PREINVESTIGATION EVALUATION OF CLEANUP ACTION TECHNOLOGIES

NEW CITY CLEANERS RICHLAND, WASHINGTON

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CONTENTS

LIST OF TABLES AND ILLUSTRATIONS iii

1 INTRODUCTION 1-1

2 SCOPE OF POTENTIAL CLEANUP ACTIONS 2-1
- 2.1 Contaminants of Potential Concern and Impacted Media 2-1
- 2.2 Assumptions 2-1
- 2.3 General Response Actions 2-2

3 POTENTIALLY APPLICABLE TECHNOLOGIES 3-1
- 3.1 Soil Cleanup Technologies 3-1
- 3.2 Groundwater Cleanup Technologies 3-3
- 3.3 Air Emission Controls 3-6

4 IMPLEMENTABILITY ISSUES 4-1
- 4.1 Implementability Issues 4-1
- 4.2 Specific RI Data Requirements 4-1
- 4.3 Treatability Studies 4-2
- 4.4 Summary 4-2

LIMITATIONS

REFERENCES

TABLES

TABLES AND ILLUSTRATIONS

End of Report

Tables

1 Potentially Applicable Technologies
2 Technology Implementability and Data Needs

1 INTRODUCTION

This report has been prepared as described in Section 4 of the Remedial Investigation Work Plan (Work Plan) for the New City Cleaners site (Site) in Richland, Washington (EMCON, 1997). Both the Work Plan and this report have been prepared pursuant to Model Toxics Control Act (MTCA) order No. 92TC-C180 issued by the Washington Department of Ecology (Ecology) to the owners of the Site. Specifically, the purpose of this report is to identify potentially applicable technologies for cleanup of impacted soil and groundwater beneath the Site and identify data that will need to be gathered in the remedial investigation to support analysis of remedial technologies during the feasibility study.

2 SCOPE OF POTENTIAL CLEANUP ACTIONS

Sections 2 and 3 of the Work Plan summarize the available site information including the history of the Site, information related to the geology/hydrogeology of the Site, local use of groundwater, and the available soil and groundwater data. This information provides a preliminary basis for identifying preliminary cleanup technologies.

2.1 Contaminants of Potential Concern and Impacted Media

Based on the existing data, contaminants of potential concern (COPCs) have been identified as:

- Tetrachloroethylene (PCE)
- Trichloroethylene (TCE)
- Benzene, toluene, ethylbenzene, and total xylenes (BTEX)
- Total petroleum hydrocarbons (TPH).

These COPCs have been detected in soil and groundwater at the Site. These potentially impacted environmental media are described below.

Soil - The potentially impacted soil at the Site exists both in piles created during excavation of underground storage tanks (USTs) and in situ. There is approximately 75 to 100 cubic yards (cy) of stockpiled soil related to the UST excavation. The volume of in situ soil that contains COPCs is unknown at this time.

Groundwater - Shallow groundwater begins at a depth of 10 to 15 feet and appears to extend to a depth of up to 80 feet. Although non-aqueous phase liquids (NAPLs) have not been observed at the site, historical operations and the available analytical data indicate that NAPL may be present.

2.2 Assumptions

Two primary assumptions were made in order to develop a range of remedial technologies for this site. These included the following:

- There is dense NAPL (DNAPL) consisting of chlorinated solvents (primarily PCE) within, or at the bottom of, the aquifer.

- There is the potential for light NAPL (LNAPL) from former fuel UST(s) within, or at the top of, the aquifer.

2.3 General Response Actions

Based on the COPCs, potentially impacted media, and assumptions discussed above, the following preliminary general response actions (GRAs) have been identified:

Soil -

- Removal
- Off site disposal
- Containment
- Ex situ treatment
- In situ treatment

Groundwater -

- Groundwater extraction
- Ex situ treatment and discharge
- Containment
- NAPL recovery
- In situ treatment
- Intrinsic remediation

In addition to these media-specific GRAs, air emissions treatment has been identified as a potentially applicable action that could be used to supplement soil treatment, groundwater treatment, or both.

3 POTENTIALLY APPLICABLE TECHNOLOGIES

Based on the information summarized above, a preliminary set of cleanup action technologies has been identified. Table 1 presents these technologies as they apply to the general categories of soil remediation, groundwater remediation, and air emissions abatement. A brief description of each technology is described below.

3.1 Soil Cleanup Technologies

Specific technologies for each of the GRAs identified in Section 2.3 are described below.

3.1.1 Removal

Removal involves excavating well-defined areas of contaminated soil by using conventional heavy construction equipment such as backhoes, trackhoes, or front-end loaders. Following special handling to remove debris and large solids (e.g., boulders), the soil is characterized to determine its regulatory status (e.g., whether it is a dangerous waste) and either treated on site or placed into waste hauling trucks and shipped off site to an approved waste treatment and disposal facility.

3.1.2 Off-Site Disposal

Off-site disposal of contaminated soil, either as dangerous and/or non-dangerous waste, in an off-site landfill is a well established cleanup action technology. It involves excavation, characterization, and transport of contaminated soil to an approved landfill appropriately permitted for disposal. The type of disposal facility used depends largely on whether or not the waste is classified as a dangerous waste.

3.1.3 Containment

For unsaturated soil, containment usually consists of some form of surface cap. At commercial or industrial facilitites, an asphalt or concrete cap can effectively reduce infiltration and prevent direct contact or ingestion of contaminated soil. Asphalt or concrete caps can either be modified to include low permeability layers within the asphalt or used in conjunction with other low permeability caps such as a geomembrane when infiltration must be minimized. The cap is sloped to drain storm water runoff.

3.1.4 Ex situ Treatment

Four general ex situ technologies are potentially applicable at this site. Aeration, thermal desorption, and soil screening could be performed on site. Incineration could be conducted off-site.

- **Aeration**. Aeration provides physical removal of contaminants from the soil by volatilization. This volatilization can be achieved through vapor extraction or mechanical mixing.

- **Thermal Desorption**. Organic contaminants are volatilized from the soil at much lower temperatures (550 to 600°F) than incinerators, with subsequent incineration of the off-gas stream in a secondary combustion chamber.

- **Soil Screening**. This technology reduces the quantity of dangerous waste or contaminated soil requiring additional treatment or disposal. Soil screening separates soil by size and provides volume reduction. Screening can also effectively treat VOC-contaminated soil by simple volatilization.

- **Incineration**. Organic contaminants are destroyed using high temperature (1,600 to 2,200°F) combustion in a mobile (on-site) or fixed (off-site) soil incinerator. Destruction efficiencies of >99.99 percent are typically achieved. Off-gases may require extensive treatment.

3.1.5 In situ Treatment

Given the site conditions and the nature of the contaminants, the only applicable in situ technology identified at this time for remediation of unsaturated soil at the site is soil vapor extraction.

- **Soil Vapor Extraction.** A negative pressure is applied to an extraction well in order to volatilize and extract the contaminant from the soil within the unsaturated zone, capillary fringe, and/or cone of depression. The contaminant-laden vapors are collected, treated if necessary, and discharged to the atmosphere.

3.2 Groundwater Cleanup Technologies

This section describes groundwater cleanup technologies that are potentially applicable to shallow groundwater.

3.2.1 Groundwater Extraction Wells

Groundwater extraction is a remedial technology used to remove contaminated water, hydraulically contain a contaminant plume, or hydraulically control contaminant migration. Groundwater extraction (pumping) is a versatile remedial measure that can be modified to address site-specific hydrogeologic conditions. Dissolved contaminants are extracted from specific parts of the saturated zone (e.g., at or close to the water table surface for contaminants with specific gravities lower than water, or towards the base of the aquifer for those with densities greater than water). A groundwater extraction system typically requires installing multiple extraction wells at regularly spaced intervals in the aquifer, then extracting contaminated groundwater via submersible pumps for treatment and disposal. Pumping groundwater from impacted aquifers induces hydraulic gradients that prevent or minimize off-site transport of contaminated groundwater and reduces the mass of contaminants in groundwater. The feasibility of installing a groundwater extraction system is a function of hydraulic properties of the aquifer, desired aquifer responses, and the ability to successfully treat and dispose of contaminated water.

3.2.2 Containment

Containment of groundwater typically occurs using one of two general methods: hydraulic control and vertical barrier walls. These two methods are described briefly below. In situ treatment technologies, including passive treatment walls, are sometimes used to provide containment of contaminants in groundwater plumes; these methods are described below in Section 3.2.5.

- **Hydraulic Containment.** Using this method, containment is provided by controlling hydraulic gradients through extraction of groundwater using wells or trenches.

- **Vertical Barrier Walls.** Vertical barrier walls are used to help control the lateral migration of contaminated groundwater. The two main types of vertical barrier walls are slurry walls and sheet piling walls. Slurry walls are constructed by excavating a trench while using a betonite and water slurry to support the trench sidewalls. The trench is then backfilled with low-permeability materials (e.g., cement-bentonite or soil-bentonite mixtures). Sheet pile walls are installed by driving interlocking sheets down to a low-permeability soil layer. The sheets are often made of steel but plastic sheets can be used in some situations.

3.2.3 Product Recovery

Product is typically classified into one of two types: DNAPL or LNAPL. Four technologies are described below for potential use in product recovery. With the exception of vacuum enhanced recovery, which is only applicable to LNAPL, each of the technologies is capable of recovering both DNAPL and LNAPL.

- **Single Phase Product and Groundwater Extraction.** Single phase product recovery is an active extraction technology which relies on depression of the groundwater table to enhance product migration to the recovery well. Single phase recovery wells contain one pump which extracts both groundwater and product from the same inlet. The recovered groundwater and product are typically pre-treated using an oil/water separator.

- **Dual Phase Product and Groundwater Extraction.** Dual phase product recovery is similar to single phase product recovery except that separate pumps are used for extraction of groundwater and product.

- **Vacuum Enhanced Product Recovery**. The recovery of floating product (LNAPL) during groundwater extraction often can be enhanced significantly by the use of vacuum extraction. Vacuum enhancement is the process of applying a negative pressure to a well in order to enhance LNAPL migration to a well or trench. Vacuum enhancement can be used to augment both dual and single phase product and groundwater extraction.

- **Passive Product Recovery.** Passive product recovery consists of hand bailing or product skimming from wells. With a passive system, product must migrate to the recovery well in order to be recovered.

3.2.4 Ex situ Treatment

After contaminated groundwater and/or NAPL is extracted from the ground, it is typically treated on-site prior to discharge. Technologies applicable to aboveground treatment of groundwater, DNAPL, and/or LNAPL are listed below. Some technologies apply to only one extracted fluid, and some extracted fluids require a combination of technologies. Specific applications of technologies are also defined below.

- **Gravity Separation**. Gravity separation removes products such as TPH (LNAPL) from water by allowing a mixture to separate according to the specific gravities of individual fluids under quiescent conditions. Gravity separation is a frequent pretreatment step for other treatment technologies. Removed product can be recycled or disposed, depending on whether additional contaminants are present in the product.

- **Air Stripping.** Dissolved contaminant molecules are transferred from contaminated groundwater into a flowing air stream. Mass transfer is provided by the concentration gradient between the liquid and gas phases. Two examples of equipment used for air stripping are packed-tower air strippers and diffusion aeration tanks. A countercurrent packed-tower air stripper disperses water into an airstream to enhance mass transfer. A typical packed tower is packed with ceramic, glass, or plastic media. A diffusion aeration tank disperses air through water to enhance mass transfer. In a typical open aeration tank, compressed air is introduced beneath the water surface through a bubble diffuser.

- **Carbon Adsorption.** Carbon adsorption involves binding a contaminant to the surface of activated carbon by physical and chemical means. The imbalance of electrical forces in the pore walls of the carbon allows contaminants to attach and concentrate. Activated carbon granules are typically contained in a vessel (filter) through which the contaminated water passes. Once adsorption has occurred, the molecular forces in the pore walls stabilize. When the carbon has been saturated, it can be regenerated in place, removed and regenerated at an off-site facility, or disposed.

- **Biological Treatment.** Biological treatment of contaminants may be performed in the presence (aerobic) or absence (anaerobic) of oxygen in contained treatment units such as a bioreactor. Treatment involves optimizing conditions for biological activity such as pH and nutrient concentrations. Petroleum hydrocarbons, TCE, and DCE may be biodegraded aerobically with the appropriate addition of nutrient supplements and oxygen. Aerobic degradation of TCE and DCE would likely require the addition of specific organic food sources to support the necessary microbial populations. PCE, TCE, DCE, and BTEX constituents may also be biodegraded anaerobically. The addition of an organic food source and/or inorganic electron acceptor (e.g., nitrate, sulfate) may be required to support anaerobic biotreatment of these compounds.

3.2.5 In situ Treatment

In situ treatment of groundwater and saturated soil can be conducted utilizing either active or passive systems. Two active and one passive in situ treatment system are described below:

- **Air Sparging and SVE**. Air sparging uses the same principle as air stripping to enhance mass transfer, except the "stripping" occurs in situ (i.e., in the aquifer). Compressed air is injected into the groundwater through an injection well to create air bubbles. Groundwater contaminants are transferred from the groundwater to the air at the bubble surface. Vapors containing contaminants are removed to the surface through an SVE system.

- **Biological Treatment**. The aerobic biodegradation of petroleum hydrocarbons, TCE, and DCE by indigenous microbial populations can be stimulated by injection of appropriate nutrient supplements and oxygen into the groundwater. Specific organic food sources may also be required to support aerobic degradation of TCE and DCE. The anaerobic biodegradation of PCE, TCE, DCE, and BTEX constituents by indigenous microbial populations can be stimulated by injection of nutrient supplements and/or the addition of anaerobic electron acceptors (e.g., nitrate or sulfate).

- **Intrinsic Remediation**. Intrinsic remediation is a remedial approach that utilizes naturally occurring processes to remediate contaminants in groundwater. Intrinsic remediation results from the integration of several subsurface attenuation mechanisms that fall into two major categories: destructive and non-destructive. The most important destructive mechanism is biodegradation. Secondary destructive mechanisms include hydrolysis, elimination, and other abiotic processes. Non-destructive processes include advection, sorption, dispersion, dilution, and volatilization. This remedial approach is most appropriate when the concentration of contaminants is reduced to regulatory limits before groundwater reaches a regulatory compliance point such as a downgradient monitoring well. Analysis of upgradient and downgradient groundwater samples for evidence of increases in microbial metabolism (e.g., decreases in oxygen, nitrate, sulfate or iron) can be used to demonstrate that degradation of contaminants is due to anaerobic microbial degradation.

3.3 Air Emission Controls

Air emission treatment may be combined with ex situ soil treatment, groundwater treatment, air sparging, and SVE systems.

3.3.1 Carbon Adsorption

Carbon adsorption for air emissions treatment works on the same principles as previously described for the treatment of groundwater.

3.3.2 Resin Adsorption

Resin adsorption is similar to carbon adsorption except that a synthetic adsorbent is used to remove volatile organic compounds from an air stream. The resin can be regenerated using an inert gas and heat. Resin adsorption treatment of volatile organic compounds (VOCs) does not result in the production of acids which are typically generated during thermal treatment of chlorinated solvent vapors.

3.3.3 Thermal Oxidation

Thermal oxidizers use combustion to convert volatile gases and vapors to carbon dioxide, water, and ash. The process usually requires supplementary fuel since the concentration of VOCs in the gas stream is generally not sufficient to sustain combustion. A heat exchanger typically is used to recover heat energy from the off-gas for use in preheating the gas emission stream before it enters the combustion chamber. When gases with high concentrations of halogenated compounds are being treated, flue gas treatment (e.g., scrubbing) is usually required.

3.3.4 Catalytic Oxidation

Catalytic oxidizers use combustion to convert volatile gases and vapors to carbon dioxide, water, and ash. They operate by passing a preheated gas stream through a catalyst bed to oxidize the combustible gases and vapors. The catalyst initiates combustion at a lower temperature than that required for standard thermal oxidation. Supplementary fuel is usually required for VOC gas stream volatiles. A heat exchanger typically is used to recover heat energy from the off-gas for use in preheating the gas emission stream before it enters the combustion chamber. Off-gas treatment may also be required for gas streams with halogenated compounds.

4 IMPLEMENTABILITY ISSUES

A summary of implementability issues associated with specific technologies for treatment of soil, groundwater, and air emissions is provided in Table 2. The following section describes general implementability issues, according to media, that are applicable to multiple technologies. Specific data requirements for each technology are then discussed.

4.1 Implementability Issues

Soil. Ex-situ treatment of soil will require a determination of the regulatory classification of the waste, which may limit the range of treatment options. On-site treatment options for soil will require that adequate space is available on site.

Groundwater. The ability to adequately define the lateral and vertical extent of groundwater contamination will affect the implementability of both in situ and ex situ treatment technologies.

Air Emissions. Carbon adsorption is ineffective in removing some constituents such as vinyl chloride, a biological degradation by-product of PCE. The remainder of the emissions treatment options do not have any technology-specific factors limiting their implementability.

4.2 Specific RI Data Requirements

This section describes the data that should be generated in the RI to support a more detailed evaluation of potential remedial action alternatives. Technology-specific data requirements are detailed in Table 2. General data requirements are described for each media below.

Soil. The lateral and vertical extent of contaminants in the soil should be defined to evaluate treatment technologies and design potential remedial alternatives. Identification and location of on-site chlorinated solvent "hot spots" is necessary for efficient cleanup action alternative development and selection. The extent of TPH contamination, and location of potential TPH hot spots, should be investigated. Site structures and underground utilities that could obstruct soil remedial activities such as drilling or excavation should be delineated. The estimated volume and average contaminant concentration of soil requiring potential excavation is necessary for evaluation of ex situ treatment options.

Groundwater. The lateral and vertical extent and concentrations of conatminants in the shallow groundwater should be defined to allow adequate evaluation of remedial technologies. The potential presence of DNAPL should be determined. Estimated contaminant concentrations and flow rates of extracted groundwater are required for evaluation of all ex-situ treatment technologies.

Isolated groundwater samples should be collected from both the top and base of the aquifer. These samples should be analyzed for the following parameters: dissolved oxygen, pH, ammonia, nitrate, sulfate, phosphate, chemical oxygen demand, hydrocarbon gases, total organic carbon, dissolved iron, calcium, magnesium, manganese, bicarbonate, carbonate, and total heterotrophic microorganisms.

Air Emissions. Technology selection for air emissions treatment requires estimated concentrations of contaminants and estimated flow rates in effluent air streams generated from treatment of in situ and ex situ soil and extracted groundwater.

4.3 Treatability Studies

Aquifer testing will be required to define aquifer characteristics for evaluation of groundwater extraction and product recovery systems. Estimated contaminant concentrations will also be necessary for evaluation of an off-gas treatment system.

SVE source tests may be required to estimate the radius of influence of SVE in the vadose zone. Estimated concentrations of removed VOCs should also be obtained during the source test for use in selecting the most applicable off-gas treatment system.

Implementation of in situ aerobic or anaerobic biological treatment would require bench-scale testing using indigenous microbial populations. Aerobic testing would require the addition of oxygen and appropriate nutrient supplements for petroleum and chlorinated solvent biodegradation. Anaerobic degradation would require the addition of nutrient supplements and electron acceptor amendments. A pilot-scale field test would also typically be required to insure that hydraulic control could be maintained in the aquifer, and that the results of the bench-scale treatability test could be repeated in situ on a larger scale.

4.4 Summary

This report identifies potentially applicable technologies for cleanup of impacted soil and groundwater beneath the Site and identifies data that will need to be gathered in the remedial investigation to support analysis of remedial technologies during the feasibility study. Specific data needs are listed in Table 2.

The RI Work Plan call for the collection of the required data, with the exception of certain groundwater parameters that may be required to evaluate biological treatment and intrinisic remediation options. Addition of some or all of these parameters will be considered prior to the last groundwater sampling event performed at the Site.

LIMITATIONS

The services described in this report were performed consistent with generally accepted professional consulting principles and practices. No other warranty, express or implied, is made. These services were performed consistent with our agreement with our client. This report is solely for the use and information of our client unless otherwise noted. Any reliance on this report by a third party is at such party's sole risk.

Opinions and recommendations contained in this report apply to conditions existing when services were performed and are intended only for the client, purposes, locations, time frames, and project parameters indicated. We are not responsible for the impacts of any changes in environmental standards, practices, or regulations subsequent to performance of services. We do not warrant the accuracy of information supplied by others, nor the use of segregated portions of this report.

REFERENCES

EMCON. 1997. Remedial Investigation Work Plan, New City Cleaners, Richland, Washington. February 13.

TABLES

Table 1

Potentially Applicable Technologies

Media	General Response Action	Cleanup Action Technology
Soil	Removal	Excavation
	Off Site Disposal	Off Site Disposal
	Containment	Surface Cap
	Ex Situ Treatment	Aeration
		Thermal Desorption
		Soil Sorting/Screening
		Incineration
	In Situ Treatment	Soil Vapor Extraction
Groundwater	Extraction	Extraction Wells
	Containment	Vertical Barrier Walls
		Hydraulic Containment
	Product Recovery	Single Phase Groundwater Extraction and Product Recovery
		Dual Phase Groundwater Extraction and Product Recovery
		Vacuum Enhanced Groundwater Product Recovery
		Passive Product Recovery
	Ex Situ Treatment	Gravity Separation
		Air Stripping
		Carbon Adsorption
		Biological Treatment
	In Situ Treatment	Air Sparging and SVE
		Biological Treatment
		Intrinsic Remediation
Air	Emission Controls	Carbon Adsorption
		Resin Adsorption
		Thermal Oxidation
		Catalytic Oxidation

Table 2

Technology Implementability and Data Needs

Media	General Response Action	Technology	Factors Affecting Implementability	Technology Specific Data Needs	Treatability Studies
Soil	Removal	Excavation	Accessibility of impacted soils. Depth of contamination. Location of underground utilities.	Location of underground utilities.	None anticipated.
	Off-Site Disposal	Off Site Disposal	Regulatory status of excavated soil (e.g., dangerous or solid waste).	No technology specific Requirements.	None anticipated.
	Containment	Surface Cap	Ability to temporarily restrict access to areas being capped.	Area of exposed soil. Area and condition of existing concrete or asphalt areas.	None anticipated.
	Ex-Situ Treatment	Aeration	Off-gas treatment requirements.	Estimated volume of soil to be treated.	None anticipated.
		Thermal Desorption	No technology specific factors.	No technology specific requirements.	None anticipated.
		Sorting and Screening	No technology specific factors.	No technology specific requirements. Define the fraction of oversized soil or debris.	None anticipated.
		Incineration	No technology specific factors.	No technology specific requirements.	None anticipated.
	In-Situ Treatment	Soil Vapor Extraction	Presence of NAPL. Subsurface lithology and impacts on air flow.	Location of NAPL zones. Delineation of subsurface lithology.	Pilot tests to determine area of influence and contaminant removal rates may be required for design.

Table 2

Technology Implementability and Data Needs

Media	General Response Action	Technology	Factors Affecting Implementability	Technology Specific Data Needs	Treatability Studies
Groundwater	Extraction	Extraction Wells	Aboveground obstructions for drilling. Underground utilities.	Vertical and lateral extent of contamination in the aquifer. Estimated groundwater production rates. Aquifer characteristics; (e.g., transmissivity, storativity).	Pump test in aquifer.
	Containment	Hydraulic Control	See Extraction Wells.	See Extraction Wells.	See Extraction Wells.
		Vertical Barrier Walls	Presence of over-sized soil materials (e.g., cobbles or boulders). Underground utilities. Depth to low-permeability layer.	Characterization of soil types and lithology.	None anticipated.
	Product Recovery	Single Phase Dual Phase Vacuum Enhanced Passive	Viscosity of DNAPL and LNAPL in aquifer. Estimated volume and lateral extent of free product. Aquifer characteristics. Depth to groundwater.	Presence and extent of DNAPL in the aquifer. Presence of LNAPL in the aquifer. Estimated volume an lateral extent of LNAPL. Determine location of off-site source of diesel.	Field pilot test in a shallow well.
	Ex-Situ Treatment	Oil/Water Separation	No technology specific factors.	Viscosity and density of NAPL.	None anticipated.

Table 2

Technology Implementability and Data Needs

Media	General Response Action	Technology	Factors Affecting Implementability	Technology Specific Data Needs	Treatability Studies
		Air Stripping	Iron content of groundwater (and other dissolved ions). Presence of non-volatile contaminants.	Analyze groundwater data for the following parameters: iron, manganese, calcium, carbonate, bicarbonate.	Pump test on aquifer to determine removal efficiencies. Bench or pilot test to determine ability to control pH and subsequent inorganic fouling.
		Carbon Adsorption	Presence of vinyl chloride or other constituents that don't sorb readily to carbon.	No technology specific requirements.	None anticipated.
		Biological Treatment	Existence of indigenous microbial populations capable of aerobic degradation of diesel and others capable of anaerobic dechlorination of PCE.	Analyze groundwater data for the following bioparameters and organic and inorganic parameters: dissolved oxygen, pH, ammonia, nitrate, sulfate, phosphate, chemical oxygen demand, total organic carbon, hydrocarbon gases (e.g., ethane, methane), dissolved iron, calcium, magnesium, manganese, bicarbonate, carbonate, and total heterotrophs.	Bench-scale aerobic treatability test for TPH and TCE, and an anaerobic treatability test for PCE and daughter products using groundwater from the site.

Table 2

Technology Implementability and Data Needs

Media	General Response Action	Technology	Factors Affecting Implementability	Technology Specific Data Needs	Treatability Studies
	In-Situ Treatment	Air Sparging and SVE	Sparging will not effectively volatilize diesel, and PCE mobilized by sparging may be sorbed into a free-product diesel layer, or be slowed by it. Subsurface lithology and its effects on the distribution of air in the aquifer.	No technology specific data required.	Pilot test following free-product removal.
		Biological Treatment	Ability to remove free product diesel prior to treatment. Existence of indigenous microbial populations capable of aerobic degradation of diesel and others capable of anaerobic dechlorination of PCE. Subsurface lithology and impacts on oxygen and substrate availability to microbial populations and contaminants.	Analyze groundwater data for the following bioparameters and organic and inorganic parameters: dissolved oxygen, pH, ammonia, nitrate, sulfate, phosphate, chemical oxygen demand, total organic carbon, dissolved iron, calcium, magnesium, manganese, bicarbonate, carbonate, and total heterotrophs.	Bench-scale aerobic treatability test for TPH and TCE, and an anaerobic treatability test for PCE and daughter products using groundwater from the site. Tracer study to show ability to maintain hydraulic control in the aquifer. Field-scale pilot tests demonstrating effectiveness in situ.
		Intrinsic Remediation	Existence of daughter products of reductive dechlorination of PCE in the aquifer.	See In Situ Remediation.	None anticipated.

Table 2

Technology Implementability and Data Needs

Media	General Response Action	Technology	Factors Affecting Implementability	Technology Specific Data Needs	Treatability Studies
Air	Emissions Treatment	Carbon Adsorption	Presence of vinyl chloride or other constituents that don't readily sorb to activated carbon.	No technology specific data required.	None anticipated.
		Resin Adsorption	No technology specific factors.	No technology specific data required.	None anticipated.
		Thermal Oxidation	No technology specific factors.	No technology specific data required.	None anticipated.
		Catalytic Oxidation	No technology specific factors.	No technology specific data required.	None anticipated.