ALASKA RAILROAD CORPORATION

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May 17, 2005

Jacques Gusmano, Project Coordinator
Alaska Operations Office
U.S. Environmental Protection Agency
222 West 7th Avenue, #19
Anchorage, Alaska 99513-7588

Re: Alaska Railroad Corporation, Anchorage Terminal Reserve RI/FS
Administrative Order on Consent EPA Docket No. CERCLA-10-2004-0065
Remedial Action Objectives Technical Memorandum

Dear Mr. Gusmano:

Enclosed please find the Remedial Action Objectives Technical Memorandum (RAO) developed under Subtask 2c of the Statement of Work for the above referenced CERCLA/RCRA Administrative Order on Consent (AOC). The RAO addresses media and constituents of potential concern, identifies preliminary ARARs, and discusses preliminary remedial action objectives for each medium. Appropriate sections of the RAO will be incorporated in the RI Work Plan.

Please do not hesitate to contact me at (907) 265-2410 if you have any questions or concerns.

Sincerely,

Chris Cosentino/For

Ernest W. Piper
Project Coordinator

cc: H. Orlean, EPA
W. Westervelt, CH2M HILL – 2 copies
B. Duncan, EPA
J. Frechione, ADEC

Remedial Action Objectives Technical Memorandum

Alaska Railroad Corporation

Anchorage Terminal Reserve
U.S. EPA Docket No. CERCLA 10-2004-0065

Prepared by:

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Prepared for:

Alaska Railroad Corporation
327 Ship Creek Avenue
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May 16, 2005

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List of Acronyms and Abbreviations

ADEC	Alaska Department of Environmental Conservation
AOC	Administrative Order on Consent
ARARs	Applicable or Relevant and Appropriate Requirements
ARRC	Alaska Railroad Corporation
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CMS	Corrective Measures Study
COPC	Constituents of potential concern
CSM	Conceptual site model
CVOC	Chlorinated volatile organic compound
DPE	Dual-phase extraction
DQO	Data quality objective
DWEL	Drinking water equivalent level
Foc	Fraction organic carbon
HDPE	High-density polyethylene
LNAPL	Light non-aqueous phase liquid
MCL	Maximum contaminant level
MNA	Monitored natural attenuation
MNR	Monitored natural recovery
NAPL	Non-aqueous phase liquid
ORC	Oxygen release compound
ORP	Oxygen-reduction potential
PAH	Polycyclic aromatic hydrocarbons
PC	Planned community
PCB	Polychlorinated biphenyls
PRG	Preliminary remediation goal
PVC	Polyvinyl chloride
RAO	Remedial Action Objectives
RCRA	Resource Conservation and Recovery Act
RETEC	The RETEC Group, Inc.
RFH	Radio frequency heating
RFI	RCRA Facility Investigation
RI/FS	Remedial Investigation and Feasibility Study
ROI	Radius of influence
SBR	Site Background Report
SOW	Statement of Work
SPSH	Six-phase soil heating
SVE	Soil-vapor extraction
SVOC	Semivolatile organic compound
TC	Toxicity characteristic
TCE	Trichloroethylene
TFE	Total fluids extraction

List of Acronyms and Abbreviations

U.S. EPA	United States Environmental Protection Agency
VOC	Volatile organic compound

1 Introduction

This document was developed under Administrative Order on Consent (AOC) No. 10-2004-0065 dated June 29, 2004 between Region 10 of the U.S. Environmental Protection Agency (U.S. EPA) and the Alaska Railroad Corporation (ARRC). The AOC was issued under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA). ARRC agreed in the AOC to conduct a CERCLA Remedial Investigation and Feasibility Study (RI/FS) at its Anchorage Terminal Reserve in Anchorage, Alaska (the Site) that also meets the requirements of a RCRA Facility Investigation and Corrective Measures Study (RFI/CMS). The AOC incorporates a Statement of Work (SOW) (U.S. EPA, 2004a) that requires ARRC to submit a draft Remedial Action Objectives (RAO) Technical Memorandum that identifies preliminary RAOs. This report is submitted in fulfillment of Subtask 2c of the SOW.

This draft technical memorandum provides preliminary and early identification of expected applicable or relevant and appropriate requirements (ARARs) and preliminary RAOs for the Site. This RAO technical memorandum is based upon the information presented in the Site Background Report (SBR) (RETEC, 2004) including its subsequent addenda (RETEC, 2005). The Site location is shown on Figure 1-1 of the SBR.

The RAO Technical Memorandum is outlined as an integral component of the RI/FS in the SOW. The purposes of the RI/FS are to 1) investigate the nature and extent of contamination at the Site, 2) identify the need for and range of potential remedial alternatives, 3) assess the potential risk to human health and the environment caused by Site contaminants, 4) develop Site-specific remedial action and corrective measure objectives (collectively, “RAOs”), 4) evaluate potential remedial alternatives that will meet both CERCLA remedial actions and RCRA corrective measure requirements, and 5) recommend a preferred remedial alternative.

1.1 Purpose and Objectives

The purpose of this technical memo is to outline preliminary RAOs for the Site which specify goals for protecting human health and the environment. As defined in Subtask 2c of the SOW, RAOs include a range of broadly defined potential remedial alternatives which are consistent with CERCLA, the NCP, and EPA interpretive guidance. The range of potential remedial technologies encompass, where appropriate, alternatives in which treatment significantly reduces the toxicity, mobility, or volume of the waste; alternatives that involve containment with little or no treatment; alternatives that include removal of waste, and a no-action alternative. Excavation, capping, in-situ treatment, monitored and enhanced natural attenuation, and other alternatives (as well as combinations of each where called for) are also included in the range of remedial action alternatives.

The objectives for this RAO technical memorandum are to:

- outline preliminary RAOs for the Site. The preliminary RAOs specify general goals for protecting human health and the environment
- summarize constituents of potential concern for the Site
- document preliminary applicable or relevant and appropriate requirements (ARARs) for the Site
- describe remedial technologies that may be used at the Site and identify data requirements needed to evaluate each remedial alternative. The data requirements maybe considered data gaps which will be addressed in the RI Work Plan.

The list of preliminary remedial alternatives includes monitored natural attenuation (MNA) and collection of MNA data will be included in a RI planning task so that it is available when needed for the FS. As the nature and extent of contamination is further determined and the risk assessments calculate risk to human health or the environment, remedial action alternatives of those areas that pose unacceptable risks to human health or the environment will be identified for screening and evaluation in the FS.

1.2 Organization

This technical memorandum is organized into the following sections:

- Section 1 provides an introduction, including background, purpose, and scope.
- Section 2 presents the media and constituents of potential concern (COPCs).
- Section 3 identifies preliminary ARARs.
- Section 4 discusses the preliminary RAOs for each medium.
- Section 5 provides references.

2 Media and Constituents of Potential Concern

This section summarizes the media to be investigated during the RI and a preliminary list of constituents of potential concern (COPCs) in those media. The media of potential concern include those potentially affected by contamination from past railroad or leased property tenant industrial operations. The constituents of potential concern were identified for the RAO Technical Memorandum through review of historical site data (i.e., from properties listed for further action in the RCRA Facility Assessment for Leased Property Report [Booz-Allen Hamilton, 2002]) to identify classes of chemicals for each media. Specific constituents of potential concern (i.e., individual analytes) will be identified using results generated from analytical sampling completed as part of the planned RI, as well as historical data, as discussed in Section 2.3. The media and COPCs provide the basis for the identification of potential remedial action alternatives for the site, which are discussed in Section 4.0.

2.1 Site Description

The ARRC offices are located at 327 West Ship Creek Avenue in Anchorage, Alaska on the north bank of Ship Creek. The area immediately surrounding the Site is primarily industrial/commercial. The marine waters of Knik Arm (extension of Cook Inlet) are located approximately 0.4 miles to the west. The site consists of approximately 600 acres of property in the lower Ship Creek valley. The railyard facility itself occupies approximately 313 of the 600 acres with the remaining 287 acres consisting of parcels that are leased to a variety of commercial and industrial businesses. The central business district of Anchorage is located on the bluff to the south of the Site; and the Government Hill residential, commercial, and light industrial district is located on the bluff due north of the Site. Elmendorf Air Force Base lies on the bluff north and northeast of the Site.

Currently, ARRC maintains a year-round rail system for freight and passengers. The use of the Site for commercial/industrial purposes is unlikely to change in the foreseeable future. Any change would be the result of ARRC management decisions since ARRC owns all the Site property and controls land uses at the Site.

Current zoning configuration for the Site vicinity, coupled with ARRC property management policies, provides the framework for the current industrial and commercial use of essentially the entire Site. The majority of the Site is zoned for heavy or light industrial uses as shown in Figure 1-2 of the SBR (RETEC, 2004). An area in the southwestern portion of the Site, which is currently zoned as a “planned community” (PC) district, includes residential use within its permitted uses. ARRC will determine the land use in this area as it will for the Site as a whole, including whether to lease any land for residential purposes.

2.2 Investigative Media

The Site incorporates areas of varying physical conditions, land use, access, and potential for risk to human health and the environment. In the RI, the goal of the Site investigation will be to ensure protection of human health and the environment with a particular focus on Ship Creek. Therefore, an extensive sediment, surface water, groundwater, and soil investigation is planned. Results of sediment, surface water, groundwater, and soil analyses completed during the RI will be used to identify potential source areas for additional authoritative soil sampling. The authoritative sampling will be designed to evaluate "worst case" conditions (i.e., areas of highest contaminant concentrations) and delineate the nature and extent of potential source areas.

For soil, geographic divisions define areas by major land use (e.g., leased properties vs. railyard) or physical separation (e.g., the area northwest of the railyard separated from the other leased properties and dominated by petroleum management facilities).

Groundwater has been divided into three investigative areas (as shown on Figure 3-2 of the SBR (RETEC, 2005)) based on site hydrology, as follows:

- Area South of Ship Creek.
- Area North of Ship Creek.
- Terminal Area.

Surface water and sediment include those complete pathways within Ship Creek and the Knik Arm of the Cook Inlet, and are shown on Figure 3-2 of the SBR (RETEC, 2005).

2.3 Constituents of Potential Concern

The historical analytical results evaluated for this report were used to identify the list of COPCs that potentially could require remediation. Review of this data indicates the following classes of constituents in sediment, surface water, groundwater or soil may require remedial action:

- Volatile organic compounds (VOCs)
- Semivolatile organic compounds (SVOCs)
- Polycyclic aromatic hydrocarbons (PAHs)
- Fuel hydrocarbons (TPH, DRO, GRO, RRO, and BTEX)
- Chlorinated solvents (TCE, PCE, vinyl chloride)
- Inorganics (i.e., metals and minerals)

- Polychlorinated biphenyls (PCBs) (i.e., aroclors)
- Dioxins and furans
- Pesticides

Not all chemicals have been analyzed at each location or in each media. Table 2-1 shows the list of chemical classes that have been detected in soil, groundwater, surface water and sediment. These chemical classes will be used in Section 4.0 to identify potential remedial technologies for the site.

3 Applicable or Relevant and Appropriate Requirements

3.1 Preliminary ARARs

In order to meet the requirements set forth in SOW Section 2.3.2, preliminary ARARs were developed as part of the planning process to assist in selecting appropriate analytical methods and setting analytical data quality objectives (DQOs). The following sources were considered in developing ARARs for the site:

- Constituent-specific potential ARARs including Safe Drinking Water Act maximum contaminant levels (MCLs and drinking water equivalent levels (DWELs), ADEC and U.S. EPA health screening levels, and ecological screening levels and benchmarks.
- Location-specific potential ARARs, including sediment concentrations for protection of benthic invertebrates.
- Action-specific potential ARARs that could affect how selected remedial alternatives would be performed.

Table 3-1 presents potential location-specific, constituent-specific, and action-specific ARARs for the Site.

4 Preliminary Remedial Action Objectives

This section presents the preliminary remedial action objectives for each medium of concern at the Site. The preliminary RAOs are medium-specific or investigative area-specific goals for protecting human health and the environment, and present a preliminary list of technologies to be considered in the FS. The RAOs presented herein specify COPCs and media of concern, exposure routes and receptors, and acceptable levels for each exposure route. RAOs identify acceptable risk levels and exposure routes because protectiveness can be achieved by reducing exposure (e.g., by capping) as well as by reducing COPC levels (e.g., by treatment or removal). Based on the preliminary list of remedial alternatives in this section, data needs and gaps will be identified for the RI which will be used to evaluate remedial technologies in the FS. Based on results of the site-specific risk assessment to be performed as part of the RI, the preliminary RAOs will be refined and proposed as part of the FS for areas and media at the site that present a risk to human health or the environment.

4.1 Preliminary List of Remedial Alternatives

Figure 4-1 provides a flow chart of the RAO development process for a site (U.S. EPA, 1989). The first step in the preliminary identification of remedial alternatives is the development of RAOs. The objectives for remedial action are site-specific cleanup goals that are protective of human health and the environment. Such goals are usually based upon existing information, such as the ARARs and available toxicological information identified in Section 3.0 or the site-specific risk assessment to be conducted as part of the RI. Thus, this evaluation has been based on conservative screening levels and ARARs where available. Figure 4-2 provides a flow chart for the iterative data collection process during the Remedial Investigation.

After RAOs are identified, the process of developing a preliminary list of alternatives for the remediation of a site is accomplished through the following six-step process:

1. Develop preliminary RAOs reflecting the requirements for compliance with ARARs (Section 3.0), including the findings of the preliminary risk assessment from the SBR (RETEC, 2005);

2. Identify general categories of responses (e.g., treatment, containment, or removal) applicable to each medium of concern that will meet or exceed the cleanup goals;

3. Estimate the types of contaminated material (i.e., COPCs identified on Table 2-1) that must be treated, and determine those remedial alternatives that are technically impractical given site conditions;

4. Identify applicable technologies within each category of remedial alternatives identified by examining the technical implementability of specific remedial technologies in each category given site conditions;

5. Provide a more detailed evaluation of the each technology and identify the site-specific data required to evaluate the technology and the currently available data; and

6. Identify the data gaps and data collection needs to evaluate each technology in the FS.

Preliminary RAOs for the Site are presented in Table 4-1, and provide the following information:

- Environmental Media: the environmental media include the media of concern identified in Section 2.0.

- Preliminary Remedial Action Objectives: Preliminary RAOs are medium-specific or investigative area-specific goals for protecting human health and the environment. Preliminary RAOs will be finalized based on results of the risk assessment to be performed as part of the RI.

- General Response Actions: General response actions are medium-specific actions that may satisfy the RAOs. General response actions may include treatment, containment, excavation, extraction, disposal, institutional actions, or a combination of these. Like remedial action objectives, general response actions are medium-specific. General response actions that might be used at a site are initially defined during scoping and are refined throughout the RI/FS as a better understanding of site conditions is gained and action-specific ARARs are identified.

- Technology Types: Technology types are remedial technologies separated into five categories (No Action/Institutional Options, Containment Technologies, Removal Technologies, Treatment Technologies, and Disposal Technologies).

- Process Options: Process options include specific processes or variations of processes, if applicable, for each remedial technology.

Several broad technology types may be identified for each general response action, and numerous technology process options may exist within each technology type. The following sections provide a summary of preliminary remedial technologies identified in Table 4-1 and the data required to evaluate each technology. Data gaps are identified for the RI and FS in Table 4-2 to complete the evaluation of each technology. In addition, a summary of no action/institutional controls is provided for all media. Once the risk assessment is completed as part of the RI, the RAOs will be refined and included in the FS prior to evaluation of remedial action alternatives.

4.2 No Action Alternative

A no action alternative is the evaluation of potential human health and ecological risks under baseline conditions. The No Action alternative is a conservative and bounding scenario since it assumes that all contaminants would remain in-place and would be available for direct contact and potential migration to groundwater and Ship Creek. A no action alternative provides an environmental baseline against which impacts of the proposed remedial action alternatives can be compared.

4.3 Engineering and Institutional Controls

Installation and use of engineering and/or institutional controls may be used to isolate potential receptors from COPCs in surface or subsurface soil, soil gas, air, or groundwater. The following sections provide examples of both engineering and institutional controls which may be applicable for the Site.

4.3.1 Engineering Controls

Engineering controls is a term for using engineered equipment to reduce or eliminate a chemical or physical hazard, either by blocking or removing possible exposure pathways to contaminated media. Examples of engineering controls that could be utilized at the Site as part of remedial alternative include:

- Soil cover
- Landscaping
- Pavement
- Subsurface vapor barriers

Soil covers, landscaping, or pavement may be used to effectively isolate contaminants present in soil and groundwater at the site from potential on-site receptors. Subsurface vapor barriers are typically used to ventilate and remove vapors from below a floor slab to eliminate its pathway into indoor air.

4.3.2 Institutional Controls

Institutional controls may also be necessary to eliminate exposure pathways to certain receptors by providing property management guidelines and restrictions regarding on-site activities, coupled with compliance and enforcement mechanisms. Institutional controls are typically defined as legally enforceable restrictions, conditions, or controls on the use of real property, groundwater, or surface water located at or adjacent to a facility where response actions are taken that are reasonably required to assure that the response actions are protective of public health or the environment. Institutional controls may include restrictions, conditions, or controls enforceable by contract, easement, restrictive covenant, statute, ordinance, or rule, including official controls such as zoning, building codes, and official maps.

Examples of institutional controls that have been effective in providing additional safeguards at similar sites include:

- Groundwater use restrictions.
- Deed restrictions to restrict uses of the property to commercial, industrial, and recreational uses.
- Landowner-imposed restrictions such requiring permits from the landowner for any contemplated excavations (to prevent uncontrolled excavation activities, which may compromise the soil cover or associated engineering controls).
- Access or use restrictions on the property to protect the integrity of surface and subsurface remediation systems (e.g., recovery, monitoring, or air sparging wells, ancillary underground piping, and associated surface mechanical systems). These institutional controls are associated with engineered controls, i.e., active remediation.

Data needs to evaluate the engineering and institutional control alternative include area accessibility, identification of the property owner(s) at the site, and knowledge of local and/or state regulations and ordinances relating to deed notification and/or groundwater use restrictions.

4.4 Remedial Technologies for Soil

Table 4-1 contains preliminary RAOs, general response actions, and a preliminary list of technologies for soil. They include the following soil remedial technologies.

4.4.1 Capping

The use of a soil cover or capping is a method of containment for contaminated soils and uses a stable cover formed with layers of sediment, soil, gravel, and/or synthetic materials to minimize direct exposure, infiltration/leaching and erosion. The cap reduces contaminant mobility and minimizes the leaching of COPCs to groundwater.

Capping is appropriate if the following circumstances apply:

1. The "no action" alternative does not provide sufficient protection from contaminants.

2. Area accessibility is possible.

3. The human health and environmental effects or the costs of moving/treating contaminated media are too great.

4. Suitable capping materials are available, which meet permeability, geotechnical and site operational requirements.

5. Hydrologic or subsurface soil conditions will not affect the design of the cover system.

An assessment of the area is important for the integrity of a soil cover. The area should be controlled with fencing or other institutional controls that minimize the impact to the cover system. Data needs to evaluate capping include the following:

- Area accessibility.

- Debris and utility presence evaluation.

- Presence and distribution of COPCs in the subsurface, including leachability given site conditions.

- Infiltration rates, hydraulic conductivity, transmissivity, hydraulic gradients, and contaminant fate and transport.

- Groundwater/surface water interaction, including possible tidal effects.

- Excavation of suitable capping materials within the vicinity of the area of concern may require utility identification and re-location.

- Background soil and geotechnical data, including permeability, of the borrow area source for cap feasibility.

4.4.2 Excavation/Disposal

Excavation/disposal is the process of removing and shipping contaminated soil to a permitted waste treatment and disposal facility. Excavation is a reliable technology that uses proven construction techniques to remove impacted soils. Soils shallower than 10 feet can be excavated by small backhoes, while deeper excavation (e.g., to depths of 20 feet) require large equipment

Data requirements to evaluate excavation and disposal include the following:

- Area accessibility.
- Debris and utility presence evaluation.
- Depth of impacted soils to determine excavation and disposal volumes and identify the extent of contamination that is required to meet the preliminary remediation goals.
- The depth to groundwater influences the rate of excavation and disposal of soil.
- Geotechnical properties including the saturation zone, gradation, and underground obstructions can influence the rate of excavation.
- Data on any hazardous characteristics of the excavated material may affect disposal requirements.

4.4.3 Landfarming

Landfarming/land treatment involves using natural bacterial processes to degrade organic COPCs in soil. The contaminated soils are spread, tilled, fertilized, and then turned periodically to help aerate the soil and enhance bacterial degradation of the contaminants. Landfarming is a bioremediation technology which, depending on the type of contaminant, may incorporate liners and other methods to control leaching of contaminants.

Soil conditions are often controlled to optimize the rate of contaminant degradation. Conditions normally controlled include:

- Moisture content (usually by irrigation or spraying).
- Aeration (by tilling the soil with a predetermined frequency, the soil is mixed and aerated).
- pH (buffered near neutral pH by adding crushed limestone or agricultural lime).

- Other amendments (e.g., soil bulking agents, nutrients, etc.).

Contaminated media are usually treated in lifts that are up to 18 inches thick. When the desired level of treatment is achieved, the lift is removed and a new lift is constructed. It may be desirable to only remove the top of the remediated lift, and then construct the new lift by adding more contaminated media to the remaining material and mixing. This serves to inoculate the freshly added material with an actively degrading microbial culture, and can reduce treatment times.

Landfarming has been proven successful in treating petroleum hydrocarbons. Because lighter, more volatile hydrocarbons such as gasoline are treated very successfully by processes that use their volatility (i.e., soil vapor extraction), the use of aboveground bioremediation is usually limited to heavier hydrocarbons. As a rule of thumb, the higher the molecular weight (and the more rings with a PAH), the slower the degradation rate. Also, the more chlorinated or nitrated the compound, the more difficult it is to degrade.

The following site and soil considerations should be addressed prior to implementation:

- Area accessibility.
- Debris/utility presence evaluation.
- Geotechnical properties: soil type and texture, soil moisture content, soil organic matter content, cat-ion exchange capacity, water-holding capacity, nutrient content, and pH.
- Temperature, precipitation, wind velocity and direction, water availability, atmospheric temperature, permeability, and microorganisms (degradative populations present at site).
- Types and concentrations of COPCs, and depth profile and distribution of contaminants.

4.4.4 In-situ Stabilization

In-situ stabilization is the process of reducing mobility and direct exposure of hazardous substances and contaminants in the environment through both physical and chemical mixing. Unlike other remedial technologies, in-situ stabilization seeks to trap or immobilize contaminants within their "host" medium (i.e., the soil, sand, and/or building materials that contain them), instead of removing them through chemical or physical treatment. In-situ stabilization techniques can be used alone or combined with other treatment and disposal methods to yield a product or material suitable for land disposal or can be applied to beneficial use. These techniques have been used as both interim and final remedial measures. The target contaminant group for in-situ stabilization is generally inorganics.

Auger/caisson systems and injector head systems are techniques used in soil stabilization. They apply in-situ stabilization agents to soils to trap or immobilize contaminants. The auger/caisson and reagent/injector head systems have limited effectiveness against SVOCs and pesticides and no expected effectiveness against VOCs.

In-situ vitrification is another form of in-situ stabilization which uses an electric current to melt soil or other earthen materials at extremely high temperatures (1,600 to 2,000 °C or 2,900 to 3,650 °F) and thereby immobilize most inorganics and destroy organic pollutants by pyrolysis. Inorganic pollutants are incorporated within the vitrified glass and crystalline mass. Water vapor and organic pyrolysis combustion products are captured in a hood, which draws the contaminants into an off-gas treatment system that removes particulates and other pollutants from the gas. The vitrification product is a chemically stable, leach-resistant, glass and crystalline material similar to obsidian or basalt rock. The process is costly but can destroy or remove organics and immobilize most inorganics in contaminated soils, sludge, or other earthen materials.

Data requirements for in-situ stabilization include the following:

- Area accessibility.
- Debris and utility presence evaluation.
- Depth of contaminants may limit some types of application processes.
- Depth of groundwater is important because processing of contamination below the water table may require dewatering.
- Geotechnical/geochemical properties include: moisture content, metal concentrations, sulfate content, organic content, density, permeability, unconfined compressive strength, leachability, pH, and microstructure analysis. For in-situ vitrification, a minimum alkali content in soil (sodium and potassium oxides) of 1.4 wt% is necessary to form glass.
- Certain wastes are incompatible with variations of this process. Treatability studies are generally required.
- Leachability testing is typically performed to measure the immobilization of contaminants.

- Valence of Specific Metals in soil.
- Fraction Organic Carbon in soil.

4.4.5 In-situ Chemical Oxidation

In-situ chemical oxidation involves injecting chemical oxidants into the vadose zone and/or groundwater to oxidize contaminants and source zones. In the subsurface oxidants have been able to cause the rapid and complete chemical destruction of many toxic organic chemicals; other organics are amenable to partial degradation as an aid to subsequent bioremediation. In general the oxidants have been capable of achieving high treatment efficiencies (e.g., > 90 percent) for unsaturated aliphatic (e.g., TCE) and aromatic compounds (e.g., benzene), with very fast reaction rates (90 percent destruction in minutes). Matching the oxidant and in-situ delivery system to the COPCs and the site conditions is the key to successful implementation and achieving performance goals. There are three common oxidants:

1. **Ozone.** Ozone gas can oxidize contaminants directly or through the formation of hydroxyl radicals. Like peroxide, ozone reactions are most effective in systems with acidic pH. The oxidation reaction proceeds with extremely fast, pseudo first order kinetics. Due to ozone's high reactivity and instability, O_3 is produced onsite, and it requires closely spaced delivery points (e.g., air sparging wells). In-situ decomposition of the ozone can lead to beneficial oxygenation and biostimulation.

2. **Peroxide.** Oxidation using liquid hydrogen peroxide (H_2O_2) in the presence of native or supplemental ferrous iron (Fe^{+2}) produces Fenton's Reagent which yields free hydroxyl radicals (OH^-). These strong, nonspecific oxidants can rapidly degrade a variety of organic compounds. Fenton's Reagent oxidation is most effective under very acidic pH (e.g., pH 2 to 4) and becomes ineffective under moderate to strongly alkaline conditions. The reactions are extremely rapid and follow second-order kinetics.

3. **Permanganate.** The reaction stoichiometry of permanganate (typically provided as liquid or solid $KMnO_4$, but also available in Na, Ca, or Mg salts) in natural systems is complex. Due to its multiple valence states and mineral forms, Mn can participate in numerous reactions. The reactions proceed at a somewhat slower rate than the previous two reactions, according to second order kinetics. Depending on pH, the reaction can include destruction by direct electron transfer or free radical advanced oxidation—permanganate reactions are effective over a pH range of 3.5 to 12.

The most common oxidant delivery methods involve injection of oxidants only; when a significant hydraulic gradient exists, targeted delivery of oxidant to the contaminant zones may require injection and extraction wells. When a passive oxidant delivery mode is used, a major benefit is that treatment of groundwater and disposal of hazardous wastes is avoided.

The following factors may limit the applicability and effectiveness of in-situ chemical oxidation:

- Subsurface heterogeneities can cause non-uniform distribution of oxidant.
- Effective porosity of the subsurface may be reduced due to the formation of metal oxide precipitates. The total porosity of soils is defined as the percentage of void volume in a unit volume of soil, whereas the effective porosity is defined as the portion of the total porosity that is the void volume per unit volume of soil after gravity drainage. The effective porosity is also sometimes called the drainage or drainable porosity.
- Sometimes requires additional applications of oxidant to address rebound effects due to non-uniform distribution of contaminants and an isotropy of soils.
- Fenton’s reagent may not be used at high alkalinity sites.
- Native organic matter exerts a demand for oxidants, thus increasing costs for chemicals.

Data requirements for in-situ chemical oxidation include the following:

- Area accessibility.
- Utility presence evaluation.
- Depth of impacted soils to identify the extent of contamination that needs to be treated to meet the preliminary remediation goals.
- Subsurface heterogeneity can interfere with uniform collection of contaminated groundwater and aeration of contaminated soil.
- Permeability, hydraulic conductivity, depth to water table, aquifer thickness, groundwater flow direction, hydraulic gradient.
- Depth to the confining layer.
- Ferrous iron in GW.

- Dissolved oxygen in GW.
- Fraction of organic carbon.
- Depth of impacted soils.
- pH.
- Leaching tests are one component of the Toxicity Characteristic (TC).
- Treatability tests.

4.4.6 In-Situ Thermal Treatment

In-situ thermal treatment includes steam or hot air injection or electrical resistance/electromagnetic/fiber optic/radio frequency heating to increase the volatilization rate of semi-volatiles and facilitate extraction. Thermally-enhanced soil vapor extraction (SVE) is a full-scale technology that uses electrical resistance/electromagnetic/fiber optic/radio frequency heating or hot-air/steam injection to increase the volatilization rate of semi-volatiles and facilitate extraction. The process is otherwise similar to standard SVE, but requires heat resistant extraction wells.

Electrical resistance heating uses an electrical current to heat less permeable soils such as clays and fine-grained sediments so that water and contaminants trapped in these relatively conductive regions are vaporized and ready for vacuum extraction. Electrodes are placed directly into the less permeable soil matrix and activated so that electrical current passes through the soil, creating a resistance which then heats the soil. The heat dries out the soil causing it to fracture. These fractures make the soil more permeable allowing the use of SVE to remove the contaminants. The heat created by electrical resistance heating also forces trapped liquids to vaporize and move to the steam zone for removal by SVE. Six-phase soil heating (SPSH) is an electrical resistance heating which uses low-frequency electricity delivered to six electrodes in a circular array to heat soils. With SPSH, the temperature of the soil and contaminant is increased, thereby increasing the contaminant's vapor pressure and its removal rate. SPSH also creates an in-situ source of steam to strip contaminants from soil. At this time SPSH is in the demonstration phase, and all large scale in-situ projects utilize three-phase soil heating.

Radio frequency heating (RFH) is an in-situ process that uses electromagnetic energy to heat soil and enhance soil vapor extraction. RFH technique heats a discrete volume of soil using rows of vertical electrodes/antennae embedded in soil (or other media). Heated soil volumes are bounded by two rows of ground electrodes with energy applied to a third row midway between the ground rows. The three rows act as a buried triplate capacitor. When radio frequency energy is applied to the electrode array, heating begins at the top center and proceeds vertically downward and laterally outward through the soil volume. The technique can heat soils to over 300 °C once groundwater has been removed.

RFH enhances SVE in four ways: (1) contaminant vapor pressure and diffusivity are increased by heating, (2) the soil permeability is increased by drying, (3) an increase in the volatility of the contaminant from in-situ steam stripping by the water vapor; and (4) a decrease in the viscosity which improves mobility. Extracted vapor can then be treated by a variety of existing technologies, such as granular activated carbon or incineration.

Hot air or steam is injected below the contaminated zone to heat up contaminated soil. The heating enhances the release of contaminants form soil matrix. Some VOCs and SVOCs are stripped from contaminated zone and brought to the surface through soil vapor extraction.

Data requirements for thermal treatment include the following:

- Area accessibility.
- Debris and utility presence evaluation.
- Depth of contaminants.
- Depth of groundwater is important because processing of contamination below the water table may require dewatering.
- Geotechnical properties include: organic content, density, permeability, and pH.
- Soil permeability.
- Certain wastes are incompatible with variations of this process. Treatability studies are generally required.
- Leachability testing is typically performed to measure the immobilization of contaminants.
- Soil gas or vapor characterization.

4.4.7 Phytoremediation

Phytoremediation is the use of plants such as grasses or trees to contain, sequester, degrade or reduce organic contaminants in soils, sediments, surface water, and groundwater. Phytoremediation may be applicable for the remediation of metals, pesticides, solvents, explosives, crude oil, PAHs, and landfill leachates. Phreatophytic trees, as well as deep-rooted grasses and herbaceous species, uptake and transpire groundwater and increase natural attenuation rates of organic contaminants in the subsurface. Mature trees can extend their roots into the water table (e.g., typical rooting depth of 12 to 15 feet) where they can draw directly from the zone of saturation (i.e., draw from groundwater). Poplars and willows are examples of phreatophytic trees that have high evapotranspiration rates, fast growth rates, deep root systems, documented phytoremediation capabilities, and are easy to plant and maintain.

The mechanisms of phytoremediation include enhanced rhizosphere biodegradation, phyto-extraction (also called phyto-accumulation), phyto-degradation, and phyto-stabilization. Enhanced rhizosphere biodegradation takes place in the soil immediately surrounding plant roots. Plant roots supply nutrients to microorganisms, which enhances their biological activities. Plant roots also loosen the soil, leaving pathways for transport of water and aeration.

Some plant species (i.e., hyper-accumulator) have the ability to store metals in their roots. They can be transplanted to sites to filter metals from wastewater. As the roots become saturated with metal contaminants, they can be harvested.

There are limitations to phytoremediation in soil, including the fact that the depth of the treatment zone is determined by the plants used in the phytoremediation. In most cases, it is limited to shallow soils and the seasonality of the plants. Also, high concentrations of hazardous materials can be toxic to plants.

Data requirements include the following:

- Area accessibility
- Debris/utility presence evaluation
- Depth of impacted soils
- Depth to groundwater
- pH
- Soil type
- Fraction of organic carbon
- Nutrient levels

4.5 Remedial Technologies for Groundwater/NAPL

Table 4-1 contains preliminary RAOs, general response actions, and a preliminary list of technologies for groundwater and NAPL. They include the following remedial technologies.

4.5.1 Pump-and-treat

Pump-and-treat is a common groundwater treatment technique that includes removal of the groundwater by pumping it to the surface and treating in it by various methods. Extraction wells are drilled into the contaminated groundwater plume to collect the water, bringing it to the surface for treatment.

Groundwater pumping is used for the removal of dissolved contaminants from the subsurface and can be used as a containment measure to prevent migration of contaminated groundwater. Pump-and-treat remediation systems can also prevent contaminant migration, to protect downgradient surface water bodies, and restore contaminated aquifers by reducing dissolved contaminant concentrations to acceptable levels. In addition, if it exists, they can recover light non-aqueous phase liquid (LNAPL) by drawing recoverable LNAPL toward the recovery wells.

The following factors may limit the applicability and effectiveness of groundwater pumping as part of the remedial process:

- The potentially long time necessary to achieve the remediation goal.
- System designs fail to contain the contaminant as predicted, allowing the plume to migrate. There also could be failure of the pumping equipment.
- Residual saturation of the contaminant in the soil pores cannot be removed by groundwater pumping. Contaminants tend to be sorbed in the soil matrix. Groundwater pumping is not effective for contaminants with high residual saturation, contaminants with high sorption capabilities, and homogeneous aquifers with hydraulic conductivity less than 10^{-5} cm/sec.

Geological characterization gives important information on the type of materials found in the subsurface and the homogeneity and heterogeneity of the materials. The following data should be collected to evaluate pump-and-treat effectiveness:

- Seasonal variations of groundwater conditions.
- Source characterization, including the volume released, the area infiltrated, and the size of the plume.
- Identifying the groundwater/surface water interaction, including tidal influence, is useful in understanding how the hydrogeology will be affected.

- Hydraulic conductivity and transmissivity are used to determine the locations and pumping rates of pumping wells and help determine migration rates of the contaminant. Also, it helps to calculate the capture zone and number of wells required for effective contaminant collection. The hydraulic gradient at the property is also necessary for plume capture zone calculations. If the flow of groundwater changes periodically, then water elevations of the site must be measured to verify the direction of flow.

- The vertical and the horizontal extent of COPCs. This is necessary for performing capture zone calculations and determining the number and locations of contaminant recovery wells. The vertical extent is needed to know how deep to screen the recovery wells.

- Identifying the depth to Bootlegger Clay (Confining Layer) is also key for determining pump-and-treat feasibility.

- LNAPL thickness and water level data help define the groundwater system so that the pump-and-treat method can be used effectively.

4.5.2 Barrier Walls

Barrier walls are subsurface barriers that impede or stop groundwater flow. Examples of barrier walls include soil-bentonite and cement-bentonite slurry walls, vibratory beam walls, sheet-pile walls, grout curtains, and deep soil mixing.

For example, slurry walls consist of trenches filled with a mixture of soil, bentonite clay and water, poured in the trenches as a “slurry”. The trenches form a filter cake that serves as a barrier. Slurry walls are used to contain contaminated groundwater, divert uncontaminated groundwater flow, and/or provide barriers for groundwater treatment systems. Slurry walls are placed at depths up to 200 feet and vary in width from 2 to 4 feet. These vertical barriers must reach down to an impermeable natural horizontal barrier, such as a clay zone, to effectively impede groundwater flow. Vertical barriers are frequently used with surface caps to produce an essentially complete containment structure.

Another impermeable wall system is a polywall barrier system. It consists of continuous sheets of high-density polyethylene. The polywall is installed in one pass: The trencher cuts through subsurface strata, installs the barrier wall and backfills all in one step. A waterproof interlocking joint system can be used for lengths over 300 feet.

Containment or barrier systems have been used to control groundwater flow. There are many different approaches to vertical wall containment design including:

1. Sheet pile cutoff walls are constructed by driving interlocking steel or high-density polyethylene (HDPE) into the ground. The joints between individual sheets are typically plugged with a clay slurry (steel sheets) or an expanding gasket (HDPE sheets).

2. Slurry walls consist of vertically excavated trenches filled with typically a mixture of bentonite and water which hydraulically shores the trench to prevent collapse and retards groundwater flow.

3. Grouting is another direct method to control the migration of contaminated groundwater. A grout wall is constructed by injecting fluids under pressure into the ground. The grout moves away from the zone of injection, fills pores in the formation, and solidifies, which reduces the hydraulic conductivity of the formation. Typical grouting compounds include cement, bentonite, and silicate.

4. Geomembranes are synthetic sheets installed in open or slurry-supported trenches to control contaminant spread. Geomembranes can provide very low hydraulic conductivity. The sheets generally are constructed of either HDPE or polyvinyl chloride (PVC). This technology is still in the development stage and there are concerns regarding long-term performance.

For best performance, the wall should extend several feet into a low-permeability layer. Installation of vertical cutoff walls will be problematic in areas that obtain obstruction in the subsurface such as construction cobble.

The following data is required to evaluate the feasibility of barrier walls:

- Area accessibility.
- Debris and utility presence.
- Depth to bedrock.
- Depth to groundwater.
- Hydraulic conductivity can influence the migration of the contaminant.

- The geohydrologic setting, chemical nature of the COPCs, and the concentration of the COPCs are all important to ensure proper operation and maintenance of vertical cutoff walls.

- pH of groundwater.

- Groundwater/surface water interaction including tidal influence.

One limitation of barrier walls is that they only contain COPCs within a specific area; they do not treat or destroy them. Also, the depth of impacted soils can impact the containment design of barrier systems. Installation at depths greater than 80 feet become significantly more costly or impossible for the methods described above, except for grouting.

4.5.3 Dual Phase Extraction/Total Fluids Extraction

Dual-phase extraction (DPE), also known as multi-phase extraction, total fluids extraction (TFE), or sometimes bioslurping, is an in-situ technology that uses pumps or high vacuum to remove various combinations of contaminated groundwater, LNAPL, and hydrocarbon vapor from the subsurface. Extracted liquids and vapor are treated and collected for disposal, or re-injected to the subsurface (where permissible under applicable laws). DPE systems can be effective in removing LNAPL from the subsurface, thereby reducing concentrations of petroleum hydrocarbons in both the saturated and unsaturated zones of the subsurface. The depressed groundwater table that results from these higher groundwater recovery rates which serves both to hydraulically control groundwater migration and open more pore space increasing the efficiency of multi-phase extraction.

Subsurface soil data requirements include the following:

- Area accessibility.

- Utility presence evaluation is necessary for any subsurface excavation activities to avoid damaging underground utilities or structures.

- The depth of groundwater influences the rate and effectiveness of vacuum applied in DPE techniques.

- Subsurface heterogeneity can interfere with uniform collection of contaminated groundwater and aeration of contaminated soil.

Groundwater / LNAPL data requirements include the following:

- LNAPL thickness and water levels are required to determine the effectiveness and extent of contamination to be treated through DPE.

- Permeability, hydraulic conductivity, LNAPL saturations, depth to water table, aquifer thickness, groundwater flow direction, gradient, and anticipated product recharge rate are useful for the design of DPE systems.

- Depth to the confining layer is useful in determining the location where DPE is required.

- LNAPL viscosity, density, composition.

- Saturated thickness and seasonal variability may influence the rates of extraction and affect the overall stability of the system.

- Soil geotechnical properties (e.g., capillary forces, effective porosity, moisture content, organic content, hydraulic conductivity, and texture).

4.5.4 Air Sparging / Biosparging

Air sparging is a method in which air is forced downward into a contaminated aquifer. Air channels formed in the saturated zone, strip volatile contaminants and contribute oxygen to the saturated zone. Air sparging wells can also be used to create a barrier treating contaminated groundwater as it leaves a site.

When used appropriately, air sparging has been found to be effective in reducing concentrations of VOCs. Air sparging is generally more applicable to the lighter gasoline constituents (i.e., BTEX), because they readily transfer from the dissolved to the gaseous phase. Air sparging is less applicable to heavier petroleum fuels such as diesel fuel and kerosene. Appropriate use of air sparging may require that it be combined with other remedial methods (e.g., SVE or pump-and-treat). An air sparging system can use either vertical or horizontal sparge wells. Well orientation should be based on Site-specific needs and conditions.

The effectiveness of air sparging depends primarily on two factors:

- Vapor/dissolved phase partitioning of the constituents determines the equilibrium distribution of a constituent between the dissolved phase and the vapor phase. Vapor/dissolved phase partitioning is, therefore, a significant factor in determining the rate at which dissolved constituents can be transferred to the vapor phase. Effective solubility and diffusion path length control the effectiveness of air sparging.

- Permeability of the soil determines the rate at which air can be injected into the saturated zone and the bubble radius of influence. It is the other significant factor in determining the mass transfer rate of the constituents from the dissolved phase to the vapor phase.

In general, air sparging is more effective for constituents with greater effective solubility and for soils with moderate permeability. Soil characteristics will also determine the preferred zones of vapor flow in the vadose zone, thereby indicating the ease with which vapors can be controlled and extracted using SVE (if used).

Biosparging is the same process as air sparging, albeit it at a lower rate to enhance indigenous microorganisms to biodegrade organic constituents in the saturated zone. Air (or oxygen) and nutrients (if needed) are injected into the saturated zone to increase the biological activity of the indigenous aerobic microorganisms in the saturated zone. Biosparging can be used to reduce concentrations of petroleum constituents that are dissolved in groundwater, adsorbed to soil below the water table, and within the capillary fringe.

Biosparging is accomplished by pushing air into wells or trenches from an above ground compressor or blower. The injected air promotes increased dissolved oxygen levels in the groundwater that increase the aerobic biodegradation of hydrocarbons. Overall, biosparging is effective in reducing hydrocarbon concentrations in groundwater if no LNAPL exists and if the air can be delivered to the groundwater effectively.

Stratified or highly variable heterogeneous soils typically create the greatest barriers to air sparging. Both the injected air and the stripped vapors will travel along the paths of least resistance (coarse-grained zones) and could travel a great lateral distance from the injection point. This phenomenon could result in the contaminant-laden sparge vapors migrating outside the vapor extraction control area.

Data requirements for air sparging and biosparging include the following:

- Area accessibility.

- Utility presence evaluation is necessary for any subsurface excavation activities to avoid damaging underground utilities or structures.

- Subsurface heterogeneity can interfere with uniform collection of contaminated groundwater and aeration of contaminated soil.

- Permeability, hydraulic conductivity, saturated thickness, groundwater flow direction, and hydraulic gradient.

- Depth to the confining layer is useful in determining the location where DPE is required.

- Saturated thickness and seasonal variability may influence the rates of extraction and affect the overall stability of the system.

- Soil geotechnical properties (e.g., capillary forces, effective porosity, moisture content, organic content, hydraulic conductivity, and texture).

Data needs for biosparging also include the following:

- pH levels: To support bacterial growth, the pH should be within the 6 to 8 range, with a value of about 7 (neutral) being optimal.

- Electron acceptors (including dissolved oxygen): The rate of biodegradation will depend, in part, on the supply of oxygen to the contaminated area, because aerobic metabolism is much faster than anaerobic metabolism. When there is an insufficient amount of dissolved oxygen available, organisms that can use other electron acceptors (e.g., nitrate, ferric iron, and sulfate) may degrade the contaminants but at slower rates.

- Nutrient concentrations. Biodegradation at most sites is oxygen-limited rather than nutrient limited, however, bacteria require inorganic nutrients such as nitrogen and phosphate to support cell growth and sustain biodegradation processes. Nutrients may be available in sufficient quantities in the aquifer but, more frequently, nutrients need to be added to maintain adequate bacterial populations. However, excessive amounts of certain nutrients (e.g., phosphate and sulfate) can repress metabolism. Laboratory biodegradation studies can be used to estimate the rate of oxygen delivery and to determine if the addition of inorganic nutrients is necessary.

The placement and number of sparge points required to aerate a dissolved phase plume is determined primarily by the soil permeability, structure of the soil, and saturated thickness as these affect the sparging pressure and distribution of air in the saturated zone.

4.5.5 Monitored Natural Attenuation

Contaminants potentially addressed by MNA include VOCs, CVOCs, SVOCs, including polychlorinated biphenyls (PCBs), PAHs, fuel hydrocarbons, and metals. MNA may be appropriate for some metals, when natural attenuation processes result in a change in the valence state of the metal that results in immobilization (e.g., chromium). Biphenyls can also be both aerobically and anaerobically degraded in groundwater. Degradation rates depend on many environmental factors including degree of chlorination, concentration on the congener, type of microbial population, available nutrients, pH and temperature. Highly chlorinated congeners such as Aroclor 1260 are less readily degraded than the less chlorinated congeners such as Aroclor 1242. The position of chlorine atoms on the rings also affects the rate of biodegradation. Not only are PCBs with para- and meta-substituted rings more easily degraded than the ortho- substituted compounds, but PCBs containing all chlorines on one ring are biodegraded faster than those which contain chlorines throughout both rings. The biodegradation rate may also decrease with high levels of organic carbon present.

In general, the following data needs are required to evaluate MNA at a site:

- Dissolved Oxygen.
- Temperature.
- pH. Microbial diversity and activity in bioremediation processes also can be affected by extreme pH ranges.
- Oxidation-Reduction Potential (ORP) of groundwater.
- Electron acceptor concentrations, including oxygen, nitrate, iron, manganese, sulfate, which support biodegradation.
- Alkalinity (Total, Carbonate, Bicarbonate).
- Dissolved permanent gases (O_2, CO, CO_2, CH_4).
- Internal tracers, such as trimethyl and tetramethylbenzenes, are normal constituents of fuels that are significantly less biodegradable than BTEX, yet have very similar transport characteristics. Thus, these "internal tracers" can be detected downgradient of the remediation area, thereby demonstrating that monitoring wells are properly placed. The concentrations of these tracers can also provide a basis to normalize the contribution of dilution from groundwater and surface water.

4.5.6 Enhanced Monitored Natural Attenuation

Enhanced monitored natural attenuation includes the addition of nutrients or amendments to groundwater to stimulate natural microbial degradation of contaminants in groundwater. For example, Oxygen Release Compound (ORC) utilizes solid peroxide formulations to release dissolved oxygen when contacted with groundwater. ORC is a patented formulation of magnesium peroxide that produces a slow and sustained release of molecular oxygen when in contact with soil moisture or groundwater. Naturally occurring micro-organisms that aerobically degrade contaminants thrive in the oxygen-enriched environment produced by ORC. When in the presence of ORC, these microbes rapidly degrade hydrocarbons in groundwater into harmless byproducts such as carbon dioxide and water. ORC also contains a percentage of potassium phosphates in a slow-release formulation to act as a nutrient for natural bacteria that degrade hydrocarbons. The additional oxygen enhances aerobic biodegradation and stimulates attenuation of hydrocarbon constituents.

Other enhancements in groundwater can increase the concentration of electron acceptors or nutrients that stimulates microbial activity for the biodegradation of contaminants. In the presence of an organic substrate, biodegradation of the substrate results in a preferential utilization of available electron acceptors by microorganisms. This preferential utilization occurs in sequence generally proceeding with the rapid utilization of oxygen by microorganisms capable of *aerobic* metabolism, followed by the utilization of nitrate, ferric iron, sulfate, and carbon dioxide by microorganisms capable of *anaerobic* metabolism.

Organic contaminants in groundwater serve as the organic substrate for biodegradation. Sulfate is one example of a primary electron acceptor which can be added to groundwater to enhance natural biodegradation. The following reaction illustrates the general oxidation-reduction reaction of benzene and sulfate mediated by microorganisms:

(Benzene) C_6H_6 + 3.75 (Sulfate) $SO_4^{2-} \longrightarrow$

6(Carbon Dioxide) CO_2 + 3.75(Sulfide) S^{2-} + 3(Water) H_2O

When compared to other common electron acceptors, such as oxygen and nitrate, sulfate is a preferred electron acceptor because it occurs naturally in groundwater and sulfate reduction is prevalent in hydrocarbon-impacted groundwater. At other sites, sulfate has shown strong potential for enhancing the biodegradation of benzene without negatively impacting the environment.

Site-specific data needs to assess enhanced MNA are identified in Section 4.11.5.

4.6 LNAPL Recoverability

Several technologies have been successfully utilized to recover LNAPL from the subsurface, including, but not limited to: skimming, dual-phase extraction, and dual-pump recovery. Skimming typically is done using a floating filter of oleophilic/hydrophobic mesh with a high affinity for nonpolar hydrocarbons and the ability to reject polar molecules such as water. A mesh cylinder is designed to float in the LNAPL layer in a recovery well. LNAPL floating on the water surface in the well passes through the mesh while water is prevented from entering by the mesh. The LNAPL collects and periodically is discharged by air pressure to a central holding tank on the surface. The pressurization cycle may be controlled by a timer, by high- and low-level switches, or manually.

Dual-pump recovery is a LNAPL recovery technology utilizing recovery wells to recovery groundwater and LNAPL from the subsurface. Each recovery well is equipped with an automated dual-pump system: one dedicated for groundwater and the other for LNAPL. A cone of depression develops around the recovery well when the water pump pumps groundwater from the well and LNAPL within the cone of depression is drawn toward the well via gravity drainage. Each well has a dedicated LNAPL pump which removes the LNAPL automatically after it reaches a predetermined thickness. Meters are attached to each water and LNAPL pump to record the quantity of liquids removed. Many systems automatically adjust for fluctuations in groundwater elevations, maintaining a constant groundwater elevation in the well.

The efficacy and lifespan of LNAPL recovery systems at a site are dependent on the following conditions:

- The volume and distribution of LNAPL present at the site
- In-situ characteristics including permeability and anisotropy
- LNAPL characterization and source
- The radius of influence for LNAPL recovery
- The achievable rate of LNAPL extraction

At a minimum, the following data needs are required to evaluate LNAPL recovery as a potential remedial technology:

- LNAPL thickness
- LNAPL baildown tests

If appreciable quantities of LNAPL exist at a site, then additional modeling of LNAPL distribution and recoverability may be warranted. For modeling, the following additional data needs will be required to evaluate LNAPL recoverability over time:

- LNAPL characteristics (LNAPL/water saturations, viscosity, oil/water surface tension, LNAPL specific gravity, and LNAPL conductivity)

- Moisture retention (i.e., capillary pressure) data from soil

4.7 Remedial Technologies for Surface Water

Remedial technologies for surface water include containment technologies (surface controls, hydraulic control/dewatering), treatment technologies (aeration/oxidation), and chemical or biological treatment. Data needs to evaluate remedial technologies for surface water are identified in Section 4.9.6.

4.8 Remedial Technologies for Sediment

Removal action technologies include excavation/disposal, and containment technologies include capping/cover. For in-situ sediment capping in water bodies soil analysis from nearby areas may be needed for determining the suitability of materials required to form the sediment layers within the soil cap. The tendency for sediments to flow because of the momentum generated during placement and slope impact should be considered to prevent sediment displacement and contaminant release. If contaminated sediment must be moved, it may be possible to deposit sediments in a natural depression or a depression formed by dredging clean sediment.

Treatment technologies in sediment include in-situ solidification, fixation, in-situ stabilization, immobilization, dewatering, physical treatment, and chemical and biological treatment. In addition, Sediment Monitored Natural Recovery (MNR) works similar to MNA to naturally reduce contaminant concentrations of organics in sediment. For sediment, MNR processes include biodegradation, dispersion, dilution, sorption, volatilization, flushing, deposition, chemical or biological stabilization, and transformation of contaminants.

4.9 Remedial Technologies for Soil Gas

Table 4-1 contains preliminary RAOs, general response actions, and a preliminary list of technologies for soil gas. They include the following remedial technologies.

4.9.1 Soil Vapor Extraction

Soil Vapor Extraction is a treatment technique that removes and treats volatile organic compounds through vapors from subsurface soils by removing air from the soils through extraction wells. This technology has been proven effective in reducing concentrations of VOCs and lighter-end SVOCs. Using this technology, a vacuum is applied to the contaminated soil matrix through extraction wells, which creates a negative pressure gradient that causes movement of vapors toward these wells. Volatile constituents in the vapor phase are readily removed from the subsurface through the extraction wells. The extracted vapors are then treated, as necessary, and discharged to the atmosphere or possibly re-injected to the subsurface (if permitted by applicable laws).

Data requirements to assess the feasibility of SVE include the following:

- Area accessibility.

- Debris/utility presence evaluation.

- Soil gas or vapor characterization is needed to ensure compliance with air permitting requirements and to determine the effectiveness of the technology.

- Soil permeability affects the rate of air and vapor movement through the soil; the higher the permeability of the soil, the faster the movement and (ideally) the greater the amount of vapors that can be extracted.

- Soil structure and stratification are important to SVE effectiveness because they can affect how and where soil vapors will flow within the soil matrix under extraction conditions. Structural characteristics (e.g., layering, fractures) can result in preferential flow behavior that can lead to ineffective or significantly extended remedial times if they are positioned so that the induced air flow occurs outside the area of contamination.

- Moisture content in soils. High soil moisture can reduce soil permeability and, consequently, the effectiveness of SVE by restricting the flow of air through soil pores. Fine-grained soils create a thicker capillary fringe than coarse-grained soils.

- Depth to groundwater is important because SVE is generally not appropriate for sites with a groundwater table located less than 3 feet below the land surface. Special considerations must be taken for sites with a groundwater table located less than 10 feet below the land surface because groundwater upwelling can occur within SVE wells under vacuum pressures, potentially occluding well screens and reducing or eliminating vacuum-induced soil vapor flow.

4.9.2 Bioventing

Bioventing uses indigenous microorganisms to biodegrade organic constituents adsorbed to soils in the unsaturated zone. In bioventing, indigenous bacteria are enhanced by inducing air (or oxygen) flow into the unsaturated zone (using extraction and/or injection wells) and, if necessary, by adding nutrients. In general, bioventing is operated at a lower air flow rate than SVE.

The most important factors that control the effectiveness of bioventing are:

- Soil permeability. This will determine the rate at which oxygen can be supplied to the hydrocarbon-degrading microorganisms found in the subsurface.

- The biodegradability of the COPCs. This will determine both the rate at which and the degree to which the constituents will be metabolized by microorganisms.

- Design Radius of Influence (ROI) is an estimate of the maximum distance from a vapor extraction well (or injection well) at which sufficient air flow can be induced to sustain acceptable degradation rates. Establishing the design ROI depends on many factors including intrinsic permeability of the soil, soil homogeneity, soil chemistry, and moisture content. The ROI should usually be determined through field pilot studies but can be estimated from air flow modeling or other empirical methods.

- Depth to groundwater. Bioventing is not appropriate for sites with groundwater tables located less than 3 feet below the ground surface. Special considerations must be taken for sites with a groundwater table located less than 10 feet below the land surface because groundwater upwelling can occur within bioventing wells under vacuum pressures, potentially occluding screens and reducing or eliminating vacuum-induced soil vapor flow.

- Fluctuations in groundwater. Significant seasonal or daily (e.g., tidal or precipitation-related) fluctuations may, at times, submerge some of the contaminated soil or a portion of the well screen, making it unavailable for air flow. These fluctuations are most important for horizontal wells, in which screens are placed parallel with the water table surface and a water table rise could occlude the entire length of screen.

- Bacteria require moist soil conditions for proper growth. Excessive soil moisture, however, reduces the availability of oxygen, which is also necessary for bacterial metabolic processes, by restricting the flow of air through soil pores. The ideal range for soil moisture is between 40 and 85 percent of the effective porosity of the soil. Generally, soils saturated with water prohibit air flow and oxygen delivery to bacteria, while dry soils lack the moisture necessary for bacterial growth. Bioventing promotes dehydration of moist soils through increased air flow through the soil, but excessive dehydration hinders bioventing performance and extends operation time.

- The presence of very high concentrations of petroleum organics or heavy metals in site soils can be toxic or inhibit the growth and reproduction of bacteria responsible for biodegradation. In addition, very low concentrations of organic material will also result in diminished levels of bacterial activity.

- pH. The optimum pH for bacterial growth is approximately 7; the acceptable range for soil pH in bioventing is between 6 and 8. Soils with pH values outside this range prior to bioventing may require pH adjustments prior to and during bioventing operations.

Airflow is particularly important for soils within the capillary fringe, where a significant portion of the constituents often reside. Fine-grained soils create a thicker capillary fringe than coarse-grained soils. The thickness of the capillary fringe can usually be determined from soil boring logs (i.e., in the capillary fringe, soils are usually described as moist or wet). The capillary fringe usually extends from one to several feet above the elevation of the groundwater table. Moisture content of soils within the capillary fringe may be too high for effective bioventing. Depression of the water table by groundwater pumping may be necessary to biovent soils within the capillary fringe.

4.10 Data Availability for Screening of Technologies

Historical data collected from the Site are limited for certain parameters and this limits ARRC's ability at this time to evaluate remediation technologies. Additional data collected during the RI/FS will fill these data gaps. Based on this additional information, remedial alternatives will be screened and evaluated in the FS based on their ability to meet RAOs (Table 4-1). The range of potential remedial alternatives encompasses those in which treatment significantly reduces the toxicity, mobility, or volume of contaminants; options for containment with little or no treatment; removal actions, institutional and other non-engineering controls; and a no-action, or base-line alternative.

4.11 Data Needs for the RI

Table 4-2 identifies data gaps needed to evaluate remedial alternatives in the RI/FS. Area accessibility and the presence of underground utilities and debris are an important consideration for any potential remedial technology for any media because it will determine possible locations for heavy equipment, excavation, capping, well locations, and distribution piping. For the RI, the following subsections identify data gaps by environmental media. Based on the results of the RI, further information may be required for the FS if remediation is required. At a minimum, the RI needs to develop the following data to evaluate potential remedial technologies.

4.11.1 Surface Soil

At a minimum, based on the RAOs and preliminary list of remediation technologies, RI data needs for surface soil include the following:

- Background soil data (metals)
- Valence of metals

4.11.2 Subsurface Soil

At a minimum, based on the RAOs and preliminary list of remediation technologies, RI data needs for subsurface soil include the following:

- Depth of impacted soil.

- Depth of impacted groundwater.

- Soil homogeneity and isotropy may impede in-situ technologies that are dependent on the subsurface flow of fluids, such as soil flushing, ORC, SVE, bioventing and in-situ biodegradation. Undesirable channeling may be created in alternating layers of clay and sand, resulting in inconsistent treatment.

- Soil permeability is one of the controlling factors in the effectiveness of in-situ treatment technologies. Low permeability also hinders the movement of air and vapors through the soil matrix. This can lessen the volatilization of VOCs in SVE processes. Similarly, nutrient solutions, used to accelerate bioventing, may not be able to penetrate low-permeability soils in a reasonable time.

4.11.3 Groundwater/NAPL

During the RI, fluid-level data will be collected from monitoring and observation wells. If NAPL is detected, NAPL samples will be collected from any new or existing monitoring well and characterized using gas chromatography analysis to help identify sources, age, dissolution potential and mobility in the subsurface.

At a minimum, based on the RAOs and preliminary list of remediation technologies, RI data needs for subsurface soil include the following:

- Aquifer Thickness
- Depth to Bootlegger Clay (Confining Layer)
- Saturated Thickness and Seasonal Variability
- Hydraulic Conductivity
- Background groundwater data (metals)
- Fate and Transport Data (Section 4.11.4)
- MNA data (Section 4.11.5)

If LNAPL is present at appreciable amounts in monitoring wells and remediation is deemed necessary, LNAPL, groundwater, and soil core samples may be collected for recoverability and mobility evaluation to be performed for the FS. LNAPL, groundwater, and soil core samples will be analyzed for the following parameters:

- Interfacial tensions
- LNAPL viscosity, density, specific gravity, and conductivity
- Moisture retention (capillary pressure) curves

4.11.4 Fate-and-Transport Modeling

Based on the results of the RI, fate-and-transport modeling may be required for COPCs and/or LNAPL. If required to evaluate remedial alternatives, a model may be necessary to evaluate the fate-and-transport of COPCs in the subsurface potentially including a multi-phase model necessary for LNAPL. Data collection may be required to address the following Site-specific challenges:

- Groundwater/surface water interaction with Ship Creek
- Spring effects on boundary conditions and groundwater flow
- Groundwater/tidal variances with Cook Inlet

Site-specific data needs for fate-and-transport modeling include the following:

- Fluid level data
- Hydraulic conductivity
- Hydraulic gradient
- Groundwater Velocity
- Fraction organic carbon content (foc)
- LNAPL gas chromatography
- Depth to groundwater
- Soil Porosity
- Soil bulk density

4.11.5 Monitored Natural Attenuation

The RI will collect data to evaluate the potential efficacy of MNA as a remedial alternative through collection of site-specific data sufficient to estimate with an acceptable level of confidence both the rate of attenuation processes and the anticipated time required to achieve remediation objectives. The following site-specific parameters will be analyzed to evaluate MNA:

- Dissolved Oxygen

- Temperature

- pH. Microbial diversity and activity in bioremediation processes also can be affected by extreme pH ranges

- Oxidation-Reduction Potential (ORP) of groundwater
- Electron acceptors, including oxygen, nitrate, iron, manganese, sulfate, which support biodegradation
- Alkalinity (Total, Carbonate, Bicarbonate)
- Dissolved permanent gases (O_2,CO,CO_2,CH_4)

Individual parameters and sample collection requirements for evaluating natural attenuation are summarized in Table 4-3.

4.11.6 Surface Water

Background surface water data will be collected for the RI. Additional data needs for evaluating potential remedial alternatives for surface water will be determined based on the risk assessment if surface water is determined to present a risk to human health or the environment. If remediation of surface water is required, and data gaps exist, sampling will be performed as needed. The process for collecting this data is shown on Figure 4-2 and data needs are identified on Table 4-2.

4.11.7 Sediment

Background sediment data will be collected during the RI, and any additional data needs for remedial alternatives for sediment will be determined based on the risk assessment and, if remediation is required, additional sampling will be performed as needed. Additional data may be required for treatability studies, depending upon the results of the RI. This data will be identified and collected for the RI, prior to submittal of the FS report. The process for collecting this data is shown on Figure 4-2 and data needs are identified on Table 4-2.

5 References

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Tables

Table 2-1
Proposed Constituents of Potential Concern

Location	Environmental Media				
	Surface Soil	Subsurface Soil	Groundwater	Surface Water	Sediment
Background (regionally occurring)	Regional metals data to be used	NA	VOCs, SVOCs, Metals, PCBs, TPH[1]	Historical Data Exists, but one sample proposed (VOCs, SVOCS, Metals, PCBs)	Historical Data Exists, but one sample proposed (VOCs, SVOCS, Metals, PCBs)
Ship Creek Surface Water and Sediment	NA	NA	NA	VOCs, SVOCs, Metals, PCBs	VOCs, SVOCs, Metals, PCBs
Railyard and Lease Lots	VOCs, SVOCs, Metals, PCBs, TPH	VOCs, SVOCs, Metals, PCBs, TPH	VOCs, SVOCs, Metals, PCBs, TPH[2]	NA	NA

Notes:

1) Background groundwater samples to be collected at four regional upgradient locations
2) Pesticides and herbiceds to be analzed at one location in railyard

SVOCs = Semi-Volatile Organic Compounds
PCBs = polychlorinated biphenyls
TPH = Total Petroleum Hydrocarbons (incl. Gasoline, Diesel and Residual Range Organics)
NA = Not applicable

Table 3-1
Potential ARARs for ARRC Anchorage Terminal Reserve

Location-specific ARARs based on federal and state standards

Location	Statute or Regulation	Description	Comments
Floodplains	Executive Order 11988, 40 CFR Part 6, Appendix A	Directs federal agencies to preserve the beneficial functions provided by floodplains in implementing federal programs and activities in 100-year floodplains	Portions of the ARRC Anchorage Terminal Reserve are located within the 100-year floodplain. Not an ARAR but a relevant federal guideline.
	RCRA location standards at 40 CFR §264.18	Hazardous waste treatment, storage and disposal (TSD) facilities operating under a RCRA Part B permit and located in a 100-year floodplain must be designed, operated and maintained to prevent washout of hazardous waste	No RCRA Part B permitted TSD facilities are located within the 100-year floodplain at the Terminal Reserve. This RCRA location restriction therefore is not applicable.
	State municipal solid waste facility location standards at 18 AAC 60.310	Municipal solid waste disposal facilities must not restrict flow of 100-year flood or result in solid waste washout	No municipal solid waste disposal facilities are located at the Anchorage Terminal Reserve

Table 3-1
Potential ARARs for ARRC Anchorage Terminal Reserve

Location	Statute or Regulation	Description	Comments
Surface Waters	Rivers and Harbors Act, Section 10 (33 USC §403); 33 CFR §§320 and 322	Generally prohibits creation of any obstruction in waters of the United States that are navigable in fact without a permit from the U.S. Army Corps of Engineers	Any remedial action at the ARRC Anchorage Terminal Reserve that involved placement of an obstruction to the navigable in fact portion of Ship Creek or Cook Inlet would need to be coordinated with the U.S. Army Corps of Engineers
	Fish and Wildlife Coordination Act, 16 USC §661-667e	Requires coordination with the U.S. Fish and Wildlife Service regarding federally-permitted impoundments, diversions or other modifications to waters of the United States to prevent loss or damage to wildlife resources	Any remedial actions involving installation of impoundments or diversions to Ship Creek should be selected following consultation with the U.S. Fish and Wildlife Service.
	Clean Water Act, 33 USC §§1311 and 1342; 40 CFR §§121-131	Point source discharges to rivers, streams and other waters of the United States generally require Clean Water Act NPDES permits and compliance with technology-based and water quality-based discharge limits	Any remedial actions that involved point source discharges to Ship Creek or Cook Inlet, for example discharges of treated water, would need to meet substantive NPDES requirements.

Table 3-1
Potential ARARs for ARRC Anchorage Terminal Reserve

Location	Statute or Regulation	Description	Comments
Surface Waters, continued	18 AAC 70.015	State anti-degradation policy, generally requiring existing water quality and water uses to be maintained	Selected remedial alternatives that involved discharge of treated water to Ship Creek or Cook Inlet would need to address state requirements regarding antidegradation, whole effluent toxicity, and state water quality standards
	18 AAC 70.020	State water quality criteria and standards for different categories of state waters	See above
	18 AAC 70.030	Prohibits discharges of effluent to state waters that impart chronic whole effluent toxicity to aquatic organisms	See above
Groundwater	Safe Drinking Water Act, 42 USC §300f et seq. (SDWA)	Sets enforceable standards for drinking water supplied by public water systems, and authorizes EPA to establish drinking water standards	The enforceable SDWA drinking water quality standards would be applicable to contaminant releases that enter surface or ground water drinking water sources used by public water systems. These standards also could be relevant and appropriate for contaminant releases to other water sources that could serve as drinking water supply

Table 3-1
Potential ARARs for ARRC Anchorage Terminal Reserve

Location	Statute or Regulation	Description	Comments
Groundwater, continued	40 CFR Part 141	Establishes primary maximum contaminant levels (MCLs) and maximum contaminant level goals (MCLGs) that are health-based standards for public water systems	MCLs are enforceable standards and could be applicable or relevant and appropriate as described above. MCLGs are non-enforceable public health goals rather than requirements and therefore do not constitute ARARs.
	18 AAC 80.010	State regulation incorporates by reference into state law the 40 CFR Part 141 requirements for public water systems	See above regarding the enforceable standards that could be applicable or relevant and appropriate
	40 CFR Part 143	Establishes secondary MCLs for public water systems regarding contaminants that cause cosmetic or aesthetic effects	Secondary MCLs are not federally-enforceable standards but are intended to serve as guidelines for the states. Secondary MCLs are not ARARs unless promulgated by states. Alaska regulations at 18 AAC 80.010(a)(36) require public water systems to monitor secondary MCL constituents but do not make the secondary MCLs enforceable. Thus they are not ARARs within Alaska.

Table 3-1
Potential ARARs for ARRC Anchorage Terminal Reserve

Location	Statute or Regulation	Description	Comments
Groundwater, continued	40 CFR Parts 144-147	Provides protection of underground sources of drinking water applicable to Underground Injection Control (UIC) program	UIC standards would be applicable or relevant and appropriate if the selected remedial alternative included injection of contaminants into the groundwater
	40 CFR §§264.92 – 264.101	Ground water protection standards, points of compliance, monitoring requirements and corrective action for releases of hazardous constituents to ground water from hazardous waste treatment, storage or disposal facilities operating under a RCRA Part B permit.	These RCRA groundwater standards are applicable only to hazardous waste TSD facilities operating under a RCRA Part B permit. No such facilities exist at the Anchorage Terminal Reserve.
	18 AAC Chapter 70	Establishes state water quality standards for surface water and ground water	18 AAC 70.005(a)(2) provides that state water quality standards, including antidegradation policy and prohibitions regarding whole effluent toxicity, are not applicable to groundwater addressed by EPA-approved remedial actions under CERCLA that meet state site cleanup standards under 18 AAC 75.325 – 75.390.

Table 3-1
Potential ARARs for ARRC Anchorage Terminal Reserve

Location	Statute or Regulation	Description	Comments
Groundwater, continued	18 AAC 75.345	State groundwater cleanup levels for discharges of oil and other state-designated hazardous substances	State standards may be applicable to any oil or state-designated hazardous substances that may be found in ground water at the Anchorage Terminal Reserve
	18 AAC 75.350	Establishes rebuttable presumption that ground water at a site being addressed under state program for site cleanup, 18 AAC 75.325 - .396, is a drinking water source	Since the Anchorage Terminal Reserve is being addressed under federal CERCLA and RCRA authority rather than under state site cleanup program, this requirement is not applicable. However it could be relevant and appropriate. The RI/FS will evaluate whether the aquifers at the site are or could be drinking water sources under the criteria listed in this state regulation.

Table 3-1
Potential ARARs for ARRC Anchorage Terminal Reserve

Location	Statute or Regulation	Description	Comments
Wetlands	Clean Water Act, 33 USC §§1311 and 1344; 33 CFR §§320 and 323	Clean Water Act Section 404 permits are generally required for discharges of dredged or fill material to waters of the United States	Any remedial actions at the ARRC Terminal Reserve that involved fills to jurisdictional wetlands would need to meet substantive requirements of Section 404 program
	Executive Order No. 11990	Direction to federal agencies to implement federal programs and activities in a manner that minimizes the loss or degradation of wetlands	Relevant guideline though not an ARAR
Land	Resource Conservation and Recovery Act, 42 U.S.C. §6901 et seq.; 40 CFR Part 268	Land Disposal Restriction (LDR) program that restricts land placement of materials that were RCRA hazardous waste at the point of generation and that exceed applicable Universal Treatment Standards (UTSs)	LDR restrictions will be applicable if the selected remedial alternative includes land disposal at the ARRC Anchorage Terminal Reserve of wastes that were RCRA hazardous at the point of generation and that exceed applicable UTSs. LDR restrictions will not be an ARAR, however, if the selected remedy incorporates Corrective Action Management Units (CAMUs) or other LDR exemptions.
	40 CFR Part 264	Regulates operation, closure and post-closure of hazardous waste TSD facilities operating under a RCRA Part B permit	No RCRA Part B permitted TSD facilities are located at the Anchorage Terminal Reserve. The RCRA hazardous waste TSD facility regulations therefore are not applicable at the site.

Table 3-1
Potential ARARs for ARRC Anchorage Terminal Reserve

Location	Statute or Regulation	Description	Comments
Land, continued	18 AAC 63.040	Active areas of hazardous waste treatment, storage or disposal facilities must meet minimum requirements for setback distance from nearby land uses	Based on current information there are no state-permitted hazardous waste TSD facilities at the site. This will be confirmed during the RI/FS. This setback requirement therefore does not appear to be applicable. This requirement nevertheless may be relevant and appropriate for any selected remedial alternative that involves excavation and land placement of remediation waste that is hazardous waste under state law.
	18 AAC 60.040(a)	Prohibits siting new solid waste landfills or a lateral expansion of an existing solid waste landfill within 500 feet of a well used for a drinking water supply	Selected remedial action at ARRC Anchorage Terminal Reserve is not expected to include construction of any solid waste disposal facility. This requirement nevertheless may be relevant and appropriate for any selected remedial alternative that involves excavation and land placement of remediation waste.

Table 3-1
Potential ARARs for ARRC Anchorage Terminal Reserve

Location	Statute or Regulation	Description	Comments
Migratory Bird Habitat	Migratory Bird Treaty Act, 16 USC §§703-712; 50 CFR §10.13	Prohibits taking, killing or selling federally-designated migratory birds	Remedial actions at ARRC Anchorage Terminal Reserve would need to avoid takings or killings of migratory birds
Bald eagle and Golden eagle Habitat	Bald Eagle and Golden Eagle Protection Act, 16 U/SC §§668-668d	Prohibits taking, killing or selling or bald eagles and golden eagles	Remedial actions at ARRC Anchorage Terminal Reserve would need to avoid takings or killings of bald eagles or golden eagles
Endangered or Threatened Species Habitat	Endangered Species Act, 16 USC §§1531-1544; 50 CFR Parts 17 (plants and wildlife) and 222 (marine species)	Prohibits the taking or killing of federally-designated endangered or threatened species and requires Federal agencies to implement their programs and activities to protect critical habitat for such species	No critical habitat for endangered or threatened species has been identified to date at the ARRC Anchorage Terminal Reserve. The RI/FS will evaluate the site to determine whether it includes any critical habitat.
State-designated Special Areas and Critical Habitat Areas	5 AAC 95.300 – 95.900	Requires Alaska Department of Fish and Game permits for activities taking place in special areas or critical habitats to protect fish and wildlife in those areas	No state-designated special areas or critical habitat areas have been identified to date at the ARRC Anchorage Terminal Reserve. The RI/FS will evaluate the site to determine whether it includes any such designated areas.

Table 3-1
Potential ARARs for ARRC Anchorage Terminal Reserve

Location	Statute or Regulation	Description	Comments
Coastal zones and oceans	Marine Mammal Protection Act, 16 USC §§1361-1407	Regulates taking of marine mammals from waters of the United States based on goal of maintaining sustainable populations	Remedial action at ARRC Anchorage Terminal Reserve is not expected to result in any taking of marine mammal species
	Ocean Dumping Act, 33 USC §1401; 33 CFR Part 324	Requires U.S. Army Corps of Engineers permits for dumping materials into waters defined as ocean waters	Remedial action at ARRC Anchorage Terminal Reserve is not expected to include any ocean dumping
	Coastal Zone Management Act, 16 USC §§1451-1465	Requires federal agencies conducting activities directly affecting a state's coastal zone to assure that such activities are consistent to the maximum extent practicable with a state's approved coastal zone management program	Remedial action for the ARRC Anchorage Terminal Reserve is not expected to adversely affect the coastal zone. The RI/FS will evaluate the potential impacts of remedial action alternatives and determine whether any CZMA consistency determination is needed in connection with these remedial alternatives.
	AS 46.40.010 et seq.; 6 AAC Chapter 80	Authorizes state development of coastal zone management program	State statute under which state coastal zone management program has been developed. RI/FS will include evaluation of whether potential remedial action alternatives require consistency determination with respect to this program.

Table 3-1
Potential ARARs for ARRC Anchorage Terminal Reserve

Location	Statute or Regulation	Description	Comments
Historic Properties and Archeological Sites	National Historic Preservation Act, 16 USC § 470 et seq.; 36 CFR Part 800	Requires federal agencies conducting or authorizing activities altering terrain where significant historic or archeological data may be threatened to preserve such data before the project commences.	This requirement may be applicable or relevant and appropriate if significant historic or archeological artifacts or other data are observed during the RI/FS or implementation of any selected remedial alternative.
	Historic Sites, Buildings, and Antiquities Act, 16 USC §461-467; 36 CFR Part 65	Requires protection of federally-designated historic sites, buildings or objects of national significance, and authorizes Secretary of the Interior to designate National Historic Landmarks	Based on current information the ARRC Anchorage Terminal Reserve does not contain federally-designated historic sites, buildings or objects of national significance. This will be confirmed during the RI/FS
	Alaska Historic Preservation Act, AS 41.35.010 et seq.; 11 AAC 16	State policy to protect historic, prehistoric and archeological resources and allow state acquisition of such resources where they are not owned by the state	May be applicable or relevant and appropriate if historic, prehistoric or archeological resources are observed during the RI/FS or implementation of the selected remedial alternative
	Alaska Historic Preservation Act, AS 41.35.030	Governor may designate any particular historic, prehistoric or archeological structure or site as a state monument or historic site subject to special state protection	Based on current information the ARRC Anchorage Terminal Reserve does not include any designated state monument or historic site. This will be confirmed during the RI/FS.

Table 3-1
Potential ARARs for ARRC Anchorage Terminal Reserve

Chemical-specific ARARs based on federal and state standards

Media	Statute or Regulation	Description	Comments
Groundwater	Safe Drinking Water Act, 42 USC §300f et seq.	Sets enforceable standards for drinking water supplied by public water systems, and authorizes EPA to establish drinking water standards	The enforceable SDWA drinking water quality standards would be applicable to contaminant releases that enter surface or ground water drinking water sources used by public water systems. These standards also could be relevant and appropriate for contaminant releases to other water sources that could serve as drinking water supply.
	40 CFR Part 141	Establishes primary maximum contaminant levels (MCLs) and maximum contaminant level goals (MCLGs) that are health-based standards for public water systems	MCLs are enforceable standards and could be applicable or relevant and appropriate as described above. MCLGs are non-enforceable public health goals rather than requirements and therefore do not constitute ARARs.
	18 AAC 80.010	State regulation incorporates by reference into state law the 40 CFR Part 141 requirements for public water systems	See above regarding the enforceable standards that could be applicable or relevant and appropriate

Table 3-1
Potential ARARs for ARRC Anchorage Terminal Reserve

Media	Statute or Regulation	Description	Comments
Groundwater, continued	40 CFR Part 143	Establishes secondary MCLs that are primarily aesthetic-based standards for public water systems	Secondary MCLs are not federally-enforceable standards but are intended to serve as guidelines for the states. Secondary MCLs are not ARARs unless promulgated by states. Alaska regulations at 18 AAC 80.010(a)(36) require public water systems to monitor secondary MCL constituents but do not make the secondary MCLs enforceable. Thus they are not ARARs within Alaska.
	40 CFR Parts 144-147	Provides protection of underground sources of drinking water applicable to Underground Injection Control (UIC) program	UIC standards would be applicable or relevant and appropriate if the selected remedial alternative included injection of contaminants into the groundwater
	40 CFR §§264.92 – 264.101	Ground water protection standards, points of compliance, monitoring requirements and corrective action for releases of hazardous constituents to ground water from hazardous waste treatment, storage or disposal facilities operating under a RCRA Part B permit.	These RCRA groundwater standards are applicable only to hazardous waste TSD facilities operating under a RCRA Part B permit. No such facilities exist at the Anchorage Terminal Reserve.

Table 3-1
Potential ARARs for ARRC Anchorage Terminal Reserve

Media	Statute or Regulation	Description	Comments
Groundwater, continued	18 AAC Chapter 70	Establishes state water quality standards for surface water and ground water	18 AAC 70.005(a)(2) provides that state water quality standards, including antidegradation policy and prohibitions regarding whole effluent toxicity, are not applicable to groundwater addressed by EPA-approved remedial actions under CERCLA that meet state site cleanup standards under 18 AAC 75.325 – 75.390.
	18 AAC 75.345	State groundwater cleanup levels for discharges of oil and other state-designated hazardous substances	Standards may be applicable for oil or state-designated hazardous substances that may be found in ground water at the Anchorage Terminal Reserve
	18 AAC 75.350	Establishes rebuttable presumption that ground water at a site being addressed under state program for site cleanup, 18 AAC 75.325 - .396, is a drinking water source	Since the Anchorage Terminal Reserve is being addressed under federal CERCLA and RCRA authority rather than under state site cleanup program, this requirement is not applicable. However it could be relevant and appropriate. The RI/FS will evaluate whether the aquifers at the site are or could be drinking water sources under the criteria listed in this state regulation.

Table 3-1
Potential ARARs for ARRC Anchorage Terminal Reserve

Media	Statute or Regulation	Description	Comments
Surface Water	Clean Water Act, 33 USC §§1251-1376	Establishes programs aimed at restoring and maintaining the chemical, physical and biological integrity of the nation's waters.	Clean Water Act is the source of a number of potential ARARs for surface water control as discussed below
	40 CFR Part 131 Water Quality Standards for surface waters	Federal water quality standards are guidelines upon which states establish their water quality standards	Federal surface water quality standards would be applicable to any point source discharges from the Anchorage Terminal Reserve to Ship Creek or Cook Inlet that contain constituents listed in those standards, and could be relevant and appropriate to nonpoint source discharges of such constituents from the site to surface waters.
	18 AAC Chapter 70	Establishes state water quality standards for surface water and ground water	State water quality standards for surface waters may be applicable or relevant and appropriate for any discharges of regulated constituents from the site to surface waters.

Table 3-1
Potential ARARs for ARRC Anchorage Terminal Reserve

Media	Statute or Regulation	Description	Comments
Surface Water, continued	40 CFR Parts 122 and 125	Establishes criteria, standards and contents for NPDES permits for point source discharges of pollutants to surface waters of the United States, including requirement that NPDES permits contain technology-based limits and additional limits as needed to meet surface water quality standards	NPDES permits and the water quality standards they incorporate are applicable to point source discharges to surface waters. They are not applicable to other discharges, such as discharges to POTWs or by reinjection to groundwater.
	40 CFR Part 403	Sets standards to control pollutants that pass through or interfere with treatment processes in publicly-owned treatment works (POTWs) or that may contaminate POTW sludge. Applicable pass through/ interference standards are set by individual POTWs.	These pretreatment standards would be applicable to any discharges of treated or untreated water generated during remedial action implementation that was sent to a POTW
	18 AAC 75.345	State surface water cleanup levels for discharges of oil and other state-designated hazardous substances	These cleanup levels may be applicable or relevant and appropriate for any discharges of oil or state-designated hazardous substances from the Anchorage Terminal Reserve to Ship Creek or Cook Inlet

Table 3-1
Potential ARARs for ARRC Anchorage Terminal Reserve

Media	Statute or Regulation	Description	Comments
Air	Clean Air Act, 42 USC §7401 et seq.	Regulates emissions from stationary and mobile sources to protect human health and the environment. Provides the statutory basis for major provisions such as NAAQS, NESHAPS, HAPs and NSPS programs.	Clean Air Act is the source of a number of potential ARARs for emissions control as discussed below
	40 CFR Part 50 National Primary and Secondary Ambient Air Quality Standards (NAAQS)	NAAQS are designed to protect human health and welfare	NAAQS are the primary standards applicable to any remedial alternative that would emit regulated air pollutants
	18 AAC 50.010	Establishes state ambient air quality standards based on federal NAAQS	State NAAQS would be applicable or relevant to current site conditions and to any treatment unit included in the selected remedial action that produced air emissions
	40 CFR Part 60 New Source Performance Standards (NSPS)	Sets emission standards for specific categories of new and modified sources	Any selected remedial alternative is unlikely to include air emission units that would be subject to NSPS

Table 3-1
Potential ARARs for ARRC Anchorage Terminal Reserve

Media	Statute or Regulation	Description	Comments
Air, continued	18 AAC 50.040	Incorporates by reference into state law most of the federal NSPS promulgated at 40 CFR Part 60	Since any selected remedial action is unlikely to include air emission units subject to NSPS, these state standards probably will not be applicable or relevant and appropriate
Soils and Solids	Resource Conservation and Recovery Act, 42 USC §§6901-6987 (RCRA)	Sets standards for municipal and other solid waste disposal facilities and specific standards for hazardous waste treatment, storage and disposal	RCRA is the source of a number of potential ARARs as discussed below
	40 CFR Part 257	Establishes criteria for use in determining which solid waste disposal facilities and practices may adversely affect human health or the environment and thereby constitute prohibited “open dumps”	Current focus of RCRA Subtitle D, which governs solid waste disposal facilities, is on municipal landfills. Selected remedial alternative very unlikely to allow site conditions that would cause any portion of the site to be classified as an open dump under Part 257.
	40 CFR Part 261	Defines solid wastes that are hazardous wastes subject to regulation under 40 CFR Parts 261-270	RCRA hazardous waste regulations are applicable only to wastes defined as RCRA hazardous wastes

Table 3-1
Potential ARARs for ARRC Anchorage Terminal Reserve

Media	Statute or Regulation	Description	Comments
Soils and Solids, continued	40 CFR Part 262	Establishes standards for hazardous waste generators	Applicable if the selected remedial alternative involves generation and off-site transport of hazardous wastes
	40 CFR Part 264 and 265	Establishes standards for hazardous waste disposal and certain types of hazardous waste treatment and storage. Part 264 requirements apply at facilities operating under a RCRA Part B permit. Part 265 requirements apply at "interim status" facilities pending issuance of a Part B permit	There are no RCRA interim status or Part B permitted hazardous waste treatment, storage or disposal facilities at the ARRC Anchorage Terminal Reserve. Thus the 40 CFR Part 264 and 265 requirements are not applicable to remedial action at the site. Some of these standards nevertheless could be relevant and appropriate if the selected remedial alternative involved on-site management of wastes that constitute RCRA hazardous wastes.
	18 AAC 75.340 - .341	State soil cleanup levels for discharges of oil and other state-designated hazardous substances	Applicable or relevant and appropriate if the selected remedial alternative addresses oil or state-designated hazardous substances in soils

Table 3-1
Potential ARARs for ARRC Anchorage Terminal Reserve

Media	Statute or Regulation	Description	Comments
Soils and Solids, continued	40 CFR Part 268	Land Disposal Restriction (LDR) program that restricts land placement of materials that were RCRA hazardous waste at the point of generation and that exceed applicable Universal Treatment Standards (UTSs)	LDR restrictions will be applicable if the selected remedial alternative includes excavation and land disposal at the ARRC Anchorage Terminal Reserve of wastes that were hazardous at the point of generation and exceed applicable UTSs. LDR restrictions will not be an ARAR, however, if the selected remedy incorporates Corrective Action Management Units (CAMUs) or other LDR exemptions.
	18 AAC Chapter 62	Incorporates by reference the RCRA hazardous waste regulations promulgated at 40 CFR Parts 261-270	See above regarding portions of the incorporated RCRA standards that could be applicable or relevant and appropriate
	40 CFR Part 279	Standards for storing, shipping, processing, disposing and other management of used oil	Applicable or relevant and appropriate if the selected remedial alternative includes management of used oil
	18 AAC 60.007	Restricts specific categories of waste, including hazardous waste and industrial solid waste, from being used as fill material	Restriction would be applicable if the selected remedial alternative included proposed use of industrial solid waste or other state-prohibited waste as fill material

Table 3-1
Potential ARARs for ARRC Anchorage Terminal Reserve

Media	Statute or Regulation	Description	Comments
Soils and Solids, continued	18 AAC 60.020	State-regulated hazardous waste and used oil must be disposed of only at permitted facilities	Potentially applicable if the selected remedial alternative addresses removal and disposal of regulated hazardous waste or used oil
	18 AAC 60.025	Establishes general requirement that "polluted soil" as defined at 18 AAC 60.990(97) must be disposed of only in a permitted municipal solid waste landfill	Applicable or relevant and appropriate if the selected remedial alternative includes excavation and disposal of soil that state regulations define as "polluted soil"
Soil, Surface Water and Groundwater	AS 46.04.020	Persons causing or allowing oil discharges to occur are required to immediately contain and clean them up	Applicable to any current or recent oil discharges above action levels that are observed at the site during the remedial action process
	AS 46.09.020	Persons in charge of a vessel or facility from which a hazardous substance is released must make "reasonable efforts" to contain and clean up those releases	As defined at AS 46.09.900(4), "hazardous substance" as used in AS Chapter 46.09 does not include "uncontaminated" crude oil or refined oil
	18 AAC 75.310 and. 315	Requires responsible persons to immediately contain and control releases of oil and hazardous substances and, after obtaining ADEC approval, clean up and dispose of the released material	Applicable or relevant and appropriate to any current or recent oil or hazardous substance releases above action levels that are observed at the site during the remedial action process

Table 3-1
Potential ARARs for ARRC Anchorage Terminal Reserve

Media	Statute or Regulation	Description	Comments
Soil, Surface Water and Groundwater, continued	18 AAC 75.320	Criteria for ADEC determinations that actions in response to a release of oil or hazardous substance have been inadequate	Criteria could be relevant and appropriate to any current or recent oil or hazardous substances releases above action levels observed at the site during the remedial action process
	18 AAC 75.325 - .396	Site cleanup rules for characterizing, controlling and cleaning up discharges of oil or hazardous substances	Rules could be relevant and appropriate with respect to remedial action requirements at the Anchorage Terminal Reserve
	40 CFR §§280.60 - .66	Standards for release response and corrective action for UST systems containing petroleum or CERCLA hazardous substances that are not RCRA hazardous wastes	Part 280 release response requirements would be applicable if the selected remedial alternative addresses releases from federally-regulated UST systems and could be relevant and appropriate for release from other underground storage tanks
	18 AAC 78.200 - .276	Corrective action requirements for petroleum releases from leaking underground storage tanks	State corrective action require-ments for leaking USTs may be applicable if the selected remedial alternative addresses releases from state-regulated petroleum USTs. These state standards would operate in lieu of the state site cleanup rules, which do not apply to releases from under-ground tanks subject to state UST regulations. See 18 AAC 75.325(c)(1)

Table 3-1
Potential ARARs for ARRC Anchorage Terminal Reserve

Media	Statute or Regulation	Description	Comments
Soil, Surface Water and Groundwater, continued	AS 46.03.320; 18 AAC Chapter 90	Establishes standards for using pesticides	Pesticide application is not likely to be part of the selected remedy and thus these state pesticide standards are not likely to be an ARAR
Occupational Exposures to On-Site Remediation Workers	Occupational Safety and Health Act, 29 USC §§651-678	Regulates worker health and safety. Sets general industry standards for workplace exposure to chemicals, and sets health and safety training requirements for workers at hazardous waste sites	As discussed below, OSHA is not an ARAR
	29 CFR Part 1910, Subpart Z	Establishes occupational exposure levels for specific contaminants	OSHA standards under 29 CFR Part 1910 are directly applicable to response action workers pursuant to 40 CFR §300.150 and thus are not an ARAR.

Table 3-1
Potential ARARs for ARRC Anchorage Terminal Reserve

Action-specific ARARs based on federal and state standards associated with selected potential remedial alternatives

Action	Statute or Regulation	Description	Comments
Air Sparging/ Biosparging, Soil Vapor Extraction, Bioventing	Clean Air Act, 42 USC §7401 et seq.	Regulates emissions from stationary and mobile sources to protect human health and the environment. Provides the statutory basis for major provisions such as NAAQS, NESHAPS, HAPs and NSPS programs.	As discussed below a number of Clean Air Act requirements could apply to the selected remedial action
	40 CFR Part 50 National Primary and Secondary Ambient Air Quality Standards (NAAQS)	NAAQS are designed to protect human health and welfare	Emissions from any treatment unit that was included in the selected remedial action would need to comply with NAAQS
	18 AAC 50.010	Establishes state ambient air quality standards based on federal NAAQS	State-promulgated NAAQS would apply to any emissions from treatment units operated as part of the selected remedial action
	40 CFR Part 60 New Source Performance Standards (NSPS)	Sets emission standards for specific categories of new and modified sources	Selected remedial alternative unlikely to include air emission units that would be subject to NSPS
	18 AAC 50.040	Incorporates by reference into state law most of the federal NSPS promulgated at 40 CFR Part 60	See above; not likely to be an ARAR

Table 3-1
Potential ARARs for ARRC Anchorage Terminal Reserve

Action	Statute or Regulation	Description	Comments
Capping of Wastes Left in Place	Resource Conservation and Recovery Act (RCRA), 42 USC §6901 et seq.	Statutory basis for capping requirements for wastes left in place at regulated surface impoundments, landfills and waste piles	Establishes basis for potential ARARs discussed below
	40 CFR §264.228(b) (surface impoundments); 40 CFR §264.258(b); 40 CFR §264.310(a) (landfills)	Requires caps to meet performance standards including the following: • Minimize migration of liquids through the cap; • Function with minimal maintenance; • Accommodate settling of the final cover	RCRA capping requirements would be applicable for closure in place of any RCRA-regulated surface impoundments, waste piles or landfills at the Anchorage Terminal Reserve that have been used for disposal of hazardous waste, and could be relevant and appropriate for covers placed over other wastes

Table 3-1
Potential ARARs for ARRC Anchorage Terminal Reserve

Action	Statute or Regulation	Description	Comments
Capping of Wastes Left in Place, continued	40 CFR §264.228(a)(2)	Eliminate free liquids and stabilize wastes before capping (for surface impoundments)	Applicable or relevant and appropriate to any surface impoundments for which remedial action is required under the selected remedial alternative
	40 CFR §264.117(c)	Restrict post-closure use of property as necessary to prevent damage to the cover	Applicable or relevant and appropriate to capping installed as part of the selected remedial alternative
	40 CFR §§264.228(b) and 264.310(b)	Prevent water run-on and run-off from damaging the cover	Same as above
	40 CFR §§264.310(b)	Protect and maintain surveyed benchmarks to locate the capped area	Same as above
	40 CFR §§264.310(b) and 264.117	General requirement for 30-year post-closure maintenance and ground water monitoring	Same as above
On-site Storage or Treatment of Remediation Wastes in Containers	40 CFR §262.34	Containers used to store or treat RCRA hazardous wastes generated during the remedial action must meet container requirements and must be shipped to a RCRA-permitted hazardous waste treatment, storage or disposal facility within 90 days of the date of generation	RCRA container storage requirements will be applicable to any containers that store RCRA hazardous waste generated by the remedial action, and could be relevant and appropriate for container storage of other wastes

Table 3-1
Potential ARARs for ARRC Anchorage Terminal Reserve

Action	Statute or Regulation	Description	Comments
On-site Storage or Treatment of Remediation Wastes in Containers, continued	40 CFR §265.171	Containers storing or treating hazardous waste must be in good condition and not leak	Applicable to containers used to store or treat RCRA hazardous waste generated from excavation or other activities conducted under the selected remedial action, and relevant and appropriate to containers used to store or treat other remediation waste generated from implementation of the selected remedial action
	40 CFR §265.172	Containers storing or treating hazardous waste must be compatible with the wastes they store	Same as above
	40 CFR §265.173	Containers storing or treating hazardous waste must be kept closed when waste is not being added or removed	Same as above
	40 CFR §265.174	Containers storing or treating hazardous wastes must be inspected weekly for deterioration	Same as above

Table 3-1
Potential ARARs for ARRC Anchorage Terminal Reserve

Action	Statute or Regulation	Description	Comments
On-site Storage or Treatment of Remediation Wastes in Tanks	40 CFR §262.34	Tank used to store or treat RCRA hazardous wastes generated during the remedial action must meet tank requirements and must be shipped to a RCRA-permitted hazardous waste treatment, storage or disposal facility within 90 days of the date of generation	RCRA tank storage requirements will be applicable to any containers used to store or treat RCRA hazardous waste generated by the remedial action, and could be relevant and appropriate for container storage of other wastes
	40 CFR §265.192	Tanks storing or treating RCRA hazardous waste must meet design and installation requirements as certified by a registered professional engineer	Same as above
	40 CFR §265.193	Tank systems storing or treating RCRA hazardous waste must have secondary containment and leak detection system	Same as above
	40 CFR §265.194	Tank systems storing or treating RCRA hazardous waste must be operated to prevent rupture or other failure of the tank system including its secondary containment	Same as above

Table 3-1
Potential ARARs for ARRC Anchorage Terminal Reserve

Action	Statute or Regulation	Description	Comments
On-site Storage or Treatment of Remediation Wastes in Tanks, continued	40 CFR §265.195	Tank systems storing or treating RCRA hazardous waste must be inspected every operating day	Same as above
	40 CFR §265.196	Response and notification requirements for releases of RCRA hazardous waste from tanks to secondary containment or the environment	Same as above
Excavation and Disposal of Remediation Waste in a Land Disposal Unit at the Site or Landfarming of Soils Containing Organic Constituents	Resource Conservation and Recovery Act, 42 U.S.C. §6901 et seq.; 40 CFR Part 268	Land Disposal Restriction (LDR) program that restricts land placement of materials that were RCRA hazardous waste at the point of generation and that exceed applicable Universal Treatment Standards (UTSs)	LDR restrictions will be applicable if the selected remedial alternative includes land disposal at the ARRC Anchorage Terminal Reserve of wastes that were RCRA hazardous at the point of generation and exceed applicable UTSs. LDR restrictions will not be an ARAR, however, if the selected remedy incorporates Corrective Action Management Units (CAMUs) or other LDR exemptions.
	18 AAC 60.040(a)	Prohibits siting of a new solid waste landfill or a lateral expansion of an existing solid waste landfill within 500 feet of a well used for a drinking water supply	Remedial action process at ARRC Anchorage Terminal Reserve is not expected to include construction or expansion of any solid waste disposal facility. This requirement nevertheless may be relevant and appropriate for any selected remedial alternative that involves excavation and land placement of remediation waste.

Table 3-1
Potential ARARs for ARRC Anchorage Terminal Reserve

Action	Statute or Regulation	Description	Comments
Excavation and Disposal of Remediation Waste in a Land Disposal Unit at the Site or Landfarming of Soils Containing Organic Constituents, continued	18 AAC 63.040	Active areas of hazardous waste treatment, storage or disposal facilities must meet minimum requirements for setback distance from nearby land uses	ARRC does not operate any state-permitted hazardous waste TSD facility at the Anchorage Terminal Reserve, and based on current information lessees at the site also do not operate any such facilities. This requirement nevertheless may be relevant and appropriate for any selected remedial alternative that involves excavation and land placement of remediation waste at the Anchorage Terminal Reserve.
	18 AAC 60.007	Restricts specific categories of waste, including hazardous waste and industrial solid waste, from being used as fill material	Restriction would be applicable if the selected remedial alternative included proposed use of industrial solid waste or other state-prohibited waste as fill material
	18 AAC 60.020	State-regulated hazardous waste and used oil must be disposed of only at permitted facilities	Potentially applicable if the selected remedial alternative addresses disposal of state-regulated hazardous waste or used oil

Table 3-1
Potential ARARs for ARRC Anchorage Terminal Reserve

Action	Statute or Regulation	Description	Comments
Excavation and Disposal of Remediation Waste in a Land Disposal Unit at the Site or Landfarming of Soils Containing Organic Constituents, continued	18 AAC 60.025	Establishes general requirement that "polluted soil" as defined at 18 AAC 60.990(97) must be disposed of only in a permitted municipal solid waste landfill	Applicable or relevant and appropriate if the selected remedial alternative includes excavation and disposal of soil that state regulations define as "polluted soil"
Excavation and disposal to wetlands or other waters of the United States of waste generated during the remediation that constituted dredged or fill material	Clean Water Act, 33 USC §§1311 and 1344; 33 CFR §§320 and 323	Clean Water Act Section 404 permits generally required for discharges of dredged or fill material to waters of the United States	Any remedial actions at the ARRC Terminal Reserve that involved fills to jurisdictional wetlands would need to be meet substantive requirements of the Section 404 program. Capping, construction of berms and on-site disposal of contaminated soil to wetlands are activities that potentially could involve discharges subject to Clean Water Act Section 404 requirements.
	Executive Order No. 11990	Direction to federal agencies to implement federal programs and activities in a manner that minimizes the loss or degradation of wetlands	Not an ARAR but a relevant federal guideline

Table 3-1
Potential ARARs for ARRC Anchorage Terminal Reserve

Action	Statute or Regulation	Description	Comments
Dredging from Ship Creek or Other Waters of the United States	Rivers and Harbors Act, Section 10 (33 USC §403); 33 CFR §§320 and 322	Generally prohibits creation of any obstruction in waters of the United States that are navigable in fact without a permit from the U.S. Army Corps of Engineers	Any remedial action at the ARRC Anchorage Terminal Reserve that involved dredging from Ship Creek or other waters of the United States would need to be done without creating an obstruction to navigable in fact waters and be coordinated with the U.S. Army Corps of Engineers
Discharges of Effluent from Remediation Waste Treatment System to Waters of the United States or State Waters	Clean Water Act, 33 USC §§1251-1376	Establishes programs aimed at restoring and maintaining the chemical, physical and biological integrity of the nation's waters.	Basis for potential ARARs discussed below
	40 CFR Part 131 Water Quality Standards for surface waters	Federal water quality standards are guidelines upon which states establish their water quality standards	Federal surface water quality standards would be applicable to any point source discharges to Ship Creek or Cook Inlet of treated water generated from water treatment units installed and operated at the Anchorage Terminal Reserve as part of the selected remedial action

Table 3-1
Potential ARARs for ARRC Anchorage Terminal Reserve

Action	Statute or Regulation	Description	Comments
Discharges of Effluent from Remediation Waste Treatment System to Waters of the United States or State Waters, continued	18 AAC Chapter 70	Establishes state water quality standards for surface water and ground water	State water quality standards for surface waters would be applicable to any discharges to Ship Creek or Cook Inlet of treated water generated from water treatment units installed and operated at the Anchorage Terminal Reserve as part of the selected remedial action
	40 CFR Parts 122 and 125	Establishes criteria, standards and contents for NPDES permits for point source discharges of pollutants to surface waters of the United States	NPDES permits and the water quality standards they incorporate would be applicable to any point source discharges to Ship Creek or Cook Inlet of treated water generated from water treatment units installed and operated at the Anchorage Terminal Reserve as part of the selected remedial action.
Discharges of Effluent from Remediation Waste Treatment Systems to a Publicly-Owned Treatment System (POTW)	40 CFR Part 403	Sets standards to control pollutants that pass through or interfere with treatment processes in publicly-owned treatment works (POTWs) or that may contaminate POTW sludge. Applicable standards are set by individual POTWs.	Potentially applicable if treated effluent from treatment system prescribed by selected remedial action is discharged to a POTW

Table 4-1
Preliminary Remedial Action Objectives, General Response Actions, Technology Types, and Process Options for the Development and Screening of Technologies

Environmental Media	Preliminary Remedial Action Objectives	General Response Actions (for all remedial action objectives)	Technology Types (for general response actions)	Process Options (for Remedial Technologies)
Groundwater	<u>For Human Health</u>: Prevent ingestion of water having [COPCs] in excess of [MCL(s)] and pose an adverse health risk*	No Action/Institutional Actions: No action Alternative water supply Monitoring	No Action/Institutional Options: Deed restrictions Groundwater use restrictions Monitored Natural Attenuation	
		Containment Actions: Containment through pumping and barriers	Containment Technologies: Groundwater Pump-and Treat Barrier Walls	
		Removal Actions: Removal through pumping or vacuum	Removal Technologies Total Fluids Extraction Dual Phase Extraction Phytoremediation	Slurry wall, sheet piling, liners, grout injection Horizontal wells Vapor extraction, vacuum enhanced recovery
		Treatment Actions: Collection/treatment discharge In-situ groundwater treatment	Treatment Technologies: Enhanced Natural Attenuation In-situ Treatment of Groundwater Phytoremediation	ORC, Sulfate Addition, Fenton's Reagent Air/biosparging
	<u>For Environmental Protection:</u> Restore Groundwater to ARARs.		Disposal Technologies: Discharge to NPDES (after treatment) Discharge to surface water (after treatment)	Oil-water separation, air stripping, carbon adsorption, UV oxidation/reduction

Notes:
COPC – Constituent of Potential Concern
* - Target risk levels to be determined as part of the upcoming Remedial Investigation Work Plan

Table 4-1
Preliminary Remedial Action Objectives, General Response Actions, Technology Types, and Process Options for the Development and Screening of Technologies

Environmental Media	Preliminary Remedial Action Objectives	General Response Actions (for all remedial action objectives)	Technology Types (for general response actions)	Process Options (for Remedial Technologies)
Soil	For Human Health: Prevent ingestion/direct contact/inhalation of soil having [COPCs] which pose an adverse health risk* For Environmental Protection: Prevent migration of contaminants that would result in groundwater contamination in excess of ARARs.	No Action/Institutional Actions: No action Access restriction Containment Actions: Containment Removal Actions: Excavation Treatment Actions: In-situ treatment	No Action/Institutional Options: Fencing Deed restrictions Containment Technologies: Capping Surface controls Sediment control barriers Dust control Removal Action Technologies: Excavation/Disposal Treatment Technologies: In-situ solidification, fixation, In-situ stabilization, immobilization, Dewatering/SVE Physical treatment Chemical treatment Biological treatment In-situ treatment Thermal treatment Phytoremediation	Clay cap, synthetic membrane, sheet piling Liners, grout injection Re-grading, soil stabilization Revegetation Dewatering/SVE Soil washing (with subsequent liquids treatment) Bioventing/SVE Surface bio-remediation/Landfarming Fate-and-transport modeling

Notes:
COPC – Constituent of Potential Concern
* - Target risk levels to be determined as part of the upcoming Remedial Investigation Work Plan

Table 4-1
Preliminary Remedial Action Objectives, General Response Actions, Technology Types, and Process Options for the Development and Screening of Technologies

Environmental Media	Preliminary Remedial Action Objectives	General Response Actions (for all remedial action objectives)	Technology Types (for general response actions)	Process Options (for Remedial Technologies)
Surface Water	<u>For Human Health:</u> Prevent ingestion of water having COPCs] in excess of [MCL(s)] and pose an adverse health risk* <u>For Environmental Protection:</u> Restore surface water to [ambient water quality criteria] for [ARAR(s)].	No Action/Institutional Actions: No action Access restrictions Monitoring Containment/Treatment Actions: Surface water runoff interception/ treatment/discharge	No Action/Institutional Options: Fencing Deed restrictions Monitored Natural Attenuation Containment Technologies: Surface controls Hydraulic control/Dewatering Treatment Technologies: Aeration/oxidation Chemical treatment Biological treatment In-situ treatment Disposal Technologies: Discharge to NPDES (after treatment)	Grading, diversion, and collection Oil-water separation, aeration Biological treatment, aerobic and anaerobic spray irrigation

Notes:
COPC – Constituent of Potential Concern
* - Target risk levels to be determined as part of the upcoming Remedial Investigation Work Plan

Table 4-1
Preliminary Remedial Action Objectives, General Response Actions, Technology Types, and Process Options for the Development and Screening of Technologies

Environmental Media	Preliminary Remedial Action Objectives	General Response Actions (for all remedial action objectives)	Technology Types (for general response actions)	Process Options (for Remedial Technologies)
Sediment	For Human Health: Prevent direct contact with sediment having [COPCs] in excess of [MCL(s)] and pose an adverse health risk* For Environmental Protection: Prevent releases of [COPCs] from sediments that would result risk to ecology or above ARARs	No Action/Institutional Actions: No action Access restrictions Monitoring Removal Actions: Excavation Containment Actions: Capping/Cover Treatment Actions: In-situ Treatment Excavation/treatment/disposal	No Action/Institutional Options: Fencing Deed restrictions Monitored Natural Recovery Removal Action Technologies: Excavation/Disposal Containment Technologies: Capping/Cover Treatment Technologies: In-situ solidification, fixation, In-situ stabilization, immobilization, Dewatering Physical treatment Chemical treatment Biological treatment In-situ treatment	Natural flushing Surface water bypass, sediments excavation Clay cap, multi-layer, liner, rip-rap Sedimentation, dewatering, and drying beds Water/solids leaching (with subsequent treatment) Sediment washing Oxidation Landfarming
Soil Gas	For Human Health: Prevent inhalation of [COPCs] in excess of [MCL(s)] and pose an adverse health risk*.	No Action/Institutional Actions: No action Access restrictions to monitoring Removal Actions: VOC collection	No Action/Institutional Options: Vapor Barriers (on new construction) Monitored Natural Attenuation Removal Technologies: Subfloor Ventilation Systems SVE Bioventing	New construction only Horizontal wells Passive vents, active collection systems

Notes:
COPC – Constituent of Potential Concern
* - Target risk levels to be determined as part of the upcoming Remedial Investigation Work Plan

Table 4-1
Preliminary Remedial Action Objectives, General Response Actions, Technology Types, and Process Options for the Development and Screening of Technologies

Environmental Media	Preliminary Remedial Action Objectives	General Response Actions (for all remedial action objectives)	Technology Types (for general response actions)	Process Options (for Remedial Technologies)
NAPL	For Human Health: Prevent inhalation of [volatile COPCs] from NAPL posing an adverse health risk.* Prevent migration of [COPCs] that would result in Groundwater concentrations in excess of [MCLs] or an adverse health risk* For Environmental Protection: Prevent migration of contaminants that would result in groundwater contamination in excess of ARARs.	No Action/Institutional Actions: No action Access restriction to [location] Containment Actions: Containment Removal Actions: NAPL Recovery/Recycling Treatment Actions: In-situ Treatment	No Action/Institutional Options: Deed restrictions Groundwater use restrictions Containment Technologies: Groundwater Pump-and Treat Barrier Walls Hanging/Slurry Wall Removal Action Technologies: Total Fluids Extraction Dual Phase Extraction NAPL Skimming Treatment Technologies: Physical treatment Chemical treatment Biological treatment Thermal treatment Disposal Technologies: NAPL recycling Water discharge to NPDES (after treatment)	Slurry wall, Liners Horizontal wells, vertical wells High-vacuum extraction Mobile unit, passive bailers, vac-truck runs Surfactants, hydraulic control Wood chips/absorption Specialized phyto methods for NAPL Steam extraction, six-phase heating

Notes:
COPC – Constituent of Potential Concern
* - Target risk levels to be determined as part of the upcoming Remedial Investigation Work Plan

Table 4-2
RI/FS Data Requirements for the Screening of Technologies

	Potential Remedies																	
Data Requirements	**No Action**	**Institutional controls**	**Soil cover or cap**	**Excavation/Disposal**	***In situ* stabilization or amendment of soils**	***In situ* Thermal Treatment of soils**	**Land treatment / landfarming of soils**	**Soil Vapor Extraction**	**Bioventing**	**Containment/Barrier**	**Pump and Treat**	**Dual Phase Extraction / Total Fluids Extraction/Dual Pump LNAPL Recovery**	**LNAPL Skimming**	**Air Sparging / Biosparging**	***In situ* chemical oxidation (Chem Ox)**	**Phytoremediation**	**Enhanced Monitored Natural Attenuation**	**Monitored Natural Attenuation**	**Description**
Applicability of Remedy to Environmental Media:																			
Surface Soil	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	No	**Yes**	No	No	No	No	No	No	No	No	**Yes**	No	No	
Subsurface Soil	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	No	No	No	No	No	**Yes**	**Yes**	No	No	
Groundwater	**Yes**	**Yes**	No	No	No	No	No	No	No	**Yes**	**Yes**	No	No	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	
LNAPL	**Yes**	**Yes**	No	No	No	No	No	No	No	No	No	**Yes**	**Yes**	**Yes**	**Yes**	No	**Yes**	**Yes**	
Surface Water	**Yes**	No	No	No	No	No	No	No	No	**Yes**	**Yes**	No	No	**Yes**	No	No	**Yes**	**Yes**	
Sediment	**Yes**	No	**Yes**	No	No	No	No	No	No	No	No	No	No	No	No	No	**Yes**	**Yes**	
Data Requirements for Remedial Investigation:																			
Physical Parameters																			
Area Accessibility / Fencing / Paving																			Data used for technology evaluation
Debris/Utility Location	NA	NA																NA	Data used for technology evaluation
Geotechnical Properties (gradation, porosity, bulk density, moisture content)	NA	NA																	If remediation required
Depth/Thickness of Impacted Soils/Smear Zone	NA	NA	NA														NA	NA	Data required for risk assessment
Depth to Groundwater	NA	NA	NA														NA	NA	Data required for risk assessment
Infiltration Rate	NA	NA		NA	NA					NA	NA	NA	NA	NA	NA				For leaching
Soil Homogeneity / Soil Lithology	NA	NA																	Data used for technology evaluation
Soil Permeability (unsaturated zone)	NA	NA		NA							NA	NA	NA	NA		NA			Data used for technology evaluation
Seasonal Variability of LNAPL Thickness	NA	NA	NA	NA	NA		NA												Data used for technology evaluation
Seasonal Variability of Water Levels	NA	NA	NA				NA												Data used for technology evaluation
Groundwater Hydraulic Conductivity	NA	NA	NA	NA	NA	NA	NA	NA	NA							NA			Data used for technology evaluation

Table 4-2
RI/FS Data Requirements for the Screening of Technologies

	Potential Remedies																		
Data Requirements	**No Action**	**Institutional controls**	**Soil cover or cap**	**Excavation/Disposal**	***In situ* stabilization or amendment of soils**	***In situ* Thermal Treatment of soils**	**Land treatment / landfarming of soils**	**Soil Vapor Extraction**	**Bioventing**	**Containment/Barrier**	**Pump and Treat**	**Dual Phase Extraction / Total Fluids Extraction/Dual Pump LNAPL Recovery**	**LNAPL Skimming**	**Air Sparging / Biosparging**	***In situ* chemical oxidation (Chem Ox)**	**Phytoremediation**	**Enhanced Monitored Natural Attenuation**	**Monitored Natural Attenuation**	**Description**
Groundwater Velocity	NA	NA	NA	NA	NA	NA	NA	NA	NA							NA			Data used for technology evaluation
Groundwater/Surface Water Interaction	NA	NA	NA	NA	NA	NA	NA												Data used for technology evaluation
Tidal Influence	NA	NA	NA	NA	NA	NA	NA												Data used for technology evaluation
Chemical Parameters																			
Background Soil Data (metals)						NA		NA	NA	NA	NA	NA	NA	NA	NA		NA	NA	Data required for risk assessment
Valence of Specific Metals in Soil (As/Cr)	NA	NA		NA		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	For mobility and toxicity
pH	NA	NA						NA	NA	NA	NA	NA	NA	NA	NA				Data used for technology evaluation
Fraction Organic Carbon (Vadose & Saturated Zones)	NA	NA	NA	NA		NA		NA	NA										For phase partitioning & mobility
Carbon-Nitrogen-Phosphorus (CNP) Ratio	NA	NA	NA	NA		NA		NA		NA	NA	NA	NA		NA				For soil amendments/fertilizer
Soil Gas or Vapor Characterization	NA	NA		NA	NA					NA	NA	NA	NA	NA		NA			If remediation required
LNAPL GC Characterization	NA	NA	NA	NA	NA	NA	NA			NA						NA	NA	NA	If remediation required. May be required to determine sources.
LNAPL Saturations, Viscosity, Surface Tension Specific Gravity, and LNAPL Conductivity	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA						NA			If remediation required
TCLP/Leaching Tests	NA	NA			NA			NA	NA	NA	NA	NA	NA	NA		NA	NA	NA	If remediation required
MNA parameters in GW (see Table 4-3)	NA	NA	NA	NA	NA	NA	NA	NA	NA			NA	NA						Data used for technology evaluation

Notes:

[gray box] - Gray shaded cell means that data not available and will be a data gap for the RI

NA - Non-applicable for the media

Table 4-3
Proposed Natural Attenuation Parameters (to be measured during RI)

Data Requirement	EPA/ASTM Method	Field or Lab
Dissolved Oxygen	EPA 360.1	Field
Temperature	NA	Field
Conductivity	NA	Field
pH	EPA 150.1	Field
Oxidation/Reduction Potential	NA	Field
Nitrate/Nitrite	EPA 300.0	Lab
Sulfate	EPA 300.0	Lab
Sulfide	EPA 376.2	Lab
Ferrous Iron (field filtered)	SW-846 6020	Lab
Dissolved Manganese (field filtered)	SW-846 6020	Lab
Alkalinity	SM20 2320B	Lab
Dissolved Gases (O_2,CO,CO_2,CH_4^+)	MS GC-Thermal	Lab

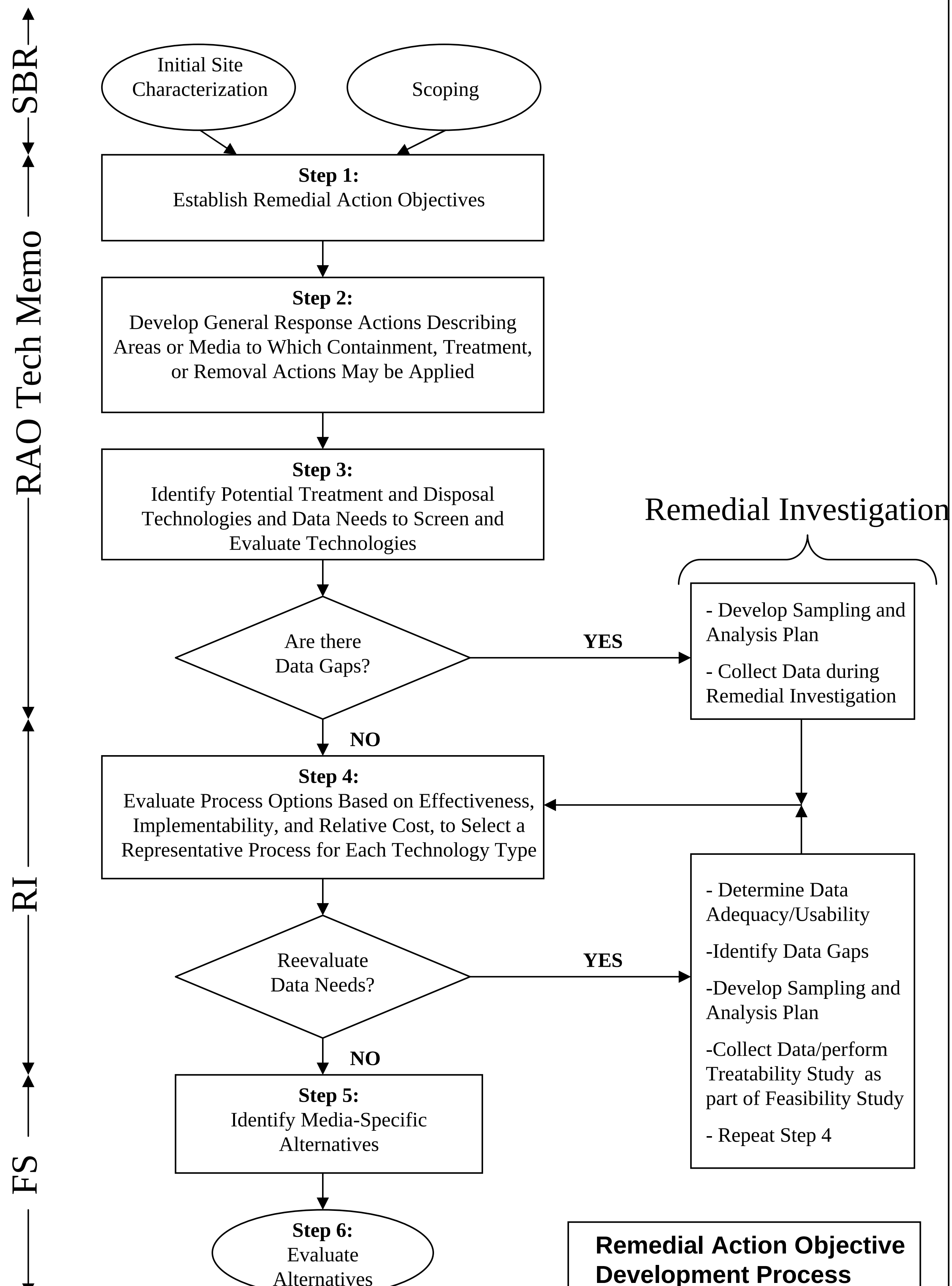
Notes:

Number and location of natural attenuation samples to be proposed in RI Work Plan.

NA = Not applicable

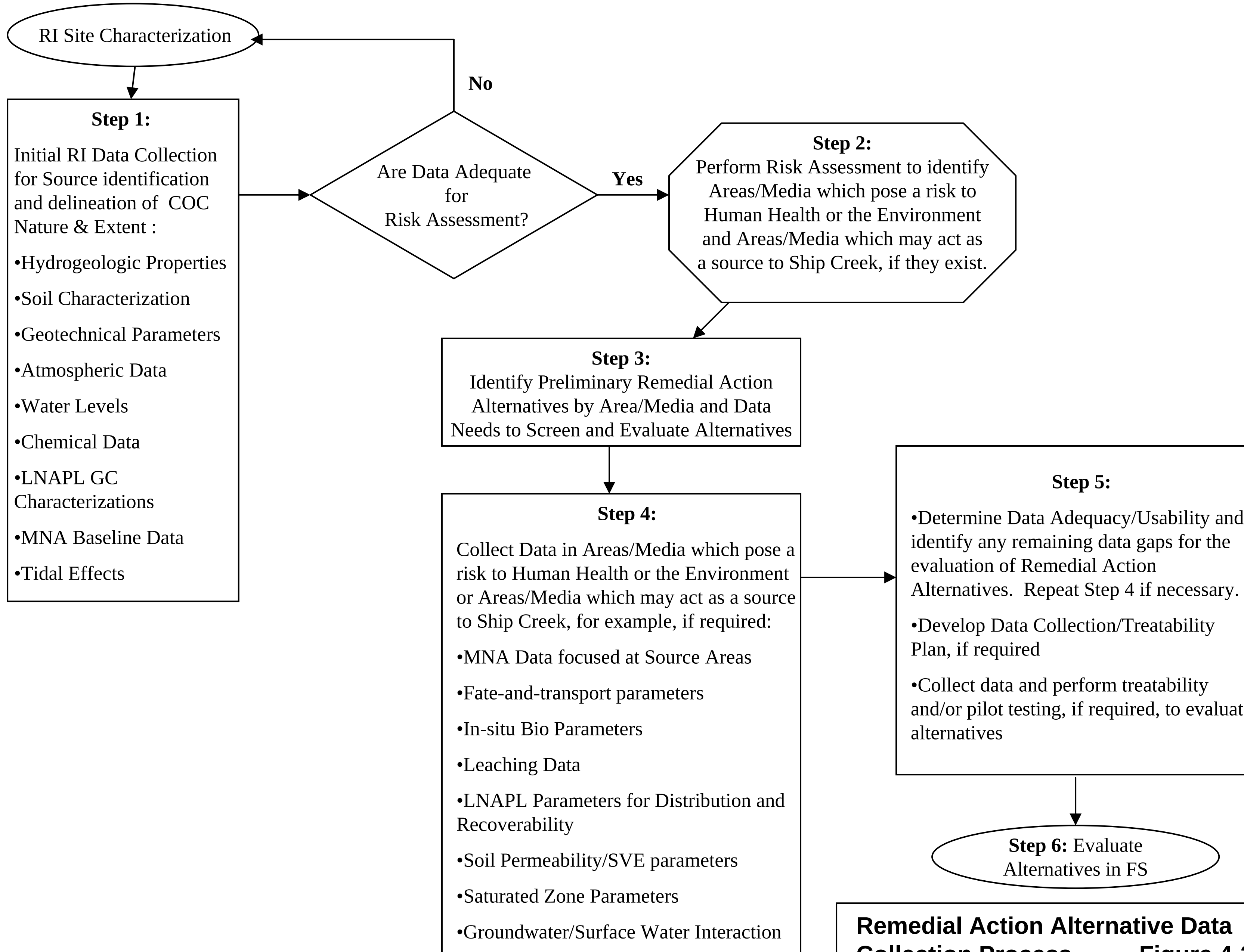
Field = Field measurement

Figures



Source: U.S. EPA, 1989

Remedial Action Objective Development Process
Figure 4-1



Remedial Action Alternative Data Collection Process Figure 4-2