenuation (passive); and
3. Treatment and/or Disposal (active).

Natural attenuation is a potentially practical alternative for most petroleum-contaminated soil within the landfill given the estimated 40 years before it erodes. However, due to the potential for localized sources (hot spots) within the landfill, which may include possible light non-aqueous phase liquids (LNAPL) or very high concentrations of petroleum-contaminated soil associated with leaking drums, this alternative is not considered practical. Natural attenuation may not adequately prevent the current and future offsite migration of contaminants into adjacent surface waters. Active zone water appears to be actively transporting dissolved contaminants (e.g., BTEX) into the adjacent surface waters, and contaminated soil is likely to erode before the petroleum hydrocarbons naturally attenuate. As discussed in Section 1.2, erosion of the landfill areas closest to the coast is projected to occur within 40 years if the current rate of erosion continues (HCG 2006a). Therefore, natural attenuation is rejected as a stand-alone alternative addressing the petroleum-contaminated soil in the landfill. However, it could be effective in combination with some of the active treatment alternatives evaluated. For example, after actively treating the soil to a level that results in conditional closure, natural attenuation of the petroleum hydrocarbons would continue. Over time, natural attenuation would ultimately result in the soil concentrations reaching cleanup levels at which full closure is achieved. Additional discussion on this subject is provided in Section 4.0.

Viable treatment options for the petroleum-contaminated soil are:

- Thermal Treatment (on site or off site);
- Biological Treatment (e.g., onsite landfarming or biopiles); and
- Offsite disposal (permitted landfill).

These alternatives are discussed further in Section 3.0. Other types of waste may be encountered during the landfill excavation. This includes the black tar-like substance, which exceeded the standard for Resource Conservation and Recovery Act (RCRA) hazardous waste based on Toxicity Characteristic Leaching Procedure (TCLP) analysis, petroleum-contaminated water, and small quantities of petroleum products (fuel or oil) or other hazardous substances contained in buried drums. The volume of these wastes, however, is not expected to be significant in comparison to the two primary waste streams. Therefore, treatment alternatives for other potential media are not evaluated in detail. Rather, it is assumed that non-hazardous waste will be sent to a landfill and the RCRA hazardous waste will be removed and shipped to a Treatment, Storage, and Disposal (TSD) facility in the lower 48 states permitted to accept RCRA hazardous waste. It is assumed the petroleum-contaminated water would be treated onsite as discussed in Section 4.0. The costs for addressing these minor wastes streams are included in the cost estimates.

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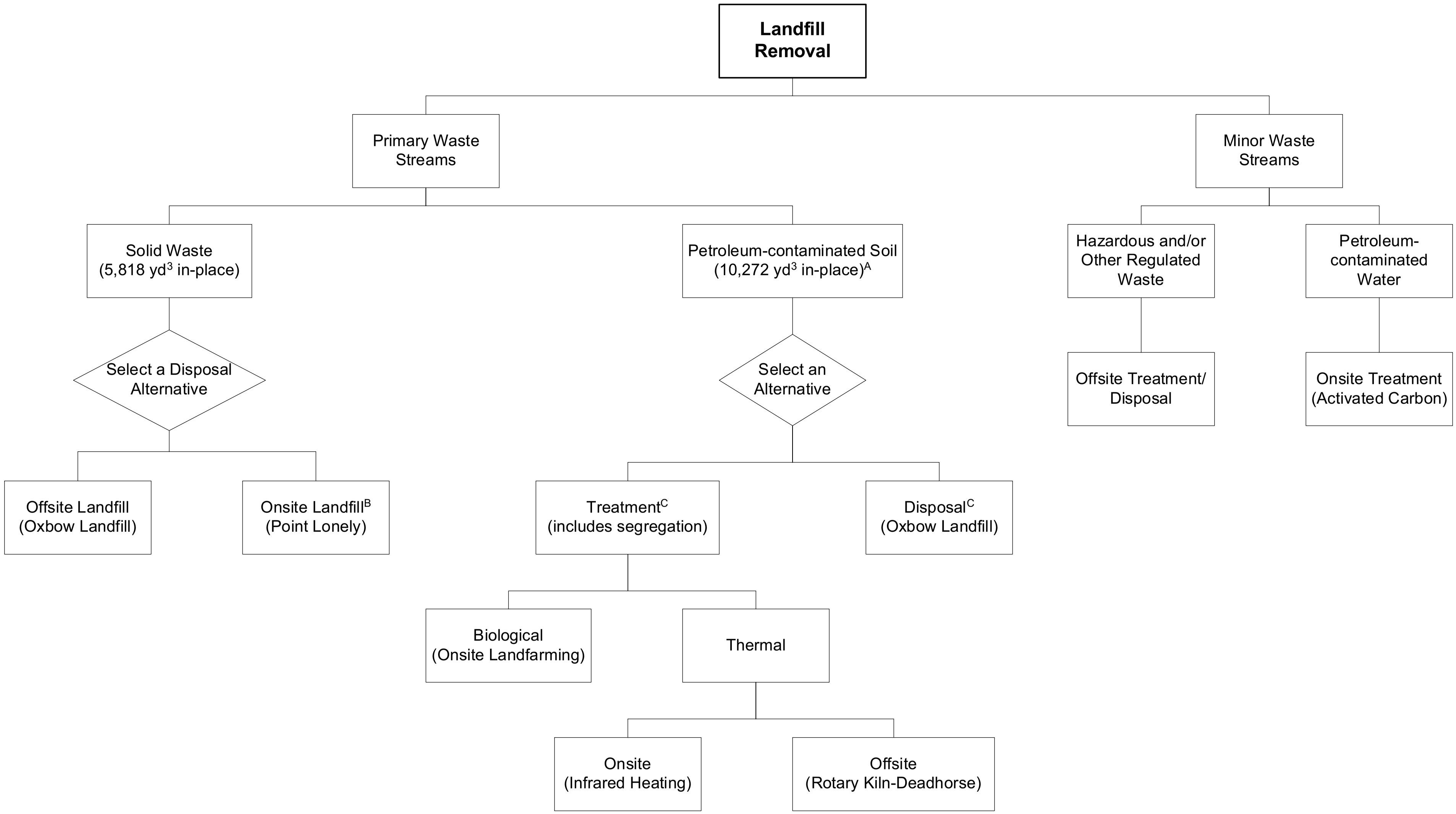
Figure 2-1 Potential Landfill Removal Alternatives Flow Chart



NOTES

[A] In-place volume listed for a 500 mg/Kg DRO cleanup level. If the cleanup level were 1,000 mg/Kg, the in-place volume of petroleum-contaminated soil would be 6,553 yd3. If the cleanup level were 2,000 mg/Kg, the in-place volume of soil would be 3,453 yd3.

[B] At present, the Point Lonely Landfill is not considered to be implementable. The landowner (BLM) has stated it is not in favor of a new landfill being built on the property.

[C] Treatment of petroleum-contaminated soil will require segregation of the soil and solid waste, unless the landfill is permitted to accept both waste streams. If disposal of the petroleum-contaminated soil is permitted,, segregation will not be necessary and both solid waste and soil could be shipped and disposed of as one waste stream (provided its cost effective). The Oxbow Landfill is currently permitted for the the disposal of petroleum-contaminated soil to the following limits in mg/Kg: GRO = 1,400, DRO = 12,500, and RRO = 9,700. Therefore, it can accept the petroleum contaminated soil at Camp Lonely.

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Table 2-1 Preliminary Screening of Alternatives for the Landfill

General Response Action	Technology	Process Options (Description)	Effectiveness	Implementability	Relative Cost	Evaluation
No Action	None	Do not take response action.	Poor. Landfill likely to erode. Debris and contamination would be released into the environment (Beaufort Sea). Debris could pose physical hazards or interfere with navigation.	Simplest to implement.	Lowest	Rejected as viable alternative but retained for comparison purposes as baseline.
Institutional Controls	Long-term monitoring, public education	Control site access to reduce exposure (e.g., erect fencing and signs).	Does not prevent future release of contaminants and debris to the environment if landfill erodes. Partial reduction in risks to humans.	Requires minor construction.	Low capital costs. Low O&M costs thereafter (if and until landfill erodes).	Rejected (low effectiveness, not able to meet PRGs or comply with regulatory requirements).
Containment	Shoreline Stabilization (Erosion Control)	Construct slope protection, a barrier, or both, to prevent erosion of the shoreline surrounding the landfill. Supplement with long-term monitoring (site inspections) and maintenance.	Effective at minimizing contaminant and debris migration, if maintained. Does not reduce toxicity or volume of waste. Long-term stability of the barrier is uncertain. Difficult to maintain if current erosion rates continue on adjacent shoreline.	Uses conventional technology and construction techniques for shoreline protection in Alaska. Minor permitting. Restriction on future land use required. Must be maintained indefinitely which may not be possible or practical given coastal erosion is likely to continue for the long-tem (> 1000 years).	Relatively moderate capital cost. High O&M costs (eventually exceeds removal costs).	Rejected (not practical to implement, highest cost over the long-term and only moderately effective in reducing risk).
Landfill Removal	Excavation and Onsite (local) Landfilling of Debris	Excavate the contaminated soil and debris using heavy equipment (e.g., excavators and loaders). Place debris and low-level contaminated soil (up to levels approved by BLM) into permitted landfill further inland in the regional vicinity (the inactive landfill [LF011] at Point Lonely SRRS, which the USAF has access to through a Right-of-Way agreement with the BLM). Treatment or offsite disposal of contaminated soil above levels permitted for disposal onsite. Hazardous waste sent to TSD in the lower 48 states.	Effective at minimizing exposure by reducing the volume, mobility, and toxicity of the waste. Provides long-term effectiveness. However, landfill located further inland may be subject to eventual erosion (450 years).	Currently not implementable. The BLM (land manager/owner) opposed to construction of new landfill. If the BLM were to grant the USAF permission to expand the existing landfill, the landfill would need to receive a new landfill permit under 18 AAC 60. Uses conventional construction methods. Uncertainties regarding the contents of the landfill may complicate and delay the excavation process.	High capital cost. Low O&M costs (total costs less than offsite landfilling provided landfill does not need to be relocated).	Rejected (currently not implementable). If it is implementable, this alternative is considered to be the most cost effective option to meet regulatory requirements. Higher costs but lower cost than offsite disposal (below). May not provide complete long-term effectiveness.
	Excavation and Offsite (remote) Landfilling of Debris	Excavate the contaminated soil and debris using heavy equipment (e.g., excavators and loaders). Dispose of debris in permitted landfill off site (e.g., Oxbow in Deadhorse, AK). Treatment (onsite or offsite) or offsite disposal of contaminated soil. See the separate evaluation for alternatives addressing petroleum-contaminated soil (Table 3-1). Hazardous waste sent to TSD in the lower 48 states.	Effective at minimizing exposure by reducing the volume, mobility, and toxicity of the waste. Provides a permanent solution.	Implementable, but may be a multi-year process due to transportation constraints (e.g., barge availability). Uses conventional construction methods. Uncertainties regarding the contents of the landfill may complicate and delay the excavation process.	High capital cost. No O&M costs.	Retained for detailed evaluation (only viable alternative).

Key
BLM - Bureau of Land Management
O&M – operations and maintenance
PRG – preliminary remediation goal
TSD – Treatment, Storage, and Disposal
USAF – U.S. Air Force

3.0 DEVELOPMENT AND ANALYSIS OF ALTERNATIVES

This section provides a more detailed description and evaluation of the remedial alternatives identified as favorable and worthy of detailed analysis based on the screening of general response action in the preceding section. The development of these alternatives is necessary for the cost estimating and evaluation process.

As discussed in Section 2.0, the removal of the landfill is the only option considered viable to meet the remedial objectives. The removal of the landfill causes two main waste streams (media) to be generated: debris (inert, nonhazardous solid waste), and petroleum-contaminated soil. There is one feasible alternative for addressing the solid waste (offsite disposal) and several alternatives for addressing the petroleum-contaminated soil. The alternative for addressing the solid waste is discussed in conjunction with the landfill removal process. The remedial alternatives for addressing the petroleum-contaminated soil are evaluated separately to facilitate the analysis. The landfill removal process and the associated alternatives for the waste streams are depicted on Figure 2-1.

3.1 Landfill Removal and Offsite Disposal

The removal the Camp Lonely Landfill and disposal of the associated waste other than petroleum-contaminated soils is described in this section. This alternative requires excavation of the landfill to remove the contaminated soil and debris, including any hazardous substances that may be contained in the debris. The removal action could potentially generate a variety of waste streams including inert solid waste, hazardous waste, and petroleum-contaminated soil. These waste streams are currently mixed within the landfill. Therefore, the excavated material would be screened and segregated into various waste streams depending on the contaminants or waste present. This separation process will be labor intensive. Debris will only be separated from soil when cost-effective (practical) or required, which will vary with disposal or treatment options.

The heterogeneous nature of the landfill material and contamination will require continuous screening to identify and segregate the waste streams. A significant portion of this screening can be achieved through visual inspections and supplemented with field test kits. However, some analytical sampling will be necessary to augment the field screening methods.

As previously discussed, the removal action will generate two main waste streams (media):

1. Debris (inert, nonhazardous solid waste); and
2. Petroleum-contaminated soil. (This soil may vary from low to high concentrations. The high concentrations are anticipated to be localized occurrences of possible LNAPL or nearly saturated soil immediately surrounding leaking drums.)

The inert solid waste will be sent to a landfill in Alaska, presumably the Oxbow Landfill in Deadhorse operated by the North Slope Borough (NSB) (see Appendix G, page 5). The Oxbow landfill is a Class I Municipal Solid Waste Landfill (Permit No. 0231-BA006), permitted in accordance with AS 46, 18 AAC15, and 18 AAC 60. The landfill permit is set to expire in April 2007. However, a permit renewal package is being assembled by the landfill operator (North

Slope Borough), and there are no indications the permit will not be renewed. The Oxbow Landfill is inspected annually by the ADEC Solid Waste Program for compliance with its permit conditions. During the 2006 inspection, it received a perfect score (100%). Copies of the 2004, 2005, and 2006 ADEC inspection reports are contained in Appendix H.

The Oxbow Landfill is permitted to accept polluted soil as defined by 18 AAC 60.025 & 330. It is currently permitted to accept soil with DRO < 12,500 mg/Kg, GRO < 1,400 mg/Kg and RRO < 9,700 mg/Kg. With the exception of RRO, these levels are the same as the Method Two cleanup levels for the Arctic Zone (18 AAC 75.341, Table B2). Based on the sampling conducted to date, the Oxbow Landfill could accept all the petroleum-contaminated soil at Camp Lonely, assuming there is at least minor homogenizing during the removal process. In the worst case, a minor quantity of soil would need to be segregated and treated separately.

The debris (Item 1) does not need to be separated from the petroleum-contaminated soil so long as the concentrations do not exceed the permitted standards for the landfill. However, it is more cost effective to sort the debris due to the weight of the containers (steel bins) that the mixed waste (soil and debris) would have to be shipped in to the Oxbow Landfill. If the soil is segregated from the debris, if can be placed in super sacks which are significantly lighter than steel bins. The lighter container weight enables a greater quantity of soil to be shipped per barge load (see Section 3.2). This is more cost effective than omitting the segregation step. In addition, sorting allows for different treatment or disposal options for the soil and debris (which is cost effective based on subsequent analysis, see Table 3-1). Therefore, debris separation is recommended and has been incorporated in the cost estimates.

During the removal process, the debris will be inspected and separated into two primary categories:

1. Nonhazardous solid waste that can be landfilled within Alaska; and
2. Regulated waste (including RCRA hazardous waste) that cannot be landfilled within Alaska.

The regulated solid waste (including recovered liquids) will require characterization and segregation depending upon its characteristics and ultimate waste classification for disposal. If drums or other containers are located in the landfill, they will be inspected and addressed appropriately to prevent the release of hazardous substances. Regulated waste will be disposed off site unless there is a practical treatment method. Petroleum-contaminated water from the dewatering of the landfill may be treatable on site with activated carbon. Most waste not regulated under the Toxic Substances Control Act (TSCA) or RCRA will be disposed of within the State of Alaska at permitted facilities. Residual oil or fuel recovered from buried drums would fit this description and would likely be burned for energy recovery. Any TSCA-regulated waste and/or RCRA hazardous waste encountered during the removal action will be shipped to a facility outside of Alaska (presumably Washington or Oregon). Based on current sample results, there is no TSCA-regulated waste in the landfill and only a small quantity of RCRA-regulated waste. The RCRA-regulated waste consists of approximately 4 yd^3 of tar-like material mixed with soil with elevated chromium. A sample of this material exceeded the RCRA toxicity characteristic of 0.5 milligrams per liter (mg/L) for chromium (HCG 2006c).

The solid nonhazardous debris will be landfilled at the Oxbow Landfill. Although there will be metal in the debris, the amount of economically recoverable metal for recycling is likely to be low. Therefore, for purposes of this FS, it is assumed that the entire volume of debris is solid waste.

During the removal process, large debris (e.g., >0.5 square feet [ft^2]) will be segregated with the aid of an excavator equipped with a thumb, or by hand. If drums or other containers are located in the landfill, they will be inspected, and addressed appropriately to prevent the release or inappropriate disposal of hazardous substances. When necessary or advantageous, the small debris will be separated from the soil by passing it through a screen (grizzly), or a series of screens.

The soil will be field screened either in place or after passing through the grizzly to separate it into three primary categories:

1. Clean soil (GRO < 100 mg/Kg, DRO < 500 mg/Kg, and RRO < 2,000 mg/Kg);
2. Petroleum-contaminated soil requiring treatment or disposal; and
3. Soil with contaminants other than petroleum hydrocarbons.

The clean soil (Item 1) will be stockpiled on site for later reuse (e.g., backfilling). Soil with petroleum contamination requiring treatment will be treated by the preferred treatment alternative (see Section 3.2). The soil with contaminants other than petroleum hydrocarbons (Item 3) will be further segregated into individual waste streams (e.g., chromium-contaminated soil).

Prior to excavating the landfill debris, the approximately 1-foot gravel cap (clean soil) will be removed and set aside to be used as backfill material. The exception will be in areas where surface contamination is present. After the landfill debris and contaminated soil have been removed, the ground surface should be close to natural grade, assuming the landfill was constructed on top of the native soils (original tundra) and native soils are not removed. As discussed in Section 1.3, it is recommended that less stringent cleanup standards be used for native soils than the criteria used for landfill soils (gravel fill) to minimize the removal of native soils. If excavations extend significantly below natural grade, the excavation area will be backfilled to approximately natural grade using local fill to allow for natural drainage with minimal ponding. The native soils will be more conducive to revegetation so they will be left in place and not covered, if possible.

If there are plans to reutilize the impacted portion of the pad, the area will require backfilling to the current pad grade with gravel. However, this is considered beyond the scope of the remedial effort and these costs are not included in the estimates. Cook Inlet Region, Inc. (CIRI), which currently holds a lease for use of the camp pad from the Bureau of Land Management (BLM), plans to lease and reutilize the impacted portions of the pad.

Unless there are plans to reutilize the pad, seeding and fertilizing of the backfilled area will be performed after activities are complete to help reestablish vegetation. The preferred grass type is one that will colonize rapidly but be replaced by native species. Backfill material will consist of the clean soil removed from the landfill (including the cap). The estimated backfill material needed is small (<1,000 yd^3) and clean soil removed from the landfill (approximately 8,000 to 15,000 yd^3) should be more than sufficient to cover backfilling and regrading needs at the landfill. The reuse of this material has the advantage of not requiring backfill material to be transported to the site. The landfill excavation, waste segregation, and backfilling are estimated to take approximately one summer field season (eight weeks).

The presence of permafrost and shallow active zone water will complicate the removal of contaminated soil and debris. Based on test pits and well points installed in the landfill during the 2005 and 2006 investigations (see Appendix G, pages 3 and 4), it is very likely that water will be encountered at depths between 1.5 to 3 feet below the pad surface in most areas during the summer thaw (late June to September). Permafrost will be present at similar or slightly greater depths (Figure 1-4).

Drums or other types of containers excavated below these depths are likely to be partially filled with water that has seeped into openings. The water may be mixed with petroleum hydrocarbons (residual fuels or oil). This water would need to be removed and treated prior to disposal of the debris (empty drums). This treatment can occur on site, if contaminants are limited to petroleum hydrocarbons. Treatment would consist of removing the free product, and then passing the water through particulate filters and a granulated activated carbon (GAC) system to remove dissolved hydrocarbons.

Excavations conducted below the water table will typically require dewatering using high capacity pumps. Water removed from excavations will typically require treatment due to the presence of petroleum sheens or dissolved petroleum hydrocarbons in excess of discharge criteria (e.g., AWQS). It may be adequate to dewater the excavation areas into another excavation on the pad (slightly cross and down gradient) after passing the water thorough an oil water separator to remove free product, if present. If discharged near the edge of the pad or on the tundra, the petroleum-contaminated water will need to be treated on site with a GAC system prior to discharge. Liners or drainage ditches may be necessary to route the active zone water in the pad east of the landfill away from the excavation area. The FS assumes some level of active zone water management (dewatering and treatment) is necessary. In addition, the excavation of the landfill will need to be conducted in progressive stages (lifts) to permit the exposed permafrost to progressively thaw. A cross section depicting a conceptual approach to the landfill removal and dewatering process is provided on Figure 3-1.

Nonhazardous solid debris removed from the landfill would be disposed of in a permitted landfill located off site. For the purposes of the FS, it is assumed that the 4,521 tons (7,534 yd^3 excavated volume) of debris will be shipped to the Oxbow Landfill located in Deadhorse, Alaska. The petroleum-contaminated soil above cleanup levels (e.g., DRO > 500 mg/Kg) would be treated by the preferred alternative (see Section 3.2).

The Oxbow Landfill is the closest landfill located on the road system in Alaska. Based on preliminary screening, it is the preferred landfill location in terms of cost and implementability. If disposal at the Oxbow Landfill is not an option, an alternative would be to ship the debris to the Fairbanks North Star Borough (FNSB) Landfill in Fairbanks or to Seattle for disposal at a landfill in the Pacific Northwest. However, the cost of these alternatives is higher due to increased shipping costs. In either scenario, the landfill operator would have to agree to accept the waste. .

Following removal, the loose debris would be placed in bulk containers (half-high steel gondolas) equipped with liners that hold approximately 8 tons of debris each and are loaded onto a barge with a large loader. The specific volumes and weight restrictions per container may vary depending on the approach and equipment used by the contractor and the shipper specifications for the vessel. If large pieces of debris (e.g., metal pipe or structural steel) are recovered, they would be banded together and shipped without containerization. The containers would be unloaded at West Dock in Deadhorse and shipped to the Oxbow Landfill by truck. This option would require an estimated 530 bulk containers. If barges are limited in number or size, or the weather is not cooperative, it may take several shipping seasons to ship all the debris. The typical shallow-draft-powered barge consistently available in the arctic would not be able to transport more than 500 tons at a time, which would require approximately 13 trips to remove the nonhazardous debris. However, there is no significant cost or environmental implication posed by the long-term staging of the debris as long as such debris is managed properly (e.g., light items containerized or covered so they will not be dispersed by wind).

The cost estimate for landfill removal and debris disposal is contained in Appendix B. The total estimated cost is $3.8 million. The cost estimate for landfill removal and disposal includes the cost of water treatment and the disposal of the waste streams other than petroleum-contaminated soil. The treatment or disposal of the petroleum-contaminated soil is discussed in the next section.

3.2 Petroleum-Contaminated Soil Remedial Action Alternatives

Five remedial alternatives for petroleum-contaminated soil are described and evaluated in this section. Table 3-1 provides a comparative analysis of the relative performance of each alternative against the three primary evaluation criteria (effectiveness, implementability, and cost). The purpose is to identify the advantages and disadvantages of each alternative relative to one another so that a preferred alternative can be identified. The alternatives include the “No Action” alternative to provide a baseline comparison. Table 3-1 lists the total cost of each alternative for treating the soil to 500 mg/Kg (exclusive of the excavation process). Appendix C provides the detailed cost estimates used to derive the total cost for each alternative evaluated. A description of these alternatives is provided in the remainder of this section. Section 5.0 identifies the preferred alternative based on the analysis provided in Table 3-1.

3.2.1 Alternative 1 – No Action

This alternative consists of taking no action and letting natural processes proceed. Over time, the concentration of petroleum hydrocarbons will be reduced by natural attenuation. Natural attenuation would proceed slowly due to the cold temperatures and subsurface location of the contaminants, especially for RRO. At some locations, the soil could erode before the contamination has sufficiently attenuated. Due to the long-term liability associated with this alternative, it is not considered a viable option to meet the remedial objectives.

3.2.2 Alternative 2 – Offsite Disposal

Under this alternative, the soil would be collected in bulk containers (5 cubic yard sacks) and loaded onto a barge. The sacks would be unloaded at West Dock and shipped to Oxbow Landfill, in Deadhorse, by truck. Each bulk soil container would hold approximately 4.75 tons of soil. As discussed in Section 3.1, the Oxbow Landfill is permitted to accept all or virtually all of the petroleum-contaminated soil at Camp Lonely based on the concentrations detected to date. This alternative would eliminate the current risk at the site. However, as this is a non-treatment alternative, some long-term risk (liability) would be associated with the disposal of the soil at the Oxbow Landfill. The soil is unlikely to degrade over time because all or the majority of the soil would be frozen. The closure plan for the Oxbow Landfill includes freezeback of the waste.

3.2.3 Alternative 3 – Onsite Landfarming

Under this alternative, the soil would be excavated, placed in a treatment cell, and landfarmed at Camp Lonely. Landfarming would consist of nutrient additions along with tilling and watering the soil to promote the natural attenuation of petroleum hydrocarbons. This technique has been used successfully to treat diesel-contaminated soil on the North Slope in the Prudhoe Bay region (BNC International, Inc. 2003). In 2002, soils with a DRO concentration of approximately 1,000 mg/Kg were remediated to approximately 500 mg/Kg over the course of 56 days. After treatment, the soils were approved by ADEC for placement back in their original location. The soils did not pose a risk to human health, and the placement location was protective of surface water. Similar results were obtained with soils treated in 2003. The majority of the petroleum-contaminated soil at Camp Lonely consists of sandy gravel with little organics or RRO. The average DRO concentration is about 1,600 mg/Kg based on previous site characterization activities. These characteristics make the petroleum-contaminated soil in the pad and landfill at Camp Lonely well suited for landfarming, especially if isolated hotspots of RRO (> 2,000 mg/Kg) or saturated soils are removed prior to landfarming. The volume of these latter soils should be small (<100 yd^3) and would be disposed offsite.

In general, the landfarming methods would follow procedures previously demonstrated to be successful and approved by ADEC. After excavation and separation from the debris, the contaminated soil would be placed in rows and graded to a maximum depth of 1.5 feet in unlined treatment cell(s) located on an unused portion of the gravel pad. The treatment area would be surrounded by containment berms set back 25 feet from the contaminated soils to prevent dispersion of the contaminated soils. Tables 1-4 lists the prospective volume of soil to be landfarmed. If all the petroleum-contaminated soil above 500 mg/Kg from the Western Landfill is landfarmed (12,840 yd^3, excavated) it would require approximately 7.2 acres. This assumes the soil is placed in 80-foot wide rows, which is recommended to allow a tanker truck to pass between the rows for watering and fertilizing (see Appendix G, page 6). Alternatively, a tractor-pulled sprayer could be used to distribute the water, which would eliminate the need for the soil to be placed in rows. This would reduce the area required for landfarming to approximately 6.1 acres. In either approach, regular turning and mixing of the soil would be performed with a tractor and a deep tine soil tiller. Sufficient space (7.2 acres) should be possible if the soil from the Western Landfill is placed on inactive portions of the facility's pad. However, if all the contaminated soil from the pad and landfills are excavated and landfarmed, there may be insufficient space on the pad (see Table A-14). In this case, it may be possible to landfarm a portion of the soil at the former location of the Western Landfill, or stockpile a portion of the soil and treat it during additional field seasons. Use of the Western Landfill area would probably require partial backfilling using clean fill from the original cap to raise the base of the landfarm sufficiently above the native tundra and water table. However, if the DRO cleanup limit is raised to 1,000 or 2,000 mg/Kg, the space requirements will be considerably less. In that case, the pad or former Western Landfill area alone would provide sufficient room to landfarm all of the soil.

The soil would be placed directly on an unlined gravel pad, pending ADEC approval. Petroleum-contaminated soil storage requirements are set out in 18 AAC 75.370. The regulations require bottom liners to be placed below soil stockpiles. However, ADEC has approved soil to be landfarmed without a bottom liner provided there is negligible migration potential and the location is verified to be clean at the conclusion of the project. This may require removal and treatment of the top few inches of the underlying gravel pad at the conclusion of the project. However, the migration potential of the petroleum hydrocarbons in the soil is anticipated to be extremely low based on the relatively low concentrations in the soil and dry site conditions. Further details regarding the landfarming project would be described in an ADEC approved work plan.

Landfarming is only considered practical during the period of late June to early September when temperatures are consistently above freezing. The soils in the treatment cell would be tilled every third day using a conventional tractor with a deep tine tiller attachment. Tilling homogenizes the soil and creates uniform contaminant concentrations. Moreover, it aerates the soil, which promotes the volatilization and bioremediation of hydrocarbons. The hydrocarbons are degraded by native microorganisms in the soil, which need sufficient moisture and air to function efficiently. Water will be applied to the soils as needed, but probably not less than once every week. To accelerate natural attenuation, nutrients (fertilizer) will be applied to the soils prior to treatment and as needed.

The treatment time would be dependent upon the initial concentration of hydrocarbons in the soil and the cleanup criteria. Mixing of soil in the landfarm will homogenize the contaminant levels. Based on the landfarming studies in Prudhoe Bay, it is assumed that after an 8-week treatment time, the following percent reductions in initial concentrations will be achieved: GRO 60%, DRO 50%, and RRO 30%. Assuming the primary contaminant in the soil is DRO with an initial average concentration of 1,600 mg/Kg, the soils could be treated in two full summer seasons (up to 20 weeks) if the remediation goal (cleanup level) is 500 mg/Kg DRO. If the cleanup level is 1,000 mg/Kg, the soil could be treated within one full treatment season (10 weeks).

Several assumptions were made in order to evaluate this alternative. The cost estimates for landfarming assume two treatment seasons are necessary to reach the remediation goal of 500 mg/Kg DRO (See Appendix C, Table C-3). These treatment seasons would start the year after the landfill removal (excavation), although it may be possible to get started on the landfarming the first field season. If the average starting concentrations are higher than estimated or treatment levels are lower than 500 mg/Kg DRO, this alternative may require more than two field seasons, which significantly increases cost. The cost estimate assumes that if hot spots of saturated soils with high DRO or RRO are encountered they will be segregated from the landfill soils and sent off site for thermal treatment. The estimates assume there will be 50 yd^3 of petroleum-contaminated soil requiring offsite thermal treatment. It was also assumed that the peaty soils at the base of the landfill will not require remediation or will be broken apart (shredded) prior to remediation. Shredding is recommended to raise the soil permeability by breaking apart the clumps of peat and root mass, and allowing an even distribution of moisture, air, and nutrients. In addition, it reduces the potential for localized hot spots of petroleum contamination. For the purposes of revegetation and permafrost protection, it would be beneficial to leave the peat layer intact at the base of the landfill. For comparison purposes, cost estimates were also performed assuming a cleanup level of 1,000 and 2,000 mg/Kg DRO which require a shorter treatment duration (<10 weeks).

One advantage of landfarming is that the treated soil is available onsite for reuse. Gravel fill is a limited resource in the Camp Lonely area. Another advantage of landfarming is that less fuel is expended during the treatment process in comparison to the offsite disposal or thermal treatment options. Thus, it is a more energy efficient process.

Another option would be to only landfarm soil with DRO less than 2,000 mg/Kg. This would reduce the volume of soil to be landfilled and the size requirements for the landfarm area. It would also reduce the average pre-treatment concentration to around 1,100 mg/Kg, which would make it easier to reach the treatment objective of 500 mg/Kg. Under such an alternative, the soils could probably be treated in one full summer season (10 weeks). The soil above 2,000 mg/Kg would be sent offsite for thermal treatment. This option was not evaluated in detail and a cost estimate was not performed.

3.2.3.1 Biopiles

Biopiles, also referred to as biocells, bioheaps or compost piles, could be used as an alternative to landfarming. This technology involves heaping the contaminated soil into piles or cells and stimulating aerobic microbial activity within the soil through aeration and/or addition of minerals, nutrients, and moisture. Biopiles are similar to landfarms. They both are above ground, engineered systems that use oxygen (air) to stimulate the growth and reproduction of aerobic bacteria, which degrades the petroleum constituents absorbed to the soil. While landfarms are aerated by tilling or plowing, biopiles are typically aerated by forcing air to move though slotted or perforated piping placed within the pile. The air is either injected by a blower or extracted with a vacuum. Alternatively, the air is allowed to passively flow through the pipes and piles. If the piping is eliminated, the piles can be mixed mechanically using a backhoe, excavator, or specialized equipment.

The typical height of a biopile is 3 to 10 feet. The length and width is not restricted, unless aeration is to occur by mechanically turning the soils. Given the remote location of Camp Lonely, passive aeration of the pile using piping would probably be the most cost effective method. Aeration could be promoted by placing the piles in windrows, orientated perpendicular to the dominant wind direction, and the piping opposite, to create an airfoil effect. Wind turbines (e.g., attic fans) may also improve airflow if connected to the upper tiers of tubing, and the pile is covered. Covering the pile with a dark liner material would absorb solar radiation and trap heat. In turn, this would raise the soil temperature, accelerate microbial action, and increase the degradation of the petroleum hydrocarbons.

Potential advantages of biopiles over landfarming are:

- A smaller treatment area is required;
- Less labor and equipment (cost) is required for operation and maintenance (provided sufficient aeration can be achieved through passive methods);
- Increased microbial degradation (provided sufficient temperatures are obtained), which could accelerate treatment times, especially for the medium or heavier end hydrocarbons (see next bullet for further explanation); and
- More effective treatment of the less volatile components of the petroleum hydrocarbons (higher molecular weight petroleum hydrocarbons such as those found in lubricating oil, and to a lesser extent diesel fuel).

Biopiles are used less frequently than landfarms to treat petroleum-contaminated soil on the North Slope of Alaska, and their effectiveness in arctic conditions is not as well documented. As indicated, there is some risk that the soil temperature in the piles would not be sufficient to enable significant biological activity. The average ambient temperature in the Point Lonely area is 47 °F (8.3 °C) in July, the warmest month of the year (based temperature reading on the Prudhoe Bay region, the nearest weather station [Alaska Climate Research Center 2007]). Bacterial growth rate and petroleum degradation is a function of temperature. Soil microbial activity has been shown to significantly decrease at temperatures below 50 °F (10 °C), (USEPA 2007). The microbial activity of most bacteria important to petroleum hydrocarbon biodegradation also diminishes at temperatures greater than 113 °F (45 °C). Within the range of 10 °C to 45 °C, the rate of microbial activity typically doubles for every 10 °C rise in temperature. Because soil temperature varies with ambient temperature, there will be long periods during the year when bacterial growth and, therefore, petroleum degradation will not occur. When ambient temperatures return to the growth range, bacterial activity will be gradually restored. Unless there is significant solar gain caused by covering of the piles, the ambient temperature data for the Point Lonely area (cited above) suggests temperatures will not be sufficient to promote significant and/or prolonged bacterial growth. It may be necessary to heat the air prior to injection into the piles to obtain sufficient bacterial activity.

If there is not significant biological activity, biopiles could take a longer time to treat the soil than landfarming because there would be less soil aeration. Aeration and the associated volatilization is the primary mechanism for the loss of the petroleum hydrocarbons if there is not significant biological activity. Landfarming achieves better aeration than biopiles because there is frequent tilling of a relatively thin layer of soil that is not covered. In addition, there is some risk that the soil may not be mixed sufficient during the construction of the soil piles. This would create hotspots of contamination, which could prolong treatment times relative to landfarming, which involves more rigorous mixing.

A cost estimate to treat the soils by biopiles at Camp Lonely was not performed. However, the cost should be on the same order of magnitude as landfarming. The USEPA lists the soil treatment costs using biopiles and landfarms as equivalent on the low end. However, biopiles have a higher range of costs ($30 to $60/ton for landfarms versus $30 to $90/ton for biopiles), (USEPA 2004). The actual cost would be dependent upon the specific approach and the need for artificial aeration or heating of the piles. If the biopile soil can be treated passively, the treatment costs should be slightly less than those for landfarming. It may be worthwhile to consider the use of both technologies. For example, soils which do not remediate sufficiently via landfarming because of a high percentage of heavy ends, could be placed in biopiles to enhance biological degradation.

3.2.4 Alternative 4 – Offsite Thermal Treatment

In this alternative, the excavated petroleum-contaminated soil will be loaded onto a barge and shipped to Deadhorse, Alaska for low temperature thermal treatment. There is a permanent soil treatment facility currently operating in Deadhorse during the summer months. The soil would be collected in bulk containers (5 cubic yard sacks) and loaded onto the barge using a loader. The sacks would be unloaded at West Dock and shipped to Deadhorse by truck. Each bulk soil container would hold approximately 4.75 tons of soil. The specific volumes and weight restrictions per container may vary if and when this alternative is implemented, depending on the approach and equipment used by the remediation contractor.

The petroleum-contaminated soil from Camp Lonely will be stockpiled and treated separately from other soil at the treatment plant. The soil treatment facility will perform post-treatment sampling to determine whether contamination levels have been adequately reduced. This alternative assumes that the soil would be loaded and hauled to Deadhorse in approximately 44 barge trips. Each trip would take approximately 2.5 days roundtrip in good conditions. This will require two shipping seasons. If barges are limited or the weather is not cooperative, it may take additional shipping seasons to ship all the soil. However, there is no significant cost or environmental implication posed by the long-term stockpiling of soil as long as it is managed properly. The treated soil would not be available for reuse at Camp Lonely unless shipped back, which is considered cost prohibitive. The treated soil from the plant in Deadhorse is typically transported to Oxbow Landfill for use as cover material.

3.2.5 Alternative 5 – Onsite Thermal Treatment (Infrared and Enhanced Thermal Conduction Technologies)

This alternative uses a combination of treatment technologies developed by Mobile Environmental Technologies, Inc. (MET), Infrared (or M1) Technology, and Enhanced Thermal Conduction (ETC) Technology. This system has been used successfully at other remote locations in Alaska. The M1 Technology utilizes infrared heating elements to heat contaminated soil (see Appendix G, page 7). Soil is placed in a sealed treatment box (except for the bottom) equipped with heating elements. The vapor pressures created by the infrared heat drive contaminants from the soil without the use of blowers or vacuums, minimizing the amount of exhaust gases and maximizing thermal efficiency. The ETC units consists of three layered treatment cells, each containing a manifold system of perforated pipe. The treatment cells are enclosed in a stainless steel Quonset hut and a gas-fired unit heats air and blows it through the pipes at 1,300 °F. Contaminants in the soil volatilize as the soil is heated to over 500 °F for several days. The volatilized contaminants are drawn into a thermal oxidizer at the opposite end of the Quonset hut and are burned.

Several M1 and ETC treatment units would be transported to Camp Lonely and treatment would occur on site. The treatment rate for a plant would be approximately 7 tons per hour on average for the various sized treatment plants. The soil is treated in batches, which require 48 to 240 hours depending upon the size of the unit. The cost estimates assume each plant operates 20-hours per day. The treated soil would likely be reduced to less than ADEC Method One cleanup levels (e.g., <500 mg/Kg DRO). Therefore, the soil should be acceptable for unrestricted use. The treatment plant would be a pre-permitted, mobile unit for treatment of petroleum-contaminated soil. However, ADEC site-specific approval to use the unit at Camp Lonely would still be required. This option would eliminate the need to ship the soil off site, but requires shipping large pieces of equipment and a significant volume of fuel to the site. A large fuel storage facility (e.g., a portable double-walled tank) would also be required. Once set up, the treatment plant would require approximately 16 weeks to treat the soil.

If there are significant delays in the soil removal, equipment breakdowns, unanticipated site conditions, fuel delivery delays, or other factors, the treatment plant could miss the shipping window and have to overwinter at the site, incurring equipment standby charges. It is not practical to operate the thermal unit outdoors in the winter in the arctic. The treatment rate decreases with lower ambient temperatures and fuel consumption increases dramatically. In addition, frozen soils must be thawed prior to treatment by the unit. Under this alternative, the cost estimate assumes the equipment is mobilized and demobilized from Deadhorse to Camp Lonely in the winter (late spring and fall) overland by rollagon to enable the treatment to be completed in one field season.

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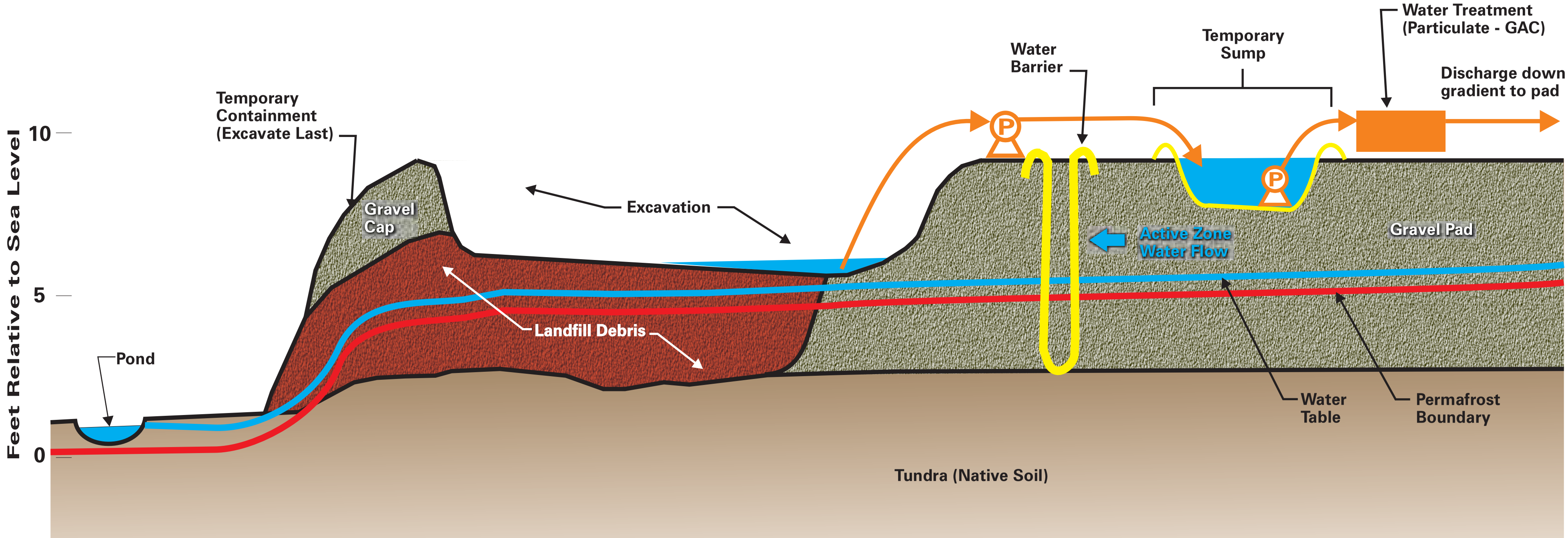

Legend

- Water Table (July 2005)
- Permafrost Boundary (July 2005)
- Impermeable Liner
- Gravel Cap/ Pad
- Landfill Debris (domestic and/or industrial)
- Tundra

Note:
Depth and dimensions are approximate.

Not To Scale

CAMP LONELY

CROSS-SECTION OF EXCAVATION AND WATER MANAGEMENT
FIGURE 3-1

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Table 3-1 Remedial Alternatives for Petroleum-Contaminated Soil

General Response Action	Technology	Process Options (Description)	Threshold Criteria	Balancing Criteria		Evaluation
			Effectiveness	Implementability	Relative Cost	
No Action (or monitored natural attenuation)	None [or In-situ Treatment using natural processes (degradation)]	Do not take response action. The un-enhanced natural processes of biodegradation, volatilization, and dispersion are used to decrease contaminants over time.	Poor. Natural attenuation will decrease the contaminants to acceptable levels given sufficient time. However, natural attenuation of petroleum hydrocarbons in the Arctic is slow (over 50 years may be required to reach PRGs). Natural attenuation will not occur in the frozen soils, and is very slow in the water saturated zone which is prevalent. Contamination will be susceptible to migration, erosion and dispersion into surface water.	Simplest to implement. May requires periodic testing of soil concentrations and surrounding water bodies. Regulatory acceptance unlikely given current site conditions.	Lowest cost.	Rejected (not effective). The contaminated soil will likely erode before the contaminants degrade. Eroding soil could cause AWQS exceedances. In addition, it would not eliminate the current AWQS exceedances causes by leachate from the landfill (presumably the areas with DRO > 2,000 mg/Kg).
Disposal	Landfilling	The petroleum-contaminated soil is disposed in the Oxbow landfill in Deadhorse, Alaska.	Moderate. Effective at eliminating current risk but less effective at reducing long-term risk than treatment alternatives.	Good. Probably the easiest to implement. Shipping delays would be the primary factor that could delay the work.	Costs slightly less than offsite treatment. Cost higher than onsite landfarming. Cost: $7.5 million	Effective at reducing current risks. The contaminants are not treated so there is some long-term risk (liability). Does not utilize the existing pad or interfere with site operations. Cost relatively high.
Active Treatment	Onsite Thermal Treatment (low temperature)	Contaminated soil would be excavated, dried, and moved to a staging area. Soil would be thermally treated in a permitted, portable treatment units mobilized to the site. Hydrocarbons are volatized from soils, captured, and incinerated. Treated soil available for reuse on site.	Good. Effective at reducing the levels of petroleum contaminants.	Good/fair. Mobile systems are readily available and can be brought to the site by barge or by air. Logistical problems (breakdowns and shipping delays) can result in significant delays at this semi-remote site. Large quantity of fuel must be shipped to Camp Lonely and stored on site. Duration: One to two years.	Second highest costs of treatment alternatives Cost: $8.6 million	Effective and implementable. High cost but less than offsite treatment (provided there are no significant delays caused by equipment breakdowns or logistics). Utilizes less pad space than onsite landfarming. Less overall risk than landfarming but greater risk (uncertainty) than offsite treatment. Treated soil would be available for reuse.
	Offsite Thermal Treatment (low temperature)	Contaminated soil would be excavated, transported, and thermally treated off site at a permitted facility (e.g., rotary kiln in Deadhorse).	Good. Effective at reducing the levels of petroleum contaminants.	Good. Permitted treatment facility is located in Deadhorse with a proven operating history. Barge shipments available but may be subject to delays. Less risk of equipment breakdowns and other uncertainties than onsite treatment. Effectiveness and regulatory approval already demonstrated. Duration: One year.	Highest costs of treatment alternatives Cost: $9.0 million	Effective and implementable Highest cost, but there is low risk that the treatment will not be successful. Does not utilize the existing pad or interfere with site operations.
	Onsite, ex-situ biological treatment (landfarming)	Contaminated soil would be excavated and placed in a treatment cell 1.5 feet thick. Soils would be tilled at regular intervals to homogenize and aerate the soils. Nutrients or other products may be added to promote natural biodegradation.	Good (given sufficient time). Effective at reducing mid- to light-end hydrocarbons (GRO and DRO). May be difficult (long treatment time) to treat high concentrations of RRO. Treatment time will vary with starting concentrations and cleanup levels.	Good/fair. The technology requires a large dedicated space to hold the soil for treatment. Regular maintenance required. Treatment time will vary depending upon initial contaminant levels, types of petroleum hydrocarbons present, and cleanup criteria (levels). Easier to implement if their will be ongoing operations in the area. Duration: Two years.	Lowest costs of treatment alternatives. However, costs could escalate if cleanup criteria cannot be met in two field seasons. Cost effectiveness increases if workers and equipment are already on site for other activities. Cost = $2.8 million	Most cost effective alternative but it has greater risk due to uncertainties regarding the duration (treatment time). In addition, it will eliminate the use of a large portion of the pad while treatment is occurring.

Key

AWQS – Alaska Water Quality Standards
DRO – diesel-range organics
ft – feet
GRO – gasoline range organics
O&M – operations and maintenance
RRO – residual range organics

Notes

The listed dollar values in the cost column are based of a treatment objective of reducing DRO to < 500 mg/Kg for the Western Landfill only. Detailed cost estimates are available in Appendix C and summarized in Table C-1.

4.0 EVALUATION OF VARIOUS DRO CLEANUP LEVELS

This section evaluates the benefits, costs, and risks of using a cleanup level higher than 500 mg/Kg DRO for petroleum-contaminated soil at Camp Lonely. For reference, Table 1-4 lists the estimated volumes of petroleum-contaminated soil at 500, 1,000 and 2,000 mg/Kg DRO for the landfills and pad at Camp Lonely, which is used as the basis for this evaluation. As indicated on Figure 4-1, the majority of the petroleum-contaminated soil at Camp Lonely is contained within the Western Landfill. This evaluation, like previous sections of the FS, focuses on the DRO cleanup level because it comprises the majority of the contaminated soil. It is assumed that cleanup of the DRO to respective levels will remove the other petroleum hydrocarbons to acceptable levels because in most cases the contaminants are co-located. In some cases, there may be a need to remove small, isolated areas of elevated RRO (e.g., surface stains with low DRO) but this should not significantly affect the costs or the conclusion of this analysis.

Figure 4-1 illustrates the changes in waste and materials volumes with the varying DRO cleanup levels for Camp Lonely. The test pits conducted in the landfill and professional judgment indicate that the entire landfill area depicted on Figure 1-3 would need to be excavated to ensure that all the debris (solid waste) is removed. The varying DRO cleanup levels have no effect on the total landfill volume that must be excavated (30,679 yd^3), or the volume of debris (6,027 yd^3). However, the volume of material classified as petroleum-contaminated soil decreases significantly with the increasing DRO cleanup levels. As indicated on Figure 4-1, the volume is reduced by approximately two-thirds if the cleanup level is raised from 500 to 2,000 mg/Kg. In turn, the estimated remediation costs decrease (Table 4-1). This cost decrease is illustrated on Figure 4-2 for the Western Landfill. The cost decreases proportionally less for some alternatives than for others, as indicated by the varying slopes of the lines. Those with a high percentage of fixed costs, such as onsite thermal treatment and landfarming, experience less of a decrease because the unit price of treatment (cost per cubic yard) increases with the decreasing soil volume. Onsite landfarming and onsite thermal treatment incorporate a high percentage of fixed costs, such as mobilization and demobilization of remediation equipment, materials, and personnel. These costs remain relatively constant regardless of the soil volume. However, Figure 4-2 illustrates that landfarming is still the least expensive cost alternative. The figure also suggests that if the soil volume decreases even further ($<2,000\ yd^3$), offsite disposal will ultimately be cheaper than landfarming.

While raising the cleanup levels reduces costs, it may also affect the site's regulatory status, monitoring requirements, and long-term liability on the part of the potentially responsible parties (PRPs). These effects are not readily quantified, and will ultimately depend on regulatory negotiations and long-term site conditions. Table 4-2 provides a summary of the evaluation criteria considered most relevant to assessing the benefits and risk associated with varying cleanup levels. It is very likely that cleanup of the site to a DRO cleanup standard above 230 mg/Kg, will result in the site receiving conditional rather than full closure under 18 AAC 75.

The ADEC has recently begun making a distinction between full and conditional closure under 18 AAC 75. The criteria for conditional versus full closure are currently not defined in ADEC regulations or guidance documents. Therefore, closure requirements are subject to site-specific evaluation and negotiations. However, ADEC has indicated that sites regulated under 18 AAC 75 that have hazardous substances above the most stringent Method Two soil cleanup levels (18 AAC 75.341, Table B2, Over 40-inch Zone, Migration to Groundwater) will likely be granted conditional closure as opposed to full closure. With respect to DRO, this level is 230 mg/Kg.

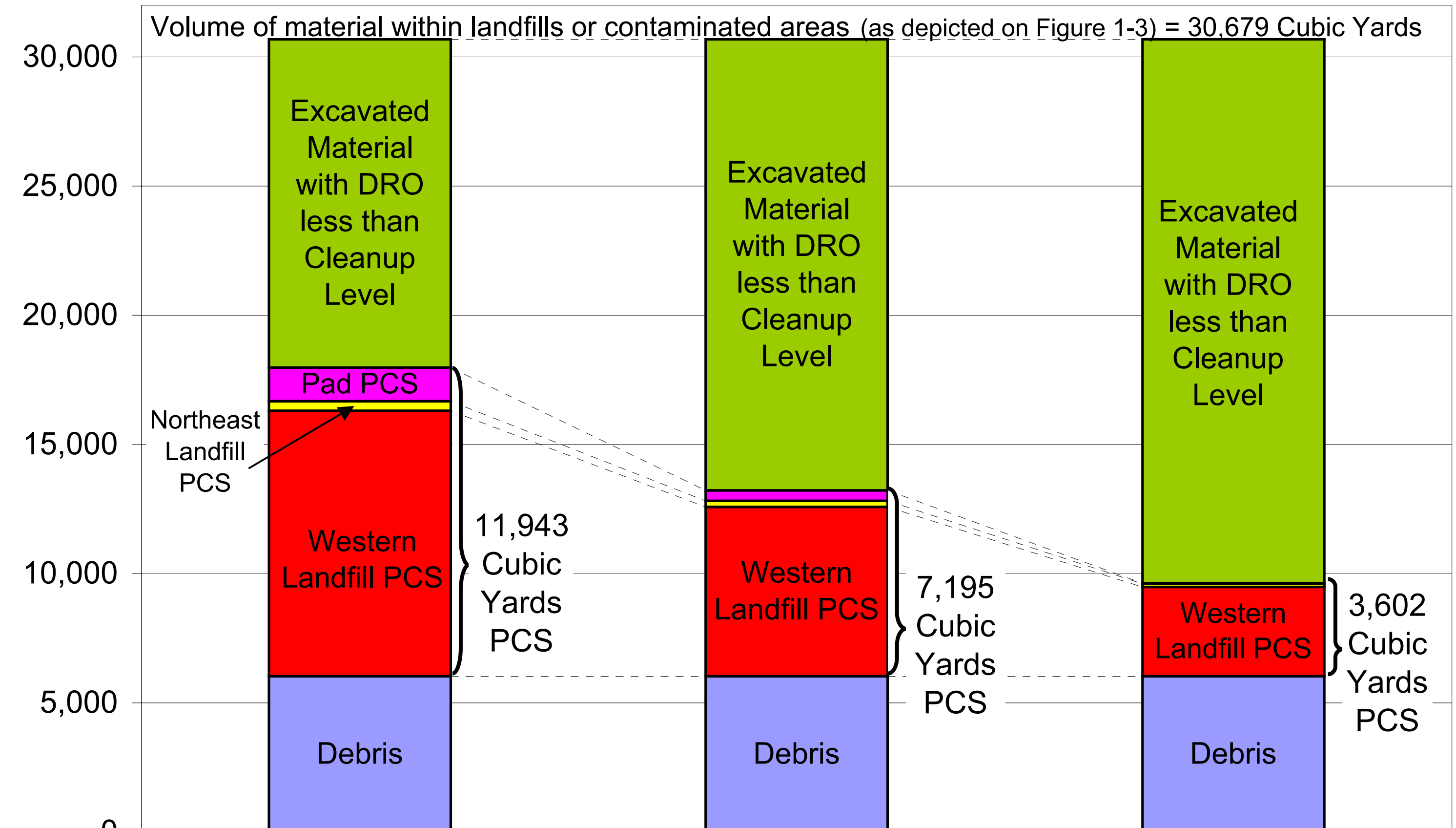
The conditional closure will have some form of institutional controls (ICs), potentially including monitoring requirements. Table 4-2 represents a best attempt to summarize the potential ICs based on comments from the ADEC on Camp Lonely and similar sites. As indicated in the table, ICs associated with the lower spectrum of DRO cleanup levels will likely be “informational” or “administrative,” while ICs at higher cleanup levels ($\geq$ 1000 mg/Kg) may require action on the part of the PRPs. At a minimum, sites granted conditional closure are retained in the ADEC contaminated sites database. In addition, the soil at the site is likely to be subject to soil movement restrictions, which require approval by ADEC prior to the offsite relocation or disposal of the soils. The typical restriction is that the soil may not be placed in surface water or other environmentally sensitive areas. The restrictions on soil movement should not be burdensome so long as the soil is not moved off the pad. Placement of any soil (fill) off the pad in the adjacent wetlands or waterbodies would typically require a Section 404 permit from the U.S. Army Corps of Engineers. Therefore, the additional ADEC restriction on soil movement should be insignificant in most circumstances.

As the cleanup level increases, there is greater risk that further corrective action will be required if the site erodes before the petroleum contamination in the soil has sufficiently degraded to prevent a sheen. However, the likelihood of this event is considered low, especially for the 1,000 mg/Kg DRO cleanup level. The potential of a future corrective action can be reduced even further by cleaning up the soil in close proximity to the edge of the pad (e.g., 50 feet) to a more conservative cleanup standard (500 mg/Kg).

If the site is initially cleaned up to a standard which requires conditional closure, the petroleum hydrocarbons should eventually naturally attenuate to a concentration at which full closure is achieved. This would be confirmed through sampling. Thus, cleanup of the site to 1,000 or 2,000 mg/Kg DRO does not prevent eventual full closure of the site. Actively remediating DRO in the soil to the apparent cleanup level required for full closure (230 mg/Kg) is not cost effective. The soil volume and associated treatment costs would approximately double. In comparison, the cost associated with the “conditions” placed on the site with soil between 230 and 500 mg/Kg DRO (or even 1,000 mg/Kg) are insignificant.

Based on Table 4-1, cleanup of the site to 1,000 mg/Kg DRO appears to represent the best balance between risk and cost. The cost savings is about $0.6 million if the DRO cleanup level is raised from 500 to 1,000 mg/Kg. The additional monitoring requirements are unlikely to exceed this cost difference over the period required for the DRO to naturally attenuate to 500 mg/Kg. Most of the monitoring is likely to consist of periodic visual monitoring for sheens during the summer. This task could be performed relatively easily by onsite personnel if the pad or Point Lonely facility is active. The qualifications for the individual completing the inspection would principally be good observational and documentation skills. If the site is not manned, an annual or biannual site visit may be required. This could be conducted by a third party contractor or one of the PRPs (with ADEC concurrence).

Figure 4-1: Changes in Camp Lonely Waste Volumes with Varying Cleanup Levels



	DRO > 500 mg/Kg	DRO > 1000 mg/Kg	DRO > 2000 mg/Kg
Excavated Material with DRO less than Cleanup Level	12,709	17,457	21,050
Pad (Non-Landfill Areas) PCS	1,301	406	24
Northeast Landfill PCS	370	236	125
Western Landfill PCS	10,272	6,553	3,453
Debris	6,027	6,027	6,027

DRO Cleanup Level (mg/Kg) and Associated Volumes of Materials (Cubic Yards)

Key
PCS - Petroleum Contaminated Soil

Note: The entire landfill areas must be excavated to ensure that all the debris is removed.
Source: Volume Calculation Estimates are provided in Appendix A, Table A-12

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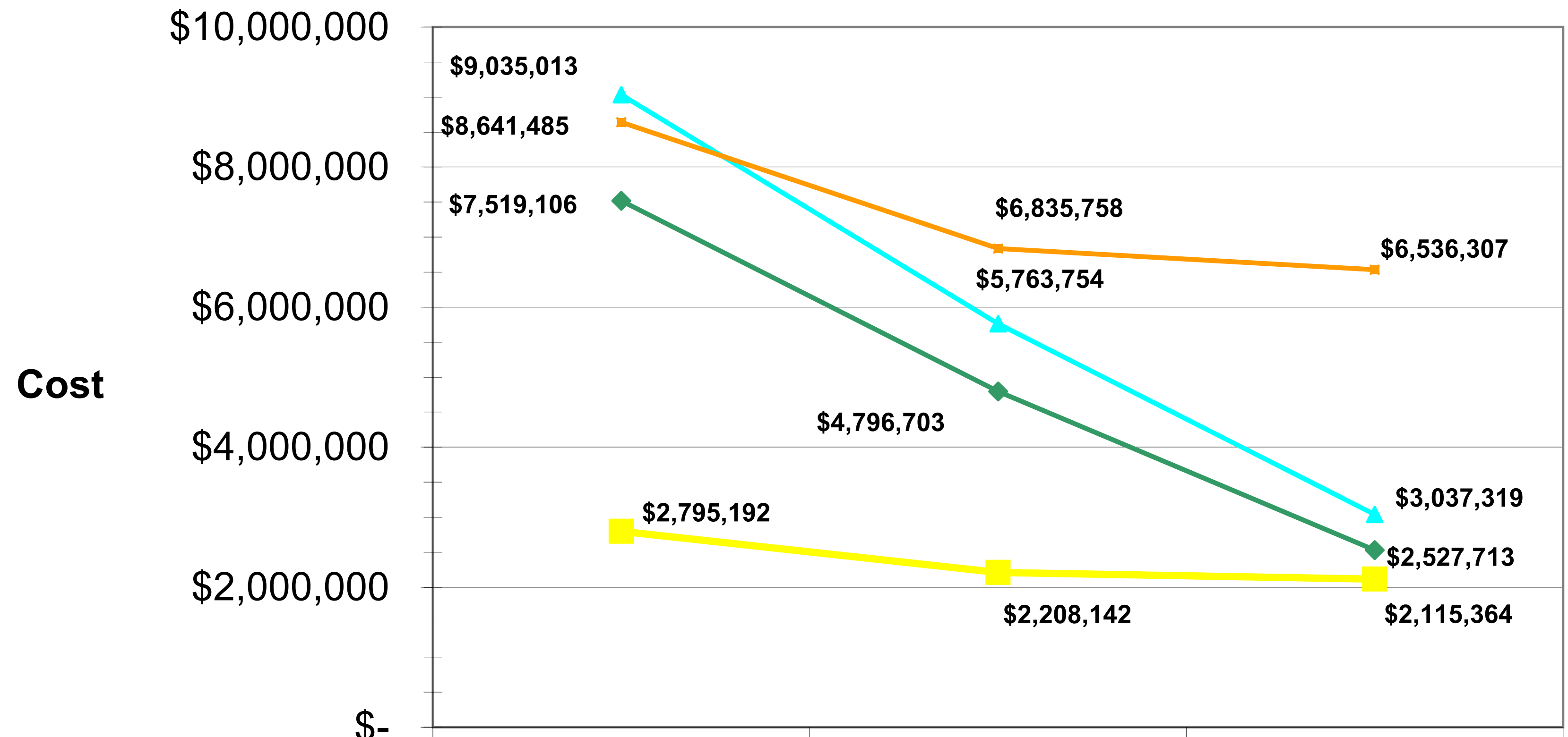
Figure 4-2: Soil Remediation Costs for Western Landfill



	DRO > 500 mg/Kg	DRO > 1,000 mg/Kg	DRO > 2,000 mg/Kg
Offsite Disposal at Oxbow	$7,519,106	$4,796,703	$2,527,713
Onsite Landfarming	$2,795,192	$2,208,142	$2,115,364
Offsite Thermal Remediation (Rotary Kiln)	$9,035,013	$5,763,754	$3,037,319
Onsite Thermal Remediation (Infrared)	$8,641,485	$6,835,758	$6,536,307

Cleanup Levels

Source: Remediation Cost Estimates are provided in Table 4-1 and Appendix F, Table F-1

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Table 4-1 Summary of Soil Treatment Cost Estimates for Camp Lonely Western Landfill at Three Cleanup Levels

Soil Treatment / Disposal Alternative	500 mg/Kg			1,000 mg/Kg			2,000 mg/Kg		
	Estimated Treatment/ Disposal Cost	Unit Price per Ton (16,640 tons)	Unit Price Reference	Estimated Treatment/ Disposal Cost	Unit Price per Ton (10,615 tons)	Unit Price Reference	Estimated Treatment/ Disposal Cost	Unit Price per Ton (5,594 tons)	Unit Price Reference
Offsite Landfilling [A]	**$7,519,106**	$452	Table C-2	**$4,796,703**	$452	Table C-2	**$2,527,713**	$452	Table C-2
Onsite Land farming [B]	**$2,795,192**	$168	Table C-3	**$2,208,142**	$208	Table D-2	**$2,115,364**	$378	Table D-3
Offsite Thermal Treatment [A]	**$9,035,013**	$543	Table C-4	**$5,763,754**	$543	Table C-4	**$3,037,319**	$543	Table C-4
Onsite Thermal Treatment [C]	**$8,641,485**	$519	Table C-5	**$6,835,758**	$644	Table C-5	**$6,536,307**	$1,168	Table C-5

General Notes for Estimates:

1. Estimates include transportation, treatment, and disposal of the treated soil only. Estimates do not include mobilization and demobilization of standard construction equipment (e.g., loader, excavator, pickup trucks and end dumps) and field crew. It is assumed that these will be covered under a general mobilization/demobilization task, since it will rely on the same equipment and crew. Mobilizing equipment and crew for each item separately would increase cost by approximately $100,000 per item.

Assumptions:

A. Offsite landfilling and offsite thermal treatment alternatives incorporate a small percentage of fixed costs. The unit rate for these alternatives was estimated to stay the same for each of the higher cleanup levels.

B. Onsite landfarming and onsite thermal remediation incorporate a large percentage of fixed costs, such as mobilization and demobilization of remediation equipment and camp facilities. For these alternatives, the unit costs increase as the volume of soil decreases, resulting smaller decreases in the overall treatment costs at the higher cleanup levels. Individual cost estimates for the landfarming alternatives at 1,000 and 2,000 mg/Kg cleanup levels were used to derive unit pricing (Appendix D, Tables D-2 and D-3).

C. For estimation purposes, the increase in the unit price per ton under the landfarming alternatives at 1,000 and 2,000 mg/Kg cleanup levels were applied to the unit prices for the onsite thermal treatment alternative. The percentage increases above the 500 mg/Kg unit price for landfarming were 25% and 125%, respectively. Due to the larger percentage of fixed costs associated with the onsite thermal treatment alternative, the percentage increases applied to the unit prices are assumed to be very conservative.

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Table 4-2 Evaluation of Alternative DRO Cleanup Levels

Evaluation Criteria	DRO Cleanup Level (mg/Kg)		
	500	1,000	2,000
Estimated Contaminated Soil Volume (yd^3, in-place)	W. Landfill: 10,272 Entire Pad: 11,789	W. Landfill: 6,553 Entire Pad: 7,129	W. Landfill: 3,453 Entire Pad: 3,590
Initial Site Status	Conditional Closure	Conditional Closure	Conditional Closure
Probable Institutional Controls or Monitoring Requirements (note 1)	Site will be retained in the ADEC contaminated sites database. ADEC must be notified prior to moving soil, and approve of placement location (no placement in wetlands or surface water, which should not be too difficult to achieve).	Same as 500 mg/Kg. In addition, monitoring to verify contaminated soil is not eroding or creating surface sheen. Sampling of surface water to verify AWQS are not exceeded will likely be required for the first few years after the initial cleanup. At some point, sampling of soils will be required to demonstrate cleanup criteria for unconditional closure has been obtained.	Same as for 1,000 mg/Kg, but monitoring will likely be more rigorous due to greater regulatory concern regarding water quality issues.
Risk Reduction	Good (best). No significant long-term liability.	Moderate: The residual contamination in the soil will likely require 5-15 years to degrade to 500 mg/Kg. If contaminated soil erodes and comes into contact with surface water before final cleanup levels are obtained, the ADEC will likely require a response action (more intensive monitoring and possibly corrective action). Corrective actions are relatively easy to implement if the site is active. Difficult and expensive if the site abandoned.	Fair. Similar to 1,000 mg/Kg level but soils will take longer to natural attenuate to 500 mg/Kg (15-30 years). There is some potential that leachate from landfill will contain detectable BTEX, although AWQS exceedances are considered unlikely.
Implementability	Hardest to implement (large area must be remediated and verified as clean).	Moderate. Confirmation sampling likely to be less rigorous because institutional controls will remain.	Easiest. Soil volume is relatively small
Relative Cost for Soil Remediation (Landfarming)	High W. Landfill: $2,795,192 Entire Pad: $3,208,114	Moderate W. Landfill: $2,208,142 Entire Pad: $2,402,341	Low W. Landfill: $2,115,364 Entire Pad: $2,198,995
Evaluation Comments	Best if PRPs want to eliminate uncertainty and management associated with the site ASAP. The site will naturally attenuate to full closure criteria (DRO < 230 mg/Kg) faster than other cleanup levels.	Best balance of cost versus risk. The likelihood that those corrective actions will be required beyond the initial cleanup phase is considered low.	Lowest cost, but there is moderate risk that corrective action will be required at some point over the natural attenuation phase. The period of long-term liability is longer, requiring greater long-term management.

Key
O&M – Operations and maintenance
PRP – Potentially responsible party
AWQS – Alaska Water Quality Standards

Note:
1) The criteria and associated requirements for sites granted conditional versus full closure are not defined in ADEC regulations or guidance. Therefore, they are subject to site-specific negotiations. The items listed are based on informal discussions with the agency and examples from other sites.

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5.0 RECOMMENDATIONS

This section presents the recommended remedial action alternatives for the Camp Lonely Western Landfill and associated pad based on the evaluation conducted in Sections 2.0, 3.0, and 4.0. The Western Landfill is discussed first. The findings from the evaluation of the Western Landfill are then applied to other landfills and petroleum-contaminated areas on the pad. A discussion of assumptions and uncertainties in the cost estimates is also included. The cost estimates included in Appendices A-F are the basis for the summary cost data presented in this section.

5.1 Western Landfill

The potential and recommended alternatives for addressing the landfill are illustrated on the flow chart on Figure 5-1. This flow chart summarizes the components of the landfill removal process, including the waste streams that will be generated. Costs for the various remedial alternatives are included on the flow chart, and the recommended alternatives are highlighted. Removal of the landfill is considered the only viable alternative to meet the remedial action objectives (Section 1.3).

5.1.1 Disposal of Non-Hazardous and Hazardous Materials and Regulated Waste

The recommendation for addressing the non-hazardous debris excavated from the Camp Lonely Western Landfill is disposal in an offsite (Oxbow) landfill. Table 5-1 illustrates the comparison between the landfill removal alternatives based on primary evaluation criteria discussed in Section 2.1. The recommendation for addressing the risk posed by hazardous materials and regulated waste is disposal in a permitted offsite facility. These recommendations appear to be the only reasonable alternative for the site, are protective of human health and the environment, and provide good long-term effectiveness.

Table 5-3 provides a cost summary for the landfill removal alternative, which includes mobilization and demobilization of personnel and equipment; water management and treatment; landfill excavation; non-hazardous debris disposal; and oil, hazardous, and regulated waste disposal. Details of this cost summary are based on the cost estimating worksheets in Appendix B. The removal of the landfill will take approximately 5 weeks. The shipping and offsite disposal of the debris will take approximately five weeks. Therefore, these steps may take one to two field seasons depending upon start dates and shipping season durations.

5.2 Petroleum-Contaminated Soil

Five alternatives for addressing the risk posed by the petroleum-contaminated soil at Camp Lonely were evaluated in detail in Section 3.2. These alternatives are summarized below:

- Alternative 1: No Action/Natural Attenuation
- Alternative 2: Offsite Disposal
- Alternative 3: Onsite Landfarming
- Alternative 4: Offsite Thermal Treatment

- Alternative 5: Onsite Thermal Treatment

The recommended remedial action alternative for addressing the risk posed by petroleum-contaminated soil at Camp Lonely is Alternative 3: onsite landfarming. This alternative is cost-effective and provides good long-term effectiveness. The other alternatives for treating petroleum-contaminated soil do so at a greater cost, without providing any significant benefit (e.g., better overall protection of human health and the environment, compliance with applicable state and federal laws and regulations, and long-term effectiveness, etc.). Table 5-2 illustrates the comparison between the remedial alternatives, based on the evaluation criteria. This table visually summarizes the petroleum-contaminated soil alternatives that were discussed in Section 3.2 and the recommended alternative.

Table 5-4 provides cost summaries of these alternatives at the 1,000 mg/Kg DRO cleanup level for the Western Landfill based on the cost estimating worksheets in Appendices C and D. Appendix C details the costs involved for the four remedial alternatives at the Western Landfill at the 500 mg/Kg DRO cleanup level.

Landfarming is estimated to take one complete field season if the DRO cleanup level is 1,000 mg/Kg, and two field seasons if the cleanup level is 500 mg/Kg. As noted in Section 3.2, it is estimated that a small portion of the petroleum-contaminated soils at Camp Lonely (< 50 cubic yards) is not suitable for efficient onsite landfarming. This would include soil saturated with fuel or soil containing a high concentration of heavy end petroleum hydrocarbons from lubricating oil (e.g., RRO >5,000 mg/Kg). These types of petroleum-contaminated soil would take multiple field seasons to treat by landfarming. Therefore, it is recommended this soil be shipped off site for disposal or treatment.

5.3 Cost and Recommendations for Entire Camp Lonely Landfill and Pad

Table 5-5 is a cost summary of the four remedial alternatives at the Camp Lonely Western Landfill for the three cleanup levels. This table shows a breakdown of the costs for the debris and petroleum-contaminated soil. Based on these cost estimates, unit rates for debris removal and soil treatment were developed and applied to the rest of the site, including the Northeast Landfill and other areas on the pad with petroleum contamination (Figure 1-3). The resulting cost estimates for cleanup of the Camp Lonely landfill areas and pad are summarized in Table 5-6 for the four remedial alternatives and three DRO cleanup levels. Detailed cost estimates and assumptions are included in Appendices A-F. It is recommended that the same alternatives for the debris and petroleum-contaminated soil at the Western Landfill are used for cleanup of the other areas on the pad (e.g., offsite debris disposal and onsite landfarming).

5.4 Recommended Cleanup levels

Recommended cleanup levels for the Camp Lonely Landfill are contained in Table 5-7. These recommended levels are based on the site characterization reports (HCG 2006a and c), including the cumulative risk calculations, and the analysis of DRO cleanup levels in Section 4.0 of this report. The cleanup levels are focused on meeting the ADEC risk management standards [18 AAC 75.325(h)] based on cumulative risk, and meeting Alaska Water Quality Standards (18

AAC 70). As indicated in the table, there are two sets of cleanup levels. The first cleanup levels are proposed for the initial, active cleanup phase. These cleanup levels should result in conditional closure from the ADEC. These cleanup levels will be achieved through removal of the landfill, treatment of the petroleum-contaminated soil above 1,000 mg/Kg DRO, and removal and offsite disposal of any contaminated soil not suitable for landfarming. The second and final set of cleanup levels will be achieved though natural attenuation of the remaining petroleum hydrocarbons. Once these final cleanup levels are attained, the site should obtain full closure under 18 AAC 75, and no longer be classified as a contaminated site by the ADEC. To minimize the risk of additional corrective actions during the natural attenuation phase, it is recommended that the more conservative final cleanup levels (Table 5-7, last column) be applied to a 25 - 50 foot buffer around the outer edge of the pad (landfill). In the case of DRO, this level would be 500 mg/Kg (irrespective of the BTEX concentrations pertaining to Method One cleanup levels).

These recommended soil cleanup levels are intended for application to the pad soils (gravel and sand) only. Numeric cleanup for the native tundra are not proposed. Contaminated tundra either under or adjacent to the landfill has not been identified. Native tundra is only recommended for removal after a risk evaluation determines its removal is necessary to protect human health and the environment, and the risk posed by the current conditions is greater than environmental damage of a removal action.

5.5 Uncertainties in Cost Estimates

As discussed in Section 1.5, this report evaluates various alternatives for the removal of the Camp Lonely landfill and associated pad. The cost estimates provide an estimated level of effort for comparative purposes between the alternatives. Once a remedial alternative is selected along with cleanup levels, a detailed Corrective Action Plan (Work Plan) and associated budget can be developed. Therefore, the estimates included in this FS should not be used for final budgeting purposes. The following uncertainties may affect the cost estimates contained in this FS:

- **Surface Area, Volume, and Types of Contamination:** The contents and degree of contamination within the landfill were estimated on sample results and site conditions. The degree of uncertainty in these estimates is high, based on the heterogeneity of the landfill and limited sample results in various areas of the landfill and pad. An increase in the areas and volumes of contamination will directly increase the cost estimates, including time for debris removal, sorting of debris and contaminated soil, and treatment and disposal of soil and debris. Alternatives that are less sensitive to the waste volume fluctuations, such as onsite landfarming, are preferred. The remote location makes alternatives that involve shipping significant quantities of materials to or from the site subject to greater risk due to the limited shipping season and the cost of transportation.

- **Mobilization/Demobilization Costs:** The current cost estimates assume mobilization and demobilization of the camp and all heavy equipment to Camp Lonely by barge. The cost estimates assume a barge season of 10 weeks based on consultation with barge companies operating on the North Slope. However, the barge season varies year to year and accessibility to the site is dependent on the amount of sea ice and nearshore water depths. Based on these unknowns, a winter mobilization effort may be preferred to curtail this uncertainty and to maximize the length of the working field season (a winter mobilization effort was included for the onsite thermal treatment costs only).

- **Barge Costs:** Barge costs were obtained from Bowhead by an experienced cost estimator for the North Slope (Drew Laughlin), who recommended a dedicated barge for this project based on the number of barge trips needed to haul waste from the site. A daily barge rate of $21,000 per day was quoted, with the daily charter fee starting when the barge first arrives at Camp Lonely. The barge will be mobilized to Camp Lonely from Seattle at the beginning of the season and utilized for the duration of the project. The use of a dedicated barge assures it will always be available and not diverted to, or delayed by, other projects.

  Based on past seasons' experience from the barge company, and the type and capacity of the barge, it was estimated that it would take two and a half (2.5) days round trip between Camp Lonely and West Dock in Deadhorse. This results in a barge rate of $52,500 round trip. Based on consultation with CIRI and their experience during the 2005 field work, barge rates were approximately $80,000 per trip. This increased rate was most likely due to multiple factors, including: (1) the use of a non-dedicated barge; and (2) the use of a barge with greater size and capacity (60 feet by 200 feet deck space, compared with 40 feet by 160 feet for the barge in the current cost estimate). As a contingency, barge costs in the cost estimate were increased to $65,000 per trip. However, the use of a dedicated and smaller barge is recommended for consideration. The smaller size barge will also incur less chance of becoming grounded on the beach.

  An alternative to barging would be to access the site in the winter via an ice road or combination of an ice road and rollagons. Preliminary estimates indicate building an ice road solely for this project is not cost effective. Alpine is the furthest westward point connected to the Alaska road system (an ice road is built to Alpine annually that connects to the Kuparuk oil field and on to Deadhorse, where the Oxbow Landfill is located). From Alpine to Camp Lonely, the distance is approximately 90 miles. Ice roads vary in cost from $60,000 to $100,000 per mile. Therefore, the estimated cost of an ice road is $5.4 to $9 million. Trucking costs would be additional. Chartering a barge for the entire season is more cost effective. However, ice roads were built further westward than Alpine for oil and gas exploration in the NPRA the last few winters. The length and location of these roads varies with exploration needs. It is possible that when the cleanup is conducted an ice road may be sufficiently close to Camp Lonely that over land travel is cost effective (assuming the ice road cost is shared among the multiple projects). This cannot be predicted at this time. However, it could be reconsidered closer to the project start date.

- **Barge Landing Accessibility:** It is assumed that the existing barge landing at Camp Lonely will be adequate for use. However, dredging or a gravel causeway may be needed for barge access to the beach due to sediment deposition along the coast. This could cost on the order of $500,000 to $1 million. In addition, rig mats at the barge landing may need to be utilized along the beach for heavy equipment traffic. These costs have not been included in the current cost estimate.

- **Weather:** Significant changes in seasonal weather patterns may affect such factors as ice or wave conditions, which could interfere with barge shipping. A cooler summer than normal could decrease the treatment rate achieved from landfarming or slow the rate of thawing during excavation of the landfill. Snow removal costs are not included in the current estimates.

- **Equipment Breakdowns:** Time and materials for routine maintenance and repair of equipment is included in the costs estimates. However, the estimates do not included standby time or repair costs for significant equipment breakdowns. An example of a significant breakdown would be ice damage to the barge in transit, which requires several weeks of repairs and inspections in Deadhorse. If desired, contingency for significant equipment breakdowns and standby time can be added. However, this additional contingency is not deemed necessary for the purposes of the FS (cost comparisons of alternatives), and has been excluded.

- **Medical Costs:** Additional costs may be needed to staff a medically trained professional (e.g., paramedic or physician's assistant) on site during the project duration. Based on the fieldwork that was conducted at Camp Lonely in 2005, upwards of $32,000 was spent to staff a medic for a six-week period. The decision to have a medic on staff will be dependent on the contractor or contract requirements for the project. These costs will be added to the final FS report, if requested. In addition, no additional costs have been included to account for injuries or lost time accidents that may occur at the job site and the resulting expenses.

- **Competing Projects:** Work (e.g., environmental cleanup or oil and gas exploration activities) in the Point Lonely area may lower the Camp Lonely project cost if some of the mobilization, demobilization or infrastructure costs can be shared. However, significant cost savings would require coordination between the projects. Staggering the start date of cleanup work at Point Lonely and Camp Lonely by one year may allow for some equipment to be mobilized from one site to the other. It may be best to let the market place (private contractors) maximize potential cost savings by allowing a degree of flexibility in the schedule. Conversely, other projects in the area may also serve to drive up costs by competing for similar resources such as barges. The use of a dedicated barge will reduce this risk.

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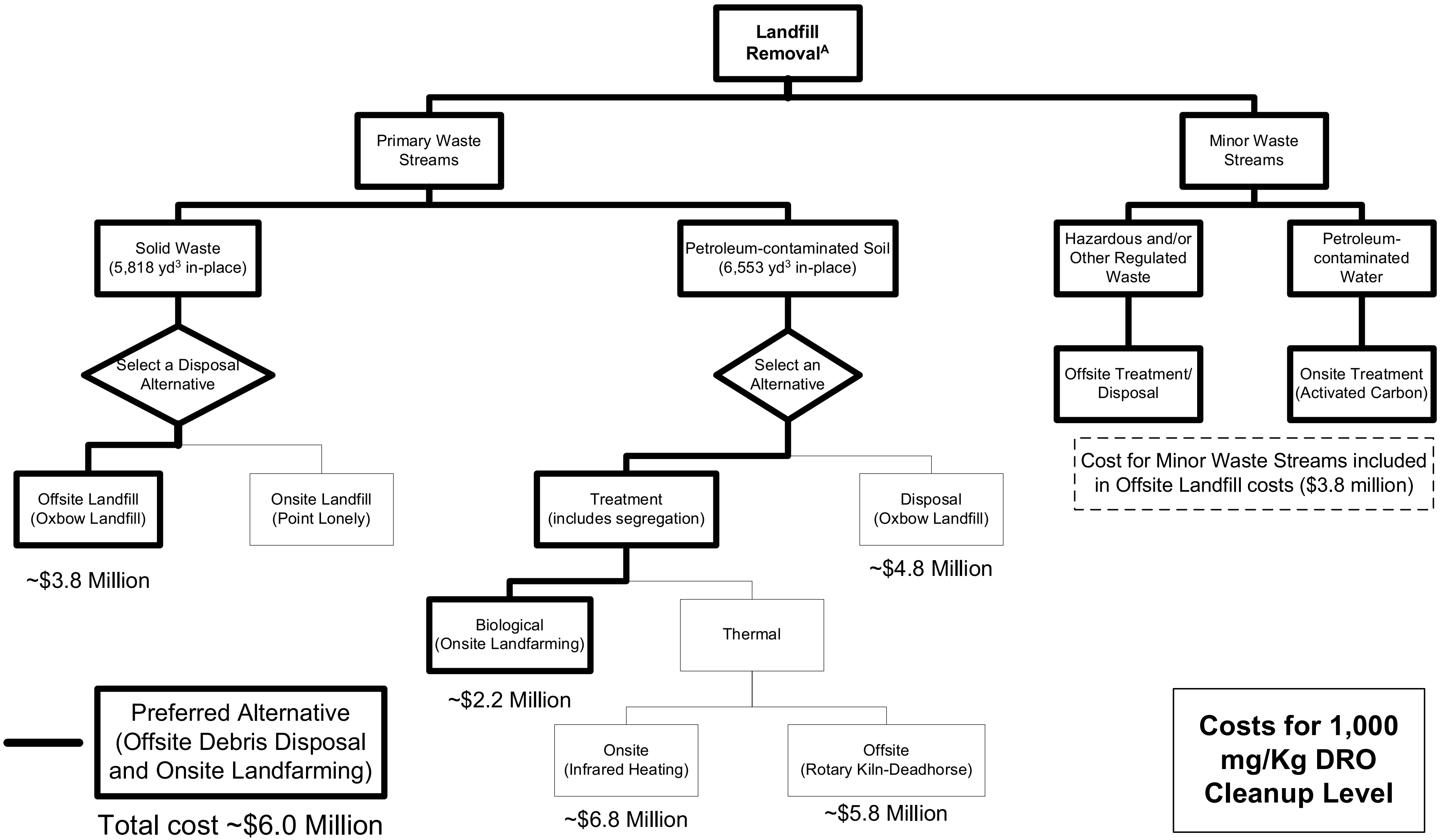
Figure 5-1 Recommended Landfill Removal and Petroleum-Contaminated Soil Remedial Alternatives and Associated Costs (Western Landfill)



NOTES

A - Costs listed are for the 1,000 mg/Kg DRO cleanup level alternative. The total cost for the preferred alternative (offsite debris disposal and onsite landfarming of petroleum-contaminated soil) at the 500 mg/Kg DRO cleanup level would be $6.6 million; the total cost would be $5.9 million at the 2,000 mg/Kg DRO cleanup level.

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Table 5-1 Summary Evaluation of Landfill Removal Alternatives at Camp Lonely

Remedial Action	Threshold Criteria	Balancing Criteria		Comments	Cumulative Evaluation Result
	Effectiveness	Implementability	Relative Cost		
No Action	○ (Worst)	● (Best)	● (Best)	Fails Threshold Criteria	Fails
Institutional Controls	○ (Worst)	◕ (Better than Average)	◕ (Better than Average)	Fails Threshold Criteria	Fails
Containment (Shoreline Stabilization)	◔ (Worse than Average)	◔ (Worse than Average)	○ (Worst)	Not practical or effective for the long term.	◔ (Worse than Average)
Excavation and Onsite (local) Landfilling of Debris	◕ (Better than Average)	○ (Worst)	◕ (Better than Average)	Currently not implementable. Lower cost than offsite landfill, if permitted.	◑ (Average)
Excavation and Offsite (remote) Landfilling of Debris	● (Best)	◑ (Average)	◑ (Average)	Provides permanent solution. May require more than one barge season. Considered the only viable option.	● (Best)

Symbol Key

Best ● Better than Average ◕ Average ◑ Worse than Average ◔ Worst ○

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Table 5-2 Summary Evaluation of Petroleum-Contaminated Soil Alternatives at Camp Lonely

Remedial Action	Threshold Criteria	Balancing Criteria		Comments	Cumulative Evaluation Result
	Effectiveness	Implementability	Relative Cost		
No Action / Monitored Natural Attenuation	○	●	●	Fails Threshold Criteria	Fails
Offsite Disposal	◑	◕	◑	Does not use existing pad. Cost relatively high. Some long-term liability.	◑
Onsite Thermal Treatment (low temperature)	●	◑	○	Highest cost (barely). Some uncertainty due to equipment breakdowns. Less risk and pad use than landfarming.*	◕
Offsite Thermal Treatment (low temperature)	●	◕	○	High cost, but low risk. Does not use existing pad.	◕
Onsite ex-situ Biological Treatment (landfarming)	◕	◕	◕	Most cost effective, but some risk due to duration of treatment time. Uses large portion of pad.*	●

* Gravel available for reuse.

Symbol Key

Best ● Better than Average ◕ Average ◑ Worse than Average ◔ Worst ○

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Table 5-3 Cost Summary for Western Landfill Removal and Offsite Debris Disposal

Alternatives: Number and Description	Estimated Total Cost	Reference
Mobilization/Demobilization	$395,113	Table B-2
Water Management and Treatment	$107,332	Table B-3
Excavation of Western Landfill	$1,292,262	Table B-4
Oil, Hazardous and Regulated Waste Disposal	$182,923	Table B-5
Debris Disposal (Oxbow Landfill)	$1,850,469	Table B-6
Total Cost	**$3,828,100**	Appendix B

General Notes:
1. Detailed cost worksheets and assumptions used to derive this cost summary are contained in Appendix B.
2. Costs include excavation of entire Western Landfill, including contaminated soil.
3. No treatment or disposal costs for soil are included in this estimate.
4. The unit rate (per ton cost) for excavation of the Western Landfill and debris disposal was applied to the Northeast Landfill. Excavation costs for petroleum-contaminated soil on the Camp Lonely pad (non-landfill areas) were estimated separately in Table B-7.

Table 5-4 Cost Comparison for Various Soil Remedial Alternatives at the 1,000 mg/Kg DRO Cleanup Level – Western Landfill

Remedial Alternative Description	Unit Price per Ton (10,615 tons)	Estimated Total Cost
Offsite Disposal (Oxbow Landfill, Deadhorse)	$452	$4,796,703
Onsite Landfarming	$208	$2,208,142
Offsite Thermal Treatment (Rotary kiln, Deadhorse)	$543	$5,763,754
Onsite Thermal Treatment (Infrared)	$644	$6,835,758

General Notes:
1. Detailed cost worksheets used to derive these unit prices and cost summaries are contained in Appendix C and D.
2. Estimated costs for the various alternatives do not include excavation of the contaminated soil. Transportation and disposal costs of treated soil are included in the estimates.

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Table 5-5 Cost Rollup for Four Treatment Alternatives at Three Cleanup Levels for Western Landfill

Item	Disposal/Treatment Option	Material/ Waste (notes 1 and 2)	Volumes (yd^3) by Material Type					
			Assuming contaminated soil defined as DRO > 500 mg/Kg		Assuming contaminated soil defined as DRO > 1,000 mg/Kg		Assuming contaminated soil defined as DRO > 2,000 mg/Kg	
			Tons	Cost	Tons	Cost	Tons	Cost
Western Landfill	Offsite Disposal of Debris and Soil at Oxbow	PCS	16,640	$ 7,520,586	10,615	$ 4,797,647	5,594	$ 2,528,211
		Debris	4,363	$ 3,828,100	4,363	$ 3,828,100	4,363	$ 3,828,100
		Total	**21,003**	**$ 11,348,686**	**14,979**	**$ 8,625,747**	**9,957**	**$ 6,356,310**
	Offsite Disposal of Debris and Onsite Landfarming	PCS	16,640	$ 2,795,208	10,615	$ 2,208,158	5,594	$ 2,115,380
		Debris	4,363	$ 3,828,100	4,363	$ 3,828,100	4,363	$ 3,828,100
		Total	**21,003**	**$ 6,623,307**	**14,979**	**$ 6,036,258**	**9,957**	**$ 5,943,480**
	Offsite Disposal of Debris and Offsite Thermal Remediation (Rotary Kiln)	PCS	16,640	$ 9,036,494	10,615	$ 5,764,698	5,594	$ 3,037,816
		Debris	4,363	$ 3,828,100	4,363	$ 3,828,100	4,363	$ 3,828,100
		Total	**21,003**	**$ 12,864,593**	**14,979**	**$ 9,592,798**	**9,957**	**$ 6,865,916**
	Offsite Disposal of Debris and Onsite Thermal (Infrared)	PCS	16,640	$ 8,641,485	10,615	$ 6,835,758	5,594	$ 6,536,307
		Debris	4,363	$ 3,828,100	4,363	$ 3,828,100	4,363	$ 3,828,100
		Total	**21,003**	**$ 12,469,585**	**14,979**	**$ 10,663,858**	**9,957**	**$ 10,364,407**

Notes:
1- PCS costs consist of cost to treat or dispose of petroleum-contaminated soil (PCS) once it is excavated and will include per diem for the duration of those tasks. Unit rates for each disposal alternative for petroleum-contaminated soil were calculated based on the soil volumes in the Western Landfill and applied to other areas of the pad. Refer to Appendices C and D for the detailed estimates of the costs and unit rates for the various alternatives and the three cleanup levels.
2 - Debris costs include excavation of landfill debris and soil, water management, and disposal of non-hazardous and hazardous debris. It also includes associated mobilization and demobilization costs of camp, personnel, and equipment. Refer to Appendix B for detailed estimates of the cost and unit rate.
3 – Detailed material and cost spreadsheets available in Appendices A-F.

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Table 5-6 Cost Rollup for Four Treatment Alternatives at Three Cleanup Levels for Entire Camp Lonely Landfill and Pad

Item	Disposal/Treatment Option	Material/ Waste (notes 1 and 2)	Volumes (yd^3) by Material Type					
			Assuming contaminated soil defined as DRO > 500 mg/Kg		Assuming contaminated soil defined as DRO > 1,000 mg/Kg		Assuming contaminated soil defined as DRO > 2,000 mg/Kg	
			Tons	Cost	Tons	Cost	Tons	Cost
CAMP LONELY TOTALS	Offsite Disposal of Debris and Soil at Oxbow	PCS	19,098	$ 8,631,571	11,549	$ 5,219,585	5,815	$ 2,628,163
		Debris/Excavation	4,521	$ 4,058,575	4,521	$ 4,058,575	4,521	$ 4,058,575
		Total	**23,619**	**$ 12,761,916**	**16,070**	**$ 9,278,160**	**10,336**	**$ 6,686,737**
	Offsite Disposal of Debris and Onsite Landfarming	PCS	19,098	$ 3,208,132	11,549	$ 2,402,359	5,815	$ 2,199,011
		Debris/Excavation	4,521	$ 4,058,575	4,521	$ 4,058,575	4,521	$ 4,058,575
		Total	**23,619**	**$ 7,448,095**	**16,070**	**$ 6,460,933**	**10,336**	**$ 6,257,586**
	Offsite Disposal of Debris and Offsite Thermal Remediation (Rotary Kiln)	PCS	19,098	$ 10,371,417	11,549	$ 6,271,685	5,815	$ 3,157,915
		Debris/Excavation	4,521	$ 4,058,575	4,521	$ 4,058,575	4,521	$ 4,058,575
		Total	**23,619**	**$ 14,466,597**	**16,070**	**$ 10,330,260**	**10,336**	**$ 7,216,490**
	Offsite Disposal of Debris and Onsite Thermal (Infrared)	PCS	19,098	$ 9,918,056	11,549	$ 7,436,941	5,815	$ 6,794,718
		Debris/Excavation	4,521	$ 4,058,575	4,521	$ 4,058,575	4,521	$ 4,058,575
		Total	**23,619**	**$ 14,022,399**	**16,070**	**$ 11,495,516**	**10,336**	**$ 10,853,293**

Notes:
1- PCS costs consist of cost to treat or dispose of petroleum-contaminated soil (PCS) once it is excavated and will include per diem for the duration of those tasks. Unit rates for each disposal alternative for petroleum-contaminated soil were calculated based on the soil volumes in the Western Landfill and applied to other areas of the pad. Refer to Appendices C and D for the detailed estimates of the costs and unit rates for the various alternatives and the three cleanup levels.
2 - Debris/Excavation costs account for excavation of the landfills (soil and debris) and the pad area (contaminated soil). Excavation costs for the landfills include mobilization/demobilization, excavation of landfill debris and soil, water management, and disposal of non-hazardous and hazardous debris. A unit rate was determined for excavation of the Western Landfill and was applied to the Northeast Landfill. A separate cost estimate was determined for excavation of the contaminated soil on the Camp Lonely Pad. Refer to Appendix B for detailed estimates of the costs and unit rates.
3 – Detailed material and cost spreadsheets available in Appendices A-F.

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Table 5-7 Recommended Cleanup Levels for the Camp Lonely Western Landfill

Location (Area)	Matrix	COCs (note 1)	2005-2006 Maximum Concentration[3]	Potential Regulatory Levels				INITIAL	FINAL
				Method One Soil Cleanup Level (Arctic Zone) or 18 AAC 70 MCL[2] for water	Method Two Soil Cleanup Level (Arctic Zone)[2]	1/10 Method Two Cleanup Level (Arctic Zone)	Method Two Cleanup Level (Over 40 Inch Zone)	Cleanup Level for Conditional Closure	Cleanup Level for Unconditional Closure
Camp Lonely Landfill	Soil (mg/Kg)	GRO[2]	930	100	1,400	--	260	150	100
		DRO[2]	6,980	500(200)[4]	12,500	--	230	1,000	500(230)[4&8]
		RRO[2]	5,120	2,000	13,700	--	9,700	2,000	2,000[8]
		Total xylenes	134.1	--	81	8.1[6]	69	81[6]	69
		Chromium	6,010	--	410	4.1[6]	23	410[6]	23
	Water (ug/L)	Benzene	8.15	5	--	--	--	5	5
		Toluene[7]	5.96	1,000	--	--	--	1,000	1,000
		Ethylbenzene[7]	2.86	700	--	--	--	700	700
		Total xylenes[7]	17.11	10,000	--	--	--	10,000	10,000
		TAH	34.08	10	--	--	--	10	10

Definitions

COC – Contaminant of concern

mg/Kg – milligrams per kilogram

ug/L – micrograms per liter

AZ – Arctic Zone

TAH – Total aromatic hydrocarbons (sum of BTEX compounds)

-- - Not Applicable

Notes

1 - COCs and information listed refers to the Western Landfill only and does not include the pad area.
2 - No samples exceeded ADEC Method Two cleanup levels for the Arctic Zone (18 AAC 75.341, Table B2) for GRO and DRO.
3 - The maximum RRO value does not include values from three surface stains sampled at the site. The values from these surface stains ranged from 20,900 to 31,200 mg/Kg and their combined estimated volume is less than 1 cubic yard.
4 - The Method One cleanup level for DRO can be raised from 200 mg/Kg to 500 mg/Kg for diesel spills on gravel pads if the total BTEX concentration is < 15 mg/Kg and benzene is < 0.5 mg/Kg. The frequency of exceedances is listed for the 500 mg/Kg level. Three samples were between 200 and 500 mg/Kg DRO. A DRO cleanup level greater than 230 mg/Kg may result in conditional closure. However, the institutional controls associated with soil between 230 and 500 mg/Kg will likely be administrative and relatively insignificant in terms of cost (especially in comparison to actively remediating the soil to 230 mg//kg).
5 - Cleanup of the soils to the initial cleanup levels and removal of the landfill debris containing hazardous substances should eliminate the COCs in the water. No direct cleanup actions for water are recommended.
6 – Per 18 AAC 75.325(g), the cumulative risk of the hazardous substances at a site must meet ADEC risk management standards for human health ($1X10^{-5}$ for cancer risk and a hazard index of 1.0). Per 18 AAC 75.340(k), a chemical that is detected at one-tenth or more of the Method Two cleanup level must be included when calculating cumulative risk. Therefore, the cleanup levels for these substances can vary so long as the ADEC risk management standards are not exceeded. Cumulative risk calculations will follow ADEC guidance (ADEC 2006).
7 – Toluene, ethylbenzene, and total xylenes are considered water COCs because they significantly contribute to the TAH exceedance.
8. Due to the very low cleanup criteria applied to DRO and RRO there may be a need to remove, or account for, the effects of natural organics on sample concentrations.

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