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EPA Superfund
Record of Decision Amendment

SOL LYNN/INDUSTRIAL TRANSFORMERS
EPA ID: TXD980873327
OPERABLE UNIT 2
HOUSTON, TEXAS
September 2004

Superfund Record of Decision Amendment
Operable Unit 2 - Ground Water

Sol Lynn/Industrial Transformers
Houston, Texas

September 2004

United States Environmental Protection Agency
Region 6

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ARAR	Applicable or Relevant and Appropriate Requirement
bgs	Below Ground Surface
CAA	Clean Air Act
CDI	Chronic Daily Intake (mg/kg-day)
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
ChemOx	Chemical Oxidation Treatment
cis-1,2-DCE	cis-1,2-dichloroethylene
cm/s	Centimeters per second
COC	Contaminants of Concern
CPT	Cone Penetrometer
CWA	Clean Water Act
DNAPL	Dense Non Aqueous Phase Liquids
DO	Dissolved Oxygen
DOT	Department of Transportation
EPA	Environmental Protection Agency
EPC	Exposure Point Concentration
ft	Feet
ft/day	Feet per Day
HAP	Hazardous Air Pollutant under the Clean Air Act
HI	Hazard Index
HQ	Hazard Quotient
IC	Institutional Controls
IRIS	Integrated Risk Information System
ISB	In-Situ Bioremediation
Kd	Soil and Ground Water Distribution Coefficient
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
mg/kg	Milligrams per Kilogram
mg/kg-day	Milligrams per Kilogram per Day
mg/L	Milligrams per Liter
MNA	Monitored Natural Attenuation
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NIOSH	National Institute for Occupational Safety and Health
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NSPS	New Source Performance Standards
O&M	Operation and Maintenance
OSHA	Occupational Safety and Health Administration
OU2	Operable Unit 2 of the Sol Lynn Superfund Site
PCB	Polychlorinated Biphenyl

PCE	Tetrachloroethylene
ppbV	Parts per Billion by Volume
PMZ	Plume Management Zone
ppm	Parts per Million
PRB	Permeable Reactive Barrier
PRP	Potentially Responsible Parties
RAGS	Risk Assessment Guidance for Superfund
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RfD	Reference Dose
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SEAR	Surfactant Enhanced Aquifer Remediation
SF	Slope Factor
TCAA	Texas Clean Air Act
TCE	Trichloroethylene
TCEQ	Texas Commission on Environmental Quality
TI	Technical Impracticability
TPDES	Texas Pollutant Discharge Elimination System
TRRP	Texas Risk Reduction Program
TSCA	Toxic Substances Control Act
TSD	Hazardous Waste Treatment, Storage, or Disposal
TXDOT	Texas Department of Transportation
TWC	Texas Water Commission
µg/L	Micrograms per Liter
$\mu g/m^3$	Micrograms per Cubic Meter
VC	Vinyl Chloride
WBZ	Water Bearing Zone
WWTP	Waste Water Treatment Plant

SOL LYNN/INDUSTRIAL TRANSFORMER SUPERFUND SITE
RECORD OF DECISION - OPERABLE UNIT 2
AMENDMENT NO. 1

PART 1: DECLARATION

1.1 Site Name and Location

Sol Lynn/Industrial Transformers
Operable Unit (OU) No. 2
EPA ID No. TXD980873327
Houston, Texas

1.2 Statement of Basis and Purpose

This decision document presents an amendment to the U.S. Environmental Protection Agency's (EPA) previously selected remedial action for the contaminated ground water, which is Operable Unit 2 ("OU2") at the Sol Lynn/Industrial Transformers Site (Site) in Houston, Texas. This new remedy was chosen in accordance with the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA), and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This decision is based on the administrative record for this Site. The State of Texas concurs with the amended selected remedy.

1.3 Assessment of the Site

Actual or threatened releases of hazardous substances from this Site, if not addressed by implementing the response action selected in this amendment to the Record of Decision (ROD) may present an imminent and substantial endangerment to public health, welfare, or the environment.

1.4 Description of the Selected Remedy

This ROD Amendment modifies the previously selected remedy for contaminated ground water at the Site. The revision affects both the ground water cleanup criteria and the cleanup technologies selected in the ROD for OU2 of the Site, dated September 23, 1988. This ROD Amendment does not affect the remedy selected in the March 1988 ROD for soils, or OU1.

The September 1988 ROD for OU2 specified extraction and treatment as the ground water remedy. The treatment process included air stripping followed by vapor and liquid phase carbon absorption. The objective of the September 1988 ROD was to remediate the contaminated ground water to a level of no more than 5 micrograms/liter (μg/L) of trichloroethene (TCE). The amended remedy for ground water consists of:

- **In-Situ Bioremediation (ISB)** for contaminant mass reduction in the source areas. Data indicates the presence of residual dense non aqueous phase liquids (DNAPL), the principal threat waste at the Site.

- **Monitored Natural Attenuation (MNA)** will be implemented for the dissolved contaminant plumes in ground water downgradient of the source areas.

- **Institutional Controls (IC)** will be used to prevent exposure to the contaminated ground water at the Site for as long as contaminants remain at levels above the drinking water standards, and to prevent residential land use over areas of ground water contamination until appropriate measures are implemented to remediate the risk from vapor intrusion into residences.

ISB is a remedy that increases the degradation of contaminants by the metabolic reactions of microorganisms. This process would be used only in the source area because of physical excess limitations resulting from I-610 and its feeder roads. Depending on the requirements of the microorganisms, the process could involve the injection of nutrients, a substrate to act as an electron donor and carbon source for cell growth, and if necessary, TCE degrading microorganisms (i.e., *dehalococcoides ethanogenes*). These microorganisms have been shown to result in the complete breakdown of TCE, cis-1,2-dichloroethylene (cis-1,2-DCE), and vinyl chloride (VC) to ethene.

The cleanup criteria for TCE contamination in ground water specified in the September 1988 ROD remains unchanged. Sampling data in recent years have identified the presence of additional ground water contaminants not identified in the September 1988 ROD, including cis-1,2-DCE and VC. Both cis-1,2-DCE and VC are daughter products of TCE, and their presence indicates the natural biodegradation of TCE because neither compound was present in the material used at the Site. One objective of this ROD Amendment is to remediate the contaminated ground water outside of the source area to no more than 70 μg/L for cis-1,2-DCE and 2 μg/L for VC. These cleanup criteria are the Maximum Contaminant Levels (MCL) for these contaminants.

ISB appears to be a promising technology to treat chlorinated solvents in ground water. This technology could be classified as an emerging technology because the record of successful full scale applications is limited. Potential treatment success depends on competition of the injected dechlorinating bacteria with other native microbial populations, and the ability to deliver the substrate, nutrients, and microorganisms uniformly into the water bearing zones. Therefore, this ROD Amendment recognizes the possibility of the future employment of one of the contingent alternative remedies for the source area, including a permeable reactive barrier (Alternative 3) downgradient from the source area for destruction of contaminants as they pass through the barrier, and including ChemOx treatment (Alternative 5) in the source area. The EPA could select either or some combination of the contingent remedies for the source areas, if ISB fails to meet the goals of source reduction and/or prevention of plume expansion. Furthermore, should MNA, the selected remedy for the dissolved ground water plume, not achieve the ground water cleanup levels, then the EPA would consider an alternate action to address the ground water contamination plume that is consistent with the remedies discussed in this ROD Amendment. No remedial modification would be undertaken by the EPA without following the procedures for the same, as set forth in the NCP.

1.5 Statutory Determinations

The selected remedy is protective of human health and the environment, complies with the Federal and State requirements that are applicable or relevant and appropriate to the remedial action, and is cost-effective. This remedy utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable for this Site, and will satisfy the statutory preference for remedies to employ treatment that reduces toxicity, mobility, or volume as a principal element.

Because this remedy will result in hazardous substances remaining on-site above health-based levels that allow for unlimited use and unrestricted exposure, a statutory review pursuant to Section 121(c) of CERCLA, 42 U.S.C. 9621(c) will be conducted at least every five years after commencement of this amended remedial action to insure that the remedy continues to provide adequate protection of human health and the environment.

1.6 Data Certification Checklist

The following information is included in the Decision Summary section of this Amended ROD. Additional information can be found in the Administrative Record file for the Site.

- Contaminants of concern (COC) and their respective concentrations (Section 2.8);
- Baseline risk represented by the COCs (Section 2.8);
- Cleanup levels established for the COCs and the basis for these levels (Section 2.9);
- How source materials constituting principal threats are addressed (Section 2.13);
- Current and potential future beneficial uses of ground water used in the baseline risk assessment and ROD (Section 2.7);
- Potential ground water use that will be available at the Site as a result of the Selected Remedy (Section 2.7);

- Estimated capital, operating and maintenance (O&M), and total present worth costs; discount rate, and the number of years over which the remedy cost estimates are projected (Section 2.12-7); and
- Key factor(s) that led to selecting the remedy (Section 2.14).

1.7 Authorizing Signature

SW for Sam Coleman

Samuel Coleman, P.E.
Director, Superfund Division
U.S. Environmental Protection Agency

9-30-04

Date

SOL LYNN/INDUSTRIAL TRANSFORMER SUPERFUND SITE
RECORD OF DECISION - OPERABLE UNIT 2
AMENDMENT NO. 1

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PART 2: DECISION SUMMARY

2.1 Site Name, Location, and Brief Description

This Amended Record of Decision (ROD) is for ground water, which is Operable Unit 2 ("OU2") at the Sol Lynn/Industrial Transformer Site. The Site is located within the city limits of Houston, Harris County, Texas, just south of Interstate Highway Loop 610 South (I-610) and west of State Highway 288. The Site, encompassing about 0.75 acres, is bounded on the north by the South Loop Feeder Street of I-610, on the east by South David Street, on the south by Mansard Street, and on the west by Knight Street.

Commercial business and light industrial areas are located directly east and south of the Site. Private, single, and multi-family dwellings are located about 3,000 feet west of the Site. The Six Flags Astroworld amusement park and the Houston Astrodome and Reliant Stadium sports facilities are located approximately 4,000 feet to the northwest.

The United States Environmental Protection Agency (EPA) Site identification Number is TXD980873327. The lead agency for this Site is the EPA. The EPA proposed the Site to the National Priorities List (NPL) on October 15, 1984, 49 Fed. Reg. 40320, 40330 (Oct. 15, 1984). The Site was finalized on the NPL on March 31, 1989. 54 Fed. Reg. 13296, 13301 (Mar. 31, 1989). The remediation of OU2 is planned to be conducted using Superfund funding.

The Site operated as a small scrap metal recycling and a chemical recycling facility from about 1965 to 1980. The Site includes two buildings and a loading area in the northern portion of the Site, with much of the southern portion paved. A wastewater treatment plant (WWTP) and decontamination pad are located in the eastern portion of the Site and are protected by locked cyclone-type fencing.

The ground water contaminants at the Site are TCE and its daughter products cis-1,2-DCE and VC. The original remedy for ground water cleanup at the Sol Lynn/ITS Site involved extracting contaminated ground water and treating it using air stripping and carbon adsorption (EPA Record of Decision, OU2, September 23, 1988). The ground water recovery system began pumping and treating contaminated ground water on October 8, 1994. The pump-and-treat system operated until October 1996 when it was shut down because of system leaks. A ground water investigation conducted in March 1998 identified new areas of contamination. Additional extraction wells and new distribution pipes were installed, and the pump-and-treat system resumed operation in December 1998. The pump-and-treat system was again shut down in early 2000, and is currently shut down.

2.2 Site History and Enforcement Activities

The Site is the location of a former electrical transformer salvage and recycling company which operated between 1965 and 1975. A chemical recycling and supply company subsequently operated at the same location from1979 through 1980.

Previous Site activities, investigations, and Superfund enforcement activities include the following:

- ***September 21, 1971***: The first documented investigation of the Site, done by the City of Houston Water Pollution Control Division, reported that workers at the Site poured oil out of electrical transformers as they were being dismantled. Oil and grease were seen on the soil and floating on ponded water on the property as well as in the ditches.

- ***September 11, 1972***: The State of Texas brought suit against Mr. Lynn, owner and operator of the Site, on charges of illegally discharging industrial waste into Braes Bayou. Mr. Lynn was subsequently ordered to pay a $100 fine for illegally discharging industrial wastes.

- ***January 13, 1980***: An inspection by the Texas Water Commission (TWC), predecessor to the Texas Commission on Environmental Quality (TCEQ), discovered old drums stored behind Sila-King, Inc., a chemical company operating at the Site. An oily discharge was found from a drum storage area behind the warehouses.

- ***September 14, 1981***: The Site was inspected by the TWC and the City of Houston Department of Health. The inspection identified approximately 75 drums that were scattered on the Site. Most of the drums were labeled "trichloroethene" and were empty and punctured.

- ***1981 - 1986***: During this time period 24 discrete sampling events were completed by either the TWC, the City of Houston, the EPA, or Mr. Lynn. A total of 21 ground water samples were analyzed for TCE. TCE was detected in 13 of these ground water samples with a maximum value of 953 parts per million (ppm).

- ***October 15, 1984***: The Site was proposed for inclusion on the second update of the National Priorities List (NPL). The Site was placed on the NPL effective May 1, 1989.

- ***March 25, 1988***: The EPA issued ROD for OU1, which included contaminated soil at the Site. The selected remedy for OU1 in the ROD was excavation of the polychlorinated biphenyls (PCB) contaminated soils and treatment with a chemical dechlorination process. Following problems with the application of the treatment technology, the soil remedy was changed with an Amended ROD dated September 16, 1992. The revised remedy was excavation and off-site disposal at a Toxic Substances Control Act (TSCA) landfill. The soil remedy was completed in 1993 and resulted in the removal of approximately 2,281 cubic yards of soil. The remedy for OU1 is not affected by this Amended ROD for OU2.

- ***July 21, 1988***: The remedial investigation (RI) report for the Site was issued in two phases. The field work for the RI was performed between January 1987 and March 1988. The RI identified two water bearing zones (WBZ), which were named the uppermost WBZ and the intermediate WBZ. Nine ground water monitoring wells were installed, six of which were in the uppermost WBZ, and three in the intermediate WBZ. In addition to the monitoring wells, a cone penetrometer (CPT) was used to collect ground water samples from the uppermost WBZ only. A total of 38 ground water samples were collected from the Site. The maximum TCE concentration, 790 parts per million (ppm), was found in the uppermost WBZ. The maximum TCE concentration in the intermediate WBZ was 26 ppm.

- ***September 23, 1988***: The EPA issued a ROD for OU2, which encompasses contaminated ground water at the Site. The remedy selected by the September ROD included extraction of ground water exceeding the drinking water standard for TCE, and treatment through an air stripper followed by liquid phase and vapor phase activated carbon units. The ROD specified disposal of treated water either in a sanitary sewer or by re-injection into the water bearing zone. The ROD estimated that the ground water plume contained 12 million gallons of TCE contaminated ground water.

- ***October 8, 1993***: Commencement of ground water remediation activity. Pumping begins from 10 wells screened in the 20-foot aquifer (previously named the uppermost WBZ), and one well screened in the 80-foot aquifer (previously named the intermediate WBZ). The treated water was discharged on-site and not used to recharge the aquifer.

- ***October 12, 1994:*** The ground water system was modified to pump from the 40-foot aquifer (six wells) in addition to the 20-foot (five wells) and 80-foot aquifers (one well). The 40-foot aquifer mentioned here for the first time was previously identified as a part of the uppermost WBZ. At the same time, re-injection of treated water began into 15 shallow aquifer recharge wells that were screened in either the 20-foot or the 40-foot aquifer. Treated water not used to recharge the aquifers was discharged to a storm sewer.

The extraction and treatment system operated until October 1996, when it was shut down after various leaks were discovered.

- ***March 1998:*** Additional investigations were conducted in March 1998 to further delineate the contaminated plume north of I-610. This investigation found the existence of another aquifer, referred to as the 60-foot aquifer, located north of I-610. After installing new distribution pipes, replacing treatment plant components, and installing additional extraction and monitoring wells, pumping resumed in December 1998.

- ***November 23, 1999***: EPA Region 6 Superfund Division Director approves the first Five Year Reviews for the Site, finding that the ground water remedy might not be protective of public health and the environment. The Director orders EPA staff to initiate and undertake a Supplemental Remedial Investigation and Feasibility Study (RI/FS), in order to determine whether the ROD requires amendment and whether additional remedial action should be implemented. The Director ordered that the remediation be continued during the interim period, while studies were ongoing. However, the ground water pump and treat system continued operating until early 2000, when it was shut down again, and it remains shut down today.

- ***2000***: In 2000, an evaluation of the ground water remediation system performance found that TCE concentrations decreased in most wells, but increased in some wells. When the Site ground water recovery system was shut down, the TCE concentrations generally increased. The 2000 report concluded that the long term remediation goals would not be achieved with the existing pump and treat system. Ground water remediation has resulted in pumping and treating approximately 15.5 million gallons of contaminated ground water, which is larger, by 29%, than the volume of contaminated ground water estimated in the initial ROD for OU2. Approximately 15 percent of the treated ground water was re-injected into the shallow and intermediate aquifers with the goal of flushing contaminants from these zones. The remaining treated water was discharged to a storm sewer.

- ***December 23, 2002***: The supplemental RI report for OU2 was issued. The field activities for the supplemental RI were completed in Spring 2002. A total of 98 new monitoring wells were installed and CPT samples were collected at 39 locations. Nine water bearing zones were identified at the Site to a depth of about 200 feet below ground surface (bgs), and over 400 ground water samples were collected from these zones. The maximum TCE concentration measured during this investigation was 333 milligrams per liter (mg/L). In addition, this investigation discovered the degradation products of TCE, including cis-1,2-dichloroethene (cis-1,2-DCE) and vinyl chloride (VC). The maximum cis-1,2-DCE and VC concentrations measured were 401 mg/L and 14.2 mg/L, respectively. TCE is expected to be present as a residual dense non-aqueous phase liquid (DNAPL) because the measured concentrations exceed 1 percent of their solubilities in water. In fact, some TCE samples approached 50 percent of their solubility. However, DNAPL was not directly observed at the Site.

- ***October 17, 2003***: The supplemental Feasibility Study (FS) report for OU2 was issued by Tetra Tech EMI on behalf of EPA Region 6. The FS includes a detailed analysis of Potential Applicable or Relevant and Appropriate Requirements (ARARs) of Federal and State environmental or facility siting laws and regulations, as well as identification, screening, and evaluation of applicable remedial technologies. The FS also developed and analyzed seven remedial alternatives for the Site, including the "no action" alternative. Those alternatives are described in some detail in the Proposed Plan, as well as in this Amended ROD.
- ***CERCLA Enforcement Activities***: The EPA entered into a Consent Decree, effective March 8, 1990, with Gulf States Utilities to clean up the PCB contaminated soils at the Site (OU1). Because of the subsequent change in the soil remedy from on-site treatment to off-site disposal, an amended Consent Decree was signed and became effective on January 12, 1993. The EPA has determined that there is no remaining Potentially Responsible Party (PRP) for cleanup of the ground water at the Site.

2.3 Community Participation

The Supplemental RI/FS Report and the Amended Proposed Plan for the Site were made available to the public in April 2004. They can be found in the Administrative Record file and the information repositories maintained at the Houston Central Library at 500 McKinney St. in Houston, Texas, at the EPA Region 6 Library at 1445 Ross Ave, Dallas, Texas, and the TCEQ Records Management Center located at 12100 Park 35 Circle, Austin, Texas. A notice informing the public about the Amended Proposed Plan, documentation of the remedy alternative analysis, the public comment period, and the date and location for a public meeting was published in the Houston Chronicle on April 7, 2004. This same notice written in Spanish was also published in a Spanish language newspaper, El Dia, on April 8, 2004. In addition, a fact sheet regarding the public meeting and proposed remedy was mailed to 40 members of the community on April 12, 2004.

The public comment period was held from April 8, 2004, to May 7, 2004, and a public meeting was held at the Radisson Hotel Astrodome in Houston, Texas, on April 15, 2004, regarding the Proposed Plan. The public meeting was attended by one community member, and one question was received during the public comment period. Section 3.1 provides more information about the public meeting and comment period.

The State of Texas and the EPA have kept the community and other interested parties informed of Site activities throughout the Site's history. Information about the Site has been distributed through press releases, fact sheets, newspaper notices, and public meetings. In addition to the recent activities noted above, below is a brief history of previous public involvement efforts:

- The initial public meeting regarding the Site was held on February 6, 1985, at the Astro Village Hotel and Lodge. This meeting followed the EPA announcement of the proposed NPL listing of the Site and was attended by 15 community members. The main concern expressed by area homeowners related to the possibility of exposure of children that might go into the contaminated area.

- On October 3, 1985, the EPA issued a press release with information that the RI and feasibility study (FS) were being conducted to determine the nature and extent of contamination, and to evaluate remedy alternatives for the Site.

- The TWC issued a news release on August 22, 1986, to provide notice of a meeting to be conducted on September 24, 1986. At the meeting, information was provided on the planned RI and FS to be conducted by Radian Corporation. The Site evaluation was divided into two separate studies, one for surface soil contamination, and the second for ground water contamination. Another information release sent by TWC on January 11, 1988, explained that greater amounts of TCE were found in the ground water, and that additional ground water monitoring walls would be installed to define the extent of contamination.

- A press release from the EPA on January 21, 1988, announced a public meeting to be held on February 2, 1988, to identify the proposed remedy for the contaminated soil at the Site. The press release listed the remedy alternatives, and stated that proposed remedy consisted of chemically treating the soil to produce a nontoxic salt. In February 1988, a Proposed Remedial Plan Fact Sheet was distributed. Approximately 35 people attended the public meeting. Another press release from the EPA on March 25, 1988, announced that the selected soil remedy would be a chemical dechlorination treatment to neutralize the PCB. The treated soil was to be returned to the Site and covered with vegetation.

- A ROD fact sheet was released in May 1988 to explain the soil remedy and to provide notice that pilot testing would be performed to determine the effectiveness of the treatment technology.

- A proposed plan and fact sheet were distributed in August 1988 to describe the initial proposed remedy for ground water contamination. The proposed remedy was ground water pumping and treatment by air stripping followed by activated carbon. A public comment period was held from August 10, 1988, to September 9, 1988. Also, a public meeting was held August 25, 1988 to present the proposed plan and discuss the alternative ground water remedial actions. Approximately 15 persons attended this meeting.

- The EPA issued a press release in September 1988 stating that the original selected ground water remedy was pumping with treatment by air stripping and carbon adsorption. This was followed up with a fact sheet issued in October 1988 that summarized the original ROD for ground water.

2.4 Basis for the ROD Amendment

Amendment of the ground water ROD is necessary because the continuing presence of high contaminant levels indicates that the remediation goal of restoring the aquifer to drinking water standards cannot be achieved with the existing system. High contaminant levels remain in spite of pumping more than 15 million gallons of ground water, which is more than the contaminated plume volume of 12 million gallons estimated in the original ground water ROD. Further, the area of contamination has spread since ground water remediation began, indicating that the remediation system was unsuccessful in containing the contaminate plumes. The Site aquifers are described below in Section 2.6 (Site Characteristics - Geology and Hydrogeology).

The continued presence of high contaminant levels and the increase in plume size support the presence of DNAPL as a continuing source. Also, contaminant concentrations are still very high, in some areas greater than 10% of their solubility in water. It is expected that the DNAPL is present as a residual phase although no free DNAPL has been observed in Site wells or borings. Residual DNAPL is, by definition, not mobile, and therefore cannot be practically removed by conventional pumping remedies. Because TCE DNAPL is only slightly soluble in water, source areas can remain for many decades. Remediation is also complicated by the fact that the water bearing zones are separated by contaminated low permeability zones, which will slowly feed contaminants into the aquifers. Historically, sites with DNAPL are very difficult to clean up to drinking water standards. The ground water pump and treat remediation system at the Site produced the following results:

- The maximum TCE concentrations in WBZ-2 (formerly known as the uppermost water bearing zone) in 1988, before ground water remediation started, were 500 ppm (Phase 1, May 1988) and 790 ppm (Phase 2, July 1988). The ground water pumping and treatment system operated for about five years, and was shut down for two years, between 1993 and 2000. Sampling conducted in November 1998 in WBZ-2 (also formerly known as the 40-foot aquifer) a maximum TCE concentration of 550 ppm. In 2002, the maximum TCE concentration was 333 mg/L (MCL 0.005 mg/L). The maximum concentrations of cis-1,2-DCE and VC, products of TCE degradation, were 401 mg/L (MCL 0.07 mg/L), and 14.2 mg/L (MCL 0.002 mg/L), respectively. Sampling performed in 2002 found that the cleanup goals were still far from being reached, even after pumping more than the originally estimated volume of contaminated water.

- Based on samples collected in November 1998 and more recent sampling done in the spring of 2002, the dissolved TCE contaminate plumes in WBZ-1, WBZ-2, and WBZ-4 have each spread to the north, east, and south during operation of the ground water remediation system. The spread of the contamination and the failure to achieve significant reductions in contaminant levels indicates that the previous pump and treat remediation system will not be successful in reaching, within a reasonable time frame, the cleanup levels set in the 1988 ground water ROD.

The EPA has determined that the contamination in the source areas at the Site can be significantly reduced with an enhanced in-situ bioremediation process. Pilot and/or field demonstration of in-situ bioremediation projects have been implemented recently and proven successful at contaminated ground water sites at Dover Air Force Base in Delaware, at Kelly Air Force Base in Texas, and at the Aerojet Superfund Site in California. In addition, bench scale tests conducted for the Supplemental RI demonstrated that bioremediation of contaminated aquifer soil samples from the Site resulted in degradation of the contaminants. MNA will be used to restore the balance of the contaminated ground water plumes, outside of the source areas, to drinking water standards. Additional information supporting the justification for a ROD amendment follows:

- An ISB pilot was conducted at Dover Air Force Base, Delaware between September 1996 and March 1998. Ground water contaminants included tetrachloroethylene (PCE), TCE, cis-1,2-DCE, and VC. The pilot consisted of three injection wells, about 20 feet apart, in a line about 60 feet up-gradient from three extraction wells, also spaced about 20 feet apart. The total pilot area was about 40 feet by 60 feet. The pilot was operated in a ground water recirculation configuration. Following nutrient, substrate, and dechlorinating microorganism injection, the TCE concentration was reduced from 7.5 ppm to less than the MCL (0.005 ppm) within 18 months.

- Another pilot for in-situ bio-remediation was conducted at the Aerojet Superfund Site in California in the summer of 2001. Contaminated ground water was pumped from two wells, a substrate was added (ethanol), and the amended water was re-injected into the aquifer. Dechlorinating microorganisms had been previously injected. Downgradient concentrations of TCE, cis-1,2-DCE, and VC were typically reduced to or below the MCLs. Based on data from the pilot, the half-life of dechlorination of TCE to ethene ranged between 4.1 and 11 days.

- An in-situ bio-remediation pilot was conducted at Kelly Air Force Base in Texas. The pilot was located near Building 360. The contaminants include PCE, TCE, and cis-1,2-DCE. The pilot consisted of one injection well and three extraction wells. The extraction wells were located in a line about 30 feet downgradient from the injection well. Based on an interwell tracer study, the travel time between the injection well and the first extraction well was four to eight hours. Methanol and acetate (electron donors) were injected initially, and later dechlorinating microorganisms were added. The pilot results indicated that the half-life of chlorinated compound dechlorination to ethene was approximately 3.8 hours.

2.5 Scope and Role of Operable Unit

The EPA divided the Site into two operable Units. Contaminated soil at the Site was included in OU1, and ground water contamination was included in OU2. This amended ROD applies to only the contaminated ground water at the Site, OU2.

- OU1 addressed remediation of contaminated soil caused by releases of PCBs resulting from operations to salvage electrical transformers. The response action for OU1, excavation and disposal in an off-site landfill, was completed previously.

- OU2, which addresses contaminated ground water at the Site, is the remedial action covered by this amended ROD. OU2 includes the residual DNAPL source areas and the dissolved chlorinated solvent ground water plumes outside of the source areas. Ground water at the Site poses a current and future risk to human health because the EPA's acceptable risk range is exceeded and concentrations of contaminants are greater than the maximum contaminant levels for drinking water. The primary purposes of this response action are to reduce the mass of contaminants in the ground water to levels below MCL ARARs, to prevent the spread of ground water contamination, and to ultimately restore the ground water outside of the source areas to drinking water standards. Exposure to ground water contamination during the conduct of the remediation will be prevented by the use of institutional controls.

The selected remedy for OU2 addresses the principal threat at the Site by in-situ treatment of residual DNAPL source material in the water bearing zones. The second operable unit is intended to be the final response action for the Site.

2.6 Site Characteristics

Site Overview

The Site is located within the city limits of Houston, Texas, just south of Interstate Highway 610 (I-610) and west of State Highway 288, as shown on Figure 1. The Site is bounded on the north by the eastbound feeder road of I-610, east by South David Street, south by Mansard Street, and west by Knight Street. Site features include two buildings and a loading area in the northern portion of the Site. Much of the southern portion of the Site is paved. The Site ground water extraction system used for the initial pump and treat ground water remedy is currently shut down. However, the waste water treatment plant (WWTP) is operational and is presently used to treat rain water that collects on the decontamination pad. Utilities in the general vicinity of the Site include buried gas lines, overhead electric lines, storm sewer and sanitary sewer pipes, telephone lines, and water supply lines. The Site boundary is detailed in Figure 2 and encompasses about 0.75 acres.

Within 1 mile of the Site are residential, commercial business, and light industrial areas. The commercial business and light industrial areas are located directly east and south of the Site, and Six Flags Astroworld, Astrodome, and Reliant Stadium recreational and sports facilities are located less than a mile to the northwest. Privately owned, single and multi-family dwellings are located about 3,000 feet west of the Site.

The residential population within a 1-mile radius of the Site is about 2,000. Maximum daily traffic of 100,000 persons is estimated to move within a 1-mile radius of the Site, primarily resulting from daily highway traffic on I-610 and recreational activities associated with Reliant Stadium, the Astrodome, and Six Flags Astroworld.

The nearest surface water body to the Site is Brays Bayou, located approximately 1.6 miles to the north. Brays Bayou flows from the southwest to the northeast into Buffalo Bayou with the confluence located approximately 4 miles northeast of the Site. The lower portion of Buffalo Bayou has been dredged to serve as a ship canal for the Port of Houston. Buffalo Bayou flows southeastward into the San Jacinto River, approximately 12 miles southeast of Houston. Brays Bayou, drains approximately 95 square miles, including the Site.

On September 14, 1981, a City of Houston work crew noted strong chemical vapors while installing a waterline along the north ditch of Mansard Road, adjacent to the Site. The Site was investigated the same day by representatives of TWC and the City of Houston Department of Health. A strong chemical odor was noted. The inspection found that approximately 75 drums were scattered on the Site at 1415, 1417, and 1419 South Loop West. Most of the drums were labeled "trichloroethene" and were empty and punctured. A strong chemical odor was detected in tap water supplied by a well at 1417 South Loop West. At that time, a worker at an adjacent business stated to a TWC field representative that he had observed persons emptying drums on the Site early in 1981. Between March 16 and March 29, 1982, the drums labeled trichloroethene disappeared from the Site.

Geology and Hydrogeology

The Site is located within the Texas Coastal Plain region. The Texas Coastal Plain region is underlain by thousands of feet of sand and clay (coastal plain) deposits, which are mostly unconsolidated. The Site is directly underlain by the Beaumont Formation of the Pleistocene Epoch, which consists of former barrier island and beach deposits made up of clay, silt, and sand. Near the Site, the Beaumont Formation consists mainly of clay and mud of low permeability with a high water storage capacity. The Beaumont Formation is estimated to be up to 500 feet thick and directly underlies the Site; it is made up of fluvial deltaic system deposits consisting of abandoned, mud-filled channels, and courses.

The uppermost regional aquifer present in the Houston-Galveston area, the Chicot, is the major aquifer near the Site. In nearby Galveston County, the Chicot aquifer is the major source of ground water. It is composed of alternating beds of clay, silt, sand, and gravel. The beds were deposited in a series of fluvial-deltaic environments and have been affected by rapid changes in sedimentation rate, regional subsidence of the Gulf of Mexico, and changes in mean sea level since the end of the Tertiary Period. These variations were manifested both laterally and vertically, making differentiation of individual beds and correlation of them more complex. Sand bodies in the upper Chicot aquifer vary in thickness and lateral continuity. Sands of the upper Chicot aquifer are typically less than 100 feet thick, although they coalesce locally, forming thicker bodies. Lenticular zone geometries are common.

Nine water bearing zones (WBZ) were identified in the Supplemental RI to a depth of about 200 feet below ground surface (bgs) at the Site. The WBZs are composed primarily of silty or sandy sediments capable of storing and transporting water. WBZs are named from shallowest to deepest as WBZ-1, WBZ-2, WBZ-3, and so on, with subunits being assigned a suffix of A, B, C, or D within a WBZ as appropriate. The top four of these WBZs have been affected by contamination from the Site. The nine water bearing zones are described below.

- *Water Bearing Zone 1*: WBZ-1 exists at depths of about 18 to 24 feet bgs. This unit was previously named the 20-Foot Zone and Shallow Aquifer. The sand in this unit is fine to very fine-grained and silty to very silty, and very moist to wet. It is thickest (4.4 feet near Cluster 3) southeast of the source area and laterally pinches out north of I-610 and to the east near Cluster 27. Figure 3 shows the thickness of WBZ-1 at the Site. Ground water flow in WBZ-1 is generally to the north-northwest near the Site, and north-northeast to the north of I-610. WBZ-1 is a semi-confined aquifer, and the results of the aquifer pump test conducted in May 2002 indicate that it is hydraulically connected with underlying WBZ-2 and WBZ-3 in localized areas of the Site. Aquifer tests conducted in 1993 on WBZ-1 determined that the hydraulic conductivity is 3.8 ft/day. Assuming a hydraulic gradient of 0.00265 ft per ft within WBZ-1 and an effective porosity of 0.21 (60 percent of measured total porosity), a ground water seepage velocity of 0.048 ft/day (17.5 ft/year) is estimated for WBZ-1. Aquifer storativity is estimated to range from 0.0002 to 0.00002

- *Water Bearing Zone 2*: WBZ-2 exists at depths of approximately 33 to 40 feet and was previously described as the Uppermost Aquifer, 40-foot Zone, and Shallow Aquifer. This unit is composed of a silty or clayey, fine-grained sand. The unit is divided into WBZ-2A and WBZ-2B. WBZ-2A is sparsely distributed and discontinuous throughout the Site. The lower portion (WBZ-2B) is more continuous throughout the Site. A structure map on the base of WBZ-2 indicates a distinct stream channel cut into the underlying low permeability zone. The most prominent stream channel divides the Site and exists along a line north from Cluster 18, trends south toward MW-12, and then trends southeast toward Cluster 1. This stream channel is relatively narrow and cuts almost 7 feet deep into the underlying clays. A less-prominent stream channel exists along a line from north of Cluster 20, trends south toward Cluster 14, and appears to then trend to the east. The WBZ-2 sand is thickest (11 feet thick) near Cluster 18 and thinnest (3.5 feet thick) to the northeast of the Site where it laterally grades into clay. Figure 4 shows the thickness of WBZ-2 at the Site. Ground water in WBZ-2 generally flows to the north-northwest with a gradient of about 0.0037 ft per ft. The WBZ-2 aquifer exhibits characteristics of a confined leaky system. Results of the aquifer pump test conducted in May 2002 indicate that WBZ-2 is leaky and hydraulically connected with both WBZ-1 above and WBZ-3 below in localized areas of the Site. A ground water seepage velocity of 41.9 ft/year is estimated for WBZ-2 based on a hydraulic conductivity of 5.9 ft/day, a hydraulic gradient of 0.0037 ft per ft, and an effective porosity of 0.19 (60 percent of measured total porosity). The storativity estimates for WBZ-2 range between 0.00002 and 0.001.

- *Water Bearing Zone 3:* WBZ-3 is a complex stratigraphic interval of sand and clay layers. This interval of sand and clay layers was described in previous investigations as the 60-foot zone. Three individual sand lenses in the WBZ-3 interval have been identified as distinct units and are named, from shallowest to deepest, WBZ-3A, WBZ-3B, and WBZ-3C. WBZ-3A is a silty to clayey fine sand existing at depths between about 43 to 50 feet bgs. The sand is present as an elongated north/south trending unit in the western portion of the Site. The unit is generally thin (0 to 3 feet), and laterally grades into clays. The next deeper sand, WBZ-3B, exists at a depth of 50 to 57 feet bgs. Near Clusters 13, 14, 23, and 26, WBZ-3A and WBZ-3B coalesce and are not separated by clays. The deepest sand, WBZ-3C, exists from about 57 to 67 feet bgs. WBZ-3C is the most widespread sand in WBZ-3. Figure 5 shows the thickness of WBZ-3C at the Site. This poorly graded, often clayey and laminated sand is unconsolidated. Core recovery in this sand interval was often poor because of the unconsolidated nature (lack of cement and compaction) of the sand. Ground water flow within WBZ-3 is to the east-northeast. A ground water seepage velocity of 36.5 ft/year is estimated for WBZ-3C based on a hydraulic conductivity of 5 ft/day, a hydraulic gradient of 0.0042 ft per ft, and an effective aquifer porosity of 0.21 (60 percent of measured total porosity).

- *Water Bearing Zone 4:* WBZ-4 exists at depths of about 80 to 90 feet bgs and was previously named the Intermediate Aquifer, the 80-foot zone, and the Deep Aquifer. WBZ-4 is fine sand, clayey and silty to poorly graded, unconsolidated, and often stratified with clay and silt layers. Analysis from three geotechnical samples collected in WBZ-4 determined an average porosity of 35.9 percent. The WBZ-4 sand or equivalent silt is present at all boring locations. Ground water in WBZ-4 generally flows to the west-northwest with a gradient of about 0.0055 ft per ft. An anomaly to this gradient exists in the northern portion of the Site where ground water flows to the east from MW2304 to MW2404. In addition, ground water flow in the eastern portion of the Site flows in a more northerly direction. These reversals in gradient produce a slight ground water elevation ridge trending north to south in the eastern portion of the Site.

  WBZ-4 exhibits characteristics of a confined aquifer. Data obtained from the May 2002 aquifer test showed no evidence of hydraulic communication between WBZ-3 and WBZ-4 near Cluster 23. However, there are indications of a hydraulic connection between WBZ-4 and the shallower WBZs, possibly in both the source area and up-gradient of Cluster 26. Aquifer tests conducted in 1991 on WBZ-4 determined that the hydraulic conductivity is 7.49 ft/day. Assuming a hydraulic gradient of 0.0055 ft per ft within WBZ-4 and an effective porosity of 0.22 (60 percent of measured total porosity), a ground water seepage velocity of 0.19 ft/day (68 ft/year) is estimated for WBZ-4.

- *Water Bearing Zones 5 - 9:* WBZ-5 through WBZ-9 occur at depths ranging from 95 to 200 feet bgs. These five water bearing zones range between sands and clayey fine sands that are separated by clay intervals.

Remedial Investigation

Ground water from the existing wells was sampled between October 30, 2000, and February 8, 2001. A total of 65 existing monitoring wells were sampled to confirm the extent of the dissolved contaminant plumes in the four WBZs previously identified at the Site and to determine baseline conditions for establishing the potential for MNA as a remedial alternative for the Site. The ground water pump and treat system was inactive for about six months before this ground water sampling activity occurred.

A second round of ground water samples were collected from existing monitoring wells between September 2001 and December 2001. Ground water samples were collected and analyzed for volatile organic compounds (VOC) and metals. Initially, four samples were analyzed for a full suite of VOCs. The analysis suite was subsequently reduced to a short list of VOCs (TCE, cis-1,2-DCE, trans-1,2-DCE, 1,1-DCE, and VC) because the majority of analytes were not detected. The samples were also analyzed for ammonia, total organic carbon, alkalinity, and anions.

A geological investigation was conducted to collect information regarding Site geologic conditions, the horizontal and vertical extent of ground water contamination, and to determine the locations and screened intervals for future monitoring wells. The geological investigation included gamma ray geophysical logging of 24 existing monitoring wells, cone penetrometer (CPT) logging at 39 locations, and direct push MIP/Conductivity logging at 99 locations at the Site.

The MIP/Conductivity equipment consists of a MIP gas measuring system and a soil conductivity measuring tool. The tools are mounted together and are driven into subsurface soils with a direct push unit. The MIP measuring device can detect various hydrocarbon compounds present in soil. It uses a gas chromatograph that was calibrated for TCE detection at the Site. MIP/Conductivity logging depth was limited by the physical durability of the MIP/Conductivity tools. The average depth that the MIP/Conductivity tool could be driven was 43 feet bgs, which was just below WBZ-2, and the maximum depth reached was 64 feet bgs.

Ground water samples were also collected using the MIP/Conductivity and CPT rigs. A total of 246 discrete ground water samples were collected at field-selected locations and depth intervals. The sample points were based on MIP/Conductivity and CPT data. Ground water samples were analyzed for volatile organic compounds and alkalinity. Some samples were also analyzed for parameters that impact natural attenuation performance, including nutrients (i.e., ammonia, nitrate, nitrite, ortho-phosphate, and total organic compounds), sulfide, ferrous iron, iron, sulfate, chloride, methane, ethane, ethene, carbon dioxide, and hydrogen. Water quality parameters were also measured, including pH, oxidation/reduction potential, dissolved oxygen, specific conductance, and alkalinity.

Soil borings were done for a number of reasons, including soil waste characterization, stratigraphic logging, monitoring well installation, aquifer testing, and microcosm sampling using the hollow stem auger method. The soil boring locations were selected based on ground water analytical results from existing wells, MIP/Conductivity and CPT logging data, and information from previous investigations. Samples were continuously collected from the borings using either a split barrel core sampler, a split spoon sampler, or Shelby tubes. During drilling, DNAPL detecting ribbon was used to screen the soil cores for the presence of DNAPL for all borings near the source area. Core samples were laid on the cloth ribbon, and if DNAPL was present, the cloth ribbon would change color. There was no evidence of the presence of DNAPL from any of the borings. Ninety-eight of the soil borings were converted to ground water monitoring wells between June and December 2001. Geotechnical samples were also collected and analyzed for moisture content, unit dry weight, specific gravity, porosity, hydraulic conductivity, organic content, and ash content. The geotechnical data were used to support fate and transport analysis and evaluate natural attenuation as a potential remedy.

The hydraulic properties at the Site were estimated from slug and pump tests conducted between January and May 2002. Slug tests were conducted in 24 monitoring wells at the Site to determine hydraulic conductivity and transmissivity values in the WBZs. The slug tests were conducted on representative wells from each WBZ to obtain information that was used to design the pump testing program. The objectives of the aquifer testing program were to characterize aquifer hydraulic parameters such as hydraulic conductivity, transmissivity, and storativity for WBZ-3, and to evaluate the extent of hydraulic communication with the overlying and underlying WBZs. The aquifer pump test program consisted of a step-drawdown test, a constant rate pumping test, and a recovery test.

On May 1 and 2, 2003, ambient air sampling was done at nine workplace locations around the Site. This sampling event was performed to determine if any of the businesses located on or near the source plume were being exposed to hazardous levels of TCE, cis-1,2-DCE, or VC.

Nature and Extent of Contamination

The Site was contaminated by releases of chlorinated solvents and transformer oils to the soil. Soil sampling data collected from 1981 to 1988 identified three possible contamination source areas in ground water based on TCE concentrations in soil samples. These formerly defined source areas (A, B, and C) are identified on Figure 6. The three major potential source areas for TCE contamination of ground water are as follows:

- Soil contamination Area A is approximately 100 ft by 50 ft. The highest concentration (2,862 mg/kg) was detected in the north-central portion of Area A.
- The dimensions of Area B are approximately 100 ft by 30 ft. The highest soil concentration of TCE (510 mg/kg) was detected in the northern portion of Area B.
- The dimensions of Area C are approximately 40 ft by 30 ft. The highest soil concentration of TCE (325 mg/kg) was detected in the southeast portion of Area C.

The TCE released at the surface migrated down to the upper four water bearing zones at the Site. A description of contamination by individual water bearing zone follows.

- *Water Bearing Zone 1:* Figure 7 shows the WBZ-1 ground water concentration of TCE. The highest detected TCE ground water concentration in WBZ-1 was 333 mg/L. This concentration is within the range of 10 to 50 percent of the solubility of TCE, which indicates that DNAPL could be present. Based on solubility values, an approximate area of 0.58 acres could be expected to contain TCE DNAPL. The dissolved plume extends from the source area to the east, west, and north under I-610. The total area of the plume with a concentration greater than the MCL is approximately 10.71 acres. The plume extends north of I-610; however, concentrations on the north side of I-610 show decreasing concentrations to the north. The extent of the TCE plume has increased in aerial extent to the north, east, and south based on a comparison of recent sampling data and previous sampling done in November 1998. The area of highest concentrations has decreased in size and has migrated to the north and east in WBZ-1.

  The cis-1,2-DCE concentrations exceeded the MCL of 0.07 mg/L in 28 of the 37 WBZ-1 wells sampled during in 2001. The highest detected cis-1,2-DCE concentration was 401 mg/L at well SZE-2, which is within the original source area. This concentration is within the range of 10 to 50 percent of the solubility of cis-1,2-DCE. Maps indicate three areas that have cis-1,2-DCE concentrations greater than 35 mg/L (1 percent of the solubility of cis-1,2-DCE). These areas total approximately 0.89 acres. One of the three areas is near the source area. A second, isolated area to the east is limited to the area immediately surrounding well MW0301, with a concentration of 199 mg/L. The third area, limited to the area immediately surrounding well MW-24 on the west side of the plume, has a concentration of 46.3 mg/L. The total area of the cis-1,2-DCE plume with a concentration greater than the MCL is approximately 4.3 acres.

The VC concentrations exceeded the MCL of 0.002 mg/L in 24 of the 37 WBZ-1 wells sampled in 2001. The remaining samples had concentrations below the laboratory detection limit. The highest detected VC concentration was 9.25 mg/L near the source area. All concentrations were below 11 mg/L (1 percent of the solubility of VC). The VC plume in WBZ-1 extends from the source area to the east and west and is restricted to an area south of I-610. The total area of the plume with a concentration greater than the MCL is approximately 3.94 acres.

- *Water Bearing Zone 2:* Figure 8 shows the WBZ-2 ground water concentration of TCE. TCE concentrations in WBZ-2 exceeded the MCL of 0.005 mg/L in 41 of the 52 wells sampled during 2001. The highest detected TCE concentration was 262 mg/L at well SE-3, within the originally defined source area. This concentration is within the range of 10 to 50 percent of the solubility of TCE, which indicates that TCE DNAPL could be present. Concentration values greater than 160 mg/L are seen in the adjacent four closest WBZ-2 wells (MW-04, SE-4, MW-11 and MW-27). Based on well samples exhibiting solubility values greater than 1 percent, an area of approximately 2.4 acres could contain DNAPL. The TCE plume extends from the source area to the east, west, and north under I-610, and is present north of I-610. The total area of the plume with a concentration greater than the MCL is approximately 13.83 acres. Concentrations greater than 11 mg/L (1 percent of solubility) extend beneath I-610 to well MW1902, with a concentration of 63.9 mg/L. Concentrations on the north side of I-610 decrease outward from MW1902. The extent of the TCE plume in WBZ-2 has increased in aerial extent to the north, east, and south based on a comparison of recent sampling data and previous sampling done in November 1998. The area of highest TCE concentrations has increased in size and has migrated to the north and southwest. The concentrations in the older wells have generally decreased.

The cis-1,2-DCE concentrations exceeded the MCL of 0.07 mg/L in 29 of the 52 WBZ-2 wells sampled in 2001. The highest detected cis-1,2-DCE concentration was 367 mg/L at well MW-07, coincident with a source area. There are two areas shown that have cis-1,2-DCE concentrations greater than 35 mg/L (1 percent of the solubility of cis-1,2-DCE). These areas total approximately 0.93 acres. One of the three areas is located near the source area (at well MW07) and extends to the west. A second, isolated area to the east is limited to the area immediately surrounding well MW0301, with a concentration of 112 mg/L. The cis-1,2-DCE plume in WBZ-2 extends north of I-610. The total area of the cis-1,2-DCE plume with a concentration greater than the MCL is approximately 6.91 acres. The extent of the cis-1,2-DCE plume in WBZ-2 has increased in aerial extent to the north, east, west, and south based on a comparison of recent sampling data and previous sampling done in September 1999. The area with solubility values greater than 1 percent has increased significantly, primarily extending to the west in WBZ-2.

The VC concentrations exceeded the MCL of 0.002 mg/L in 24 of the 52 WBZ-2 wells sampled in 2001. The highest detected VC concentration was 14.2 mg/L at well SE-4, north and west of the source area. This concentration is greater than 1 percent of the solubility of VC. The plume extends north of I-610. The total area of the VC plume in WBZ-2 with a concentration greater than the MCL is approximately 5.94 acres.

- *Water Bearing Zone 3:* Figure 9 shows the ground water concentration of TCE in WBZ-3C, which is the most widespread of the WBZ-3 sub-zones. The maximum TCE concentration in WBZ-3A&B is 282 mg/L. This concentration is within the range of 10 to 50 percent of the solubility of TCE, which indicates that TCE DNAPL could be present. The maximum cis-1,2-DCE concentration in WBZ-3A&B is 3.81 mg/L. This concentration is less than 1 percent of the solubility of cis-1,2-DCE. None of the WBZ-3A&B wells contained VC concentrations above the MCL. However, the result from well MW0303 was reported as less than 0.02 mg/L. Because the reporting limit is greater than the MCL, the exact limit of contamination near this well not certain.

  TCE concentrations in WBZ-3C exceeded the MCL of 0.005 mg/L in 18 of the 23 WBZ-3C wells sampled. The highest detected WBZ-3C TCE concentration was 25.6 mg/L at well 1903, north of I-610. This concentration is within the range of one to 10 percent of the solubility of TCE, which indicates that DNAPL could be present. Based on wells exhibiting solubility values greater than 1 percent, an area of approximately 0.04 acres could contain DNAPL. The total area of the TCE plume with a concentration greater than the MCL is approximately 15.03 acres.

  The cis-1,2-DCE concentrations exceeded the MCL of 0.07 mg/L in two of the 19 WBZ-3C wells sampled in 2001. The highest detected cis-1,2-DCE concentration in WBZ-3C was 0.282 mg/L at well DS-3, just north of I-610. The cis-1,2-DCE plume in WBZ-3C extends from the lesser source areas defined by MW0703 to the northwest in a thin band. The total area of the plume with a concentration greater than the MCL is approximately 0.75 acres.

The VC concentrations exceeded the MCL of 0.002 mg/L in two of the 27 WBZ-3C wells sampled in 2001. The highest detected WBZ-3C VC concentration was 0.182 mg/L at well DS-3, just north of I-610. The concentration in the sample from this well falls within the range of 0.01 to 1 percent of the solubility of VC. The only other VC concentration (0.004 mg/L) was detected in well MW1103. Based on the VC concentrations, VC DNAPL is not expected in WBZ-3C.

- *Water Bearing Zone 4:* Figure 10 shows the WBZ-4 ground water concentration of TCE. TCE concentrations exceeded the MCL of 0.005 mg/L in 17 of the 33 WBZ-4 wells sampled during 2001. The highest detected TCE concentration was 1.58 mg/L at well MW1304. This concentration is less than 1 percent of the solubility of TCE, which indicates that TCE DNAPL is not expected to occur within the WBZ-4. The plume extends from the source area to the east, west, and north, likely extending under I-610. The total area of the plume with a concentration greater than the MCL is approximately 3.76 acres. Three isolated zones with concentrations above the MCL are seen in the area. Two are on the north side of I-610 and one is on the eastern portion of the Site. On the north side of I-610, MW2604 has a concentration of 0.138 mg/L, and MW 2204 has a concentration of 0.006 mg/L, which is just above the MCL. The extent of the TCE plume in WBZ-4 has increased in aerial extent to the north, east, and south based on a comparison of recent sampling data and previous sampling done in September 1999. The area of highest concentrations has decreased in size and has migrated to the west, coinciding with ground water flow direction.

  The cis-1,2-DCE concentrations exceeded the MCL of 0.07 mg/L in one of the 33 WBZ-4 wells sampled in 2001. The only detected cis-1,2-DCE concentration was 1.02 mg/L (from the sample at well IE-1). This well is located near the source area. Twenty-one wells were below the laboratory reporting limits.

  No VC concentrations exceeded the MCL of 0.002 mg/L in any of the 33 WBZ-4 wells sampled in 2001.

- *Water Bearing Zones 5 through 9:* No cis-1,2-DCE or VC was detected in any of these water bearing zones. While TCE was present in most of these zones, none of the samples exceeded the MCL for TCE with the exception of one sample from WBZ-7. The TCE concentration in this sample was 0.0064 mg/L, which is slightly above the MCL for TCE (i.e., 0.005 mg/L). The EPA does not judge this sample result to be significant because it was an isolated sample result from a zone below two shallower zones that did not exceed the MCL.

In summary, the largest ground water plumes are in WBZ-1, WBZ-2, and WBZ-3C. The total areas of the TCE plumes in these WBZs range from 10 to 15 acres. In WBZ-4, the TCE plume is less than 4 acres. The cis-1,2-DCE and VC plumes are largest in WBZ-1 and WBZ-2, where they are about one-third to one-half the area of the TCE plumes. In WBZ-3, the cis-1,2-DCE and VC plumes represent only about 5 percent of the area of the TCE plume. Neither cis-1,2-DCE nor VC is significant in WBZ-4. It appears that greater than 80 percent of the ground water contamination (by area) has migrated beyond the Sol Lynn property boundaries. The Site history establishes that cis-1,2-DCE and VC were not used at the Site, and therefore are likely the result of degradation of TCE.

Indoor Air

Indoor air sampling was conducted at nine commercial locations in the vicinity of the Site. The addresses ranged between 1400 and 1419 South Loop West, and at Sarah Ave. Figure 11 shows these indoor air sampling locations. Indoor air samples from six of the locations did not detect any TCE, cis-1,2-DCE, or VC. Two of the air sample locations, located at 1417 and 1417B South Loop West, found indoor cis-1,2-DCE concentrations of 0.7 and 2.2 ppbV, respectively. Neither of these two locations detected any TCE nor VC. The highest indoor air concentrations were found at 1419 South Loop West. At that location, a total of three air samples collected in May and June 2003. The maximum detected indoor air concentrations were, for TCE: 5.6 ppbV; for cis-1,2-DCE: 61.6 ppbV; and for VC: 0.9 ppbV. Additional indoor air samples collected at 1419 South Loop West in 2004 found TCE at 2.7 ppbV and VC at 2.8 ppbV. Also in 2004, sample results from a commercial building located just southwest of the Site did not detect any TCE or VC.

Fate and Transport of Contaminants

The current source of contamination is the solvent-contaminated soil and ground water that has accumulated contaminants in pore space of the vadose zone and in the WBZs. The release mechanisms include desorption and dissolution of chemical compounds from the free or residual product (i.e., DNAPL). Ground water flow (vertical and horizontal) is one potential migration route for the contaminants at the Site. Contaminants can also volatilize and migrate through the vadose zone to the surface and the indoor air of any building located above the ground water plumes. Volatilization is typically significant in the vadose zone and near the water table for the contaminants, but is generally negligible below the water table.

Transport of contaminants in the ground water occurs by processes including advection and dispersion. Advection is the movement of contaminants with the ground water, and is one of the predominant transport processes in ground water. The velocity of advective transport is affected by the velocity of the ground water and the rate of adsorption/desorption of the contaminants to the aquifer matrix. A contaminant that is readily adsorbed will be transported slower that a contaminant that is less readily adsorbed. This movement occurs in a vertical downward direction in the vadose zone and in both horizontal and vertical directions in aquifers. At the Site, advection of the dissolved plumes of TCE, cis-1,2-DCE, and VC follow the ground water flow mainly in the horizontal direction. Dispersion is an important transport process in ground water that is applicable to all chemical groups. Dispersion is the tendency for a solute to spread out from the route that it would be expected to follow according to the hydraulics of an aquifer. It generally causes dilution and the spreading of contaminant plumes.

DNAPL was not directly observed during the supplemental remedial investigation. However, because concentrations exceeded 1% of the solubility in water, DNAPL is presumed to exist as residual droplets trapped in pores by surface tension, and is essentially immobile in the source areas. As pore water moves past the residual DNAPL, TCE dissolves into the aqueous phase. As long as residual DNAPL is present, this source of TCE contamination to ground water will persist. Many years could be required for the entire mass of residual DNAPL to be dissolved. Once in the aqueous state, TCE, though somewhat retarded by adsorption onto the soil matrix, will migrate downgradient with ground water flow. As it migrates, dissolved TCE can degrade under anaerobic geochemical conditions to cis-1,2-DCE, which, in turn, will degrade to VC. The resultant daughter products, cis-1,2-DCE and VC, will, in turn, migrate with ground water and sorb onto the soil matrix and undergo degradation.

The partitioning, or distribution, of contaminants between soil and ground water can be expressed by the distribution coefficient (Kd). The distribution coefficient of an organic compound is the ratio of concentration of the compound in soil to that in ground water, or the partitioning between soil and ground water. Based on Site data, distribution coefficients for the contaminants were estimated for WBZ-1, WBZ-2, and WBZ-3. All of the contaminants at the Site are considered mobile in ground water. However, TCE will adsorb most to soil, followed by cis-1,2-DCE, and VC will adsorb the least. In WBZ-1 and WBZ-2 virtually all of the contaminant mass is in the aqueous phase. For example, in WBZ-1, the Kd for TCE is 0.08, which predicts that only 8% of TCE will be adsorbed onto the soil, and 92% would be dissolved in the ground water. For WBZ-3, which contains a greater amount of organic carbon, the ratio of adsorbed to aqueous contamination can be about equal. An exception is VC, which tends to not adsorb because of its low organic carbon partitioning coefficient.

The least adsorbed, and therefore least retarded, contaminants are those with the greatest transport velocities. Of the contaminants present, VC is the most mobile, cis-1,2-DCE is slower, and TCE is the slowest because it is adsorbed to a greater extent than the others. The estimated transport velocities are in the range of 26 to 36 feet per year for VC, 18 to 25 feet per year for cis-1,2-DCE, and eight to 21 feet per year for TCE.

The fate of contaminants in ground water can be affected by a number of processes, including biodegradation. Biodegradation refers to the process in which chemicals are metabolized by microorganisms in soil and ground water. The most important destructive mechanism for highly chlorinated solvents is anaerobic reductive dechlorination, which is the process considered to be dominant at the Site. Anaerobic reductive dechlorination is the biologically driven reductive degradation of chlorinated compounds. It generally involves the sequential replacement of chlorine atoms on a chlorinated solvent with hydrogen atoms. With reductive dechlorination, the more oxidized of the chlorinated ethenes, such as TCE, are most favored to be dechlorinated, with fewer oxidized compounds, such as cis-1,2-DCE followed by VC, the least susceptible.

In addition to reductive dechlorination, cis-1,2-DCE and VC can be destroyed by other mechanisms, specifically cometabolic reactions and direct aerobic degradation. Cometabolic reactions are incidental to the microorganisms' normal metabolic functions. However, cometabolic reactions are generally relatively slow and have limited significance under natural conditions because of the non-interaction with microbial metabolism involved and the necessary environmental conditions required for significant transformation to occur. Under aerobic conditions, VC is readily degraded, but cis-1,2-DCE can prove persistent. These conditions are likely to be most prevalent in the downgradient regions of the ground water plumes. VC is the most hazardous of the chlorinated solvents at the Site, and the transformation of TCE to VC might render the plume more hazardous if VC persists and is not transformed to non-toxic ethene.

Reductive dechlorination occurs when the microorganisms causing the reaction gains energy and grows as the chlorinated contaminant is degraded (or oxidized) by removal of chlorine atoms. With reductive dechlorination, the contaminants are not used as a direct substrate (or carbon source for cell growth), rather as the electron acceptor in an oxidation-reduction chemical reaction within the microorganism. The contaminant acting as an electron acceptor is analogous to oxygen acting as an electron acceptor in aerobic environments. An alternate source of carbon is used as the substrate (electron donor) to facilitate bacterial growth. In general, the source of carbon can be other contaminants (fuel hydrocarbons, waste oil, landfill leachate, etc.). At the Site, other than waste oils disposed of at the surface, which would affect biodegradation rates in WBZ-1, the source of carbon is not clear. It is likely to be naturally occurring organic material. The biodegradation reaction rates at the Site are probably limited by the low availability of substrate (carbon source) to facilitate microbial cell growth.

Fate and Transport Modeling

BIOCHLOR Version 2.2 was used to assess the migration in ground water of TCE, cis-1,2-DCE, and VC from the Site in WBZ-1, WBZ-2, WBZ-3, and WBZ-4. BIOCHLOR is a screening model that simulates remediation by natural attenuation of dissolved solvents in ground water. The model is programmed in the Microsoft Excel spreadsheet environment and based on the Domenico analytical solute transport model. It has the ability to simulate 1-D advection, 3-D dispersion, linear adsorption, and biotransformation via reductive dechlorination. Dissolved solvent degradation is assumed to follow a sequential first order decay process. To assist model calibration, BIOCHLOR Version 2.2 incorporates the Buschek and Alcantar (1995) rate constant estimation method, which is a method to automatically provide an approximate calibration of the model to site-specific field data entered by the user. Site-specific rate constants were estimated for each WBZ, and the models were calibrated using a simulation period of 30 years, which is the approximate time since release occurred at the Site. Predictive simulations were then conducted to estimate future plume behavior after 100 years, which is 70 years in the future, using the site-specific rate constants. The model assumes that there is a constant concentration source of DNAPL at the Site that is approximately 200 feet wide and uses a retardation coefficient of 2.87 for all chlorinated ethenes and all WBZs. The model was found to significantly over-predict concentrations and extent of VC, and the associated model predictions are not usable for predicting future VC plume behavior at the Site.

- *Water Bearing Zone 1:* A value of 20 feet per year was used for the ground water seepage velocity. The match between the model results and observed WBZ-1 field data for TCE is good, but the match between the model results and field data for cis-1,2-DCE is less reliable. The model predicted that there would be little TCE plume growth in the next 70 years, from 575 feet downgradient currently to 600 feet downgradient after 70 years, for a 25 foot or a 4% increase. The model also predicted the cis-1,2-DCE plume would not have any growth in the next 70 years.

- *Water Bearing Zone 2:* A value of 50 feet per year was used for the ground water seepage velocity. The match between the model results and observed WBZ-2 field data for TCE was reasonable in areas and substantially below observed concentrations in others. The matches between the model results and field data for cis-1,2-DCE were reasonable. The model predicted that the TCE and cis-1,2-DCE plumes would not have any growth in the next 70 years.

- *Water Bearing Zone 3:* A value of 50 feet per year was used for the ground water seepage velocity. The model results matched observed TCE concentrations in WBZ-3 reasonably well, but tended to over predict the cis-1,2-DCE concentrations. The model predicted that there would be significant TCE and cis-1,2-DCE plume growths in the next 70 years. For the modeled conditions, including continuing DNAPL source, the TCE plume was predicted to expand from the current location of 1,100 feet downgradient to 2,150 feet downgradient after 70 years, for a 1050 foot or a 95% increase. Likewise, the cis-1,2-DCE plume was predicted to expand from the current position of 950 feet downgradient to 1,700 feet downgradient after 70 years, for a 750 foot or a 79% increase.

- *Water Bearing Zone 4:* A value of 50 feet per year was used for the ground water seepage velocity. Detectable chloroethene concentrations in WBZ-4 were found in only one well beyond the source area. Even though the model results for TCE and cis-1,2-DCE provided a good match to the measured values in that well (MW-1204), the limited number of samples in the inferred flow path limits confidence in the model results. No vinyl chloride was detected in any WBZ-4 well. The model results, which estimated a 760 foot VC plume under current conditions, did not match the field VC data and are not valid. Regarding TCE and cis-1,2-DCE, the model predicted that there would be small plume growths in the next 70 years. For the modeled conditions, the TCE plume was predicted to expand from the current location of 830 feet downgradient to 960 feet downgradient after 70 years, for a 130 foot or a 16% increase. Likewise, the cis-1,2-DCE plume was predicted to expand from the current position of 710 feet downgradient to 830 feet downgradient after 70 years, for a 120 foot or a 17% increase.

2.7 Current and Potential Future Site and Resource Uses

Land Uses

The City of Houston does not use zoning ordinances, and therefore the Site is not zoned for any particular type of usage. Within a one-mile radius of the Site, the primary land uses are industrial/commercial, recreational, and residential. Major facilities include Reliant Stadium, Houston Astrodome, and Six Flags Astroworld. At the Site and in its immediate vicinity south of I-610 are various small business and light industrial concerns. These industries consist of commercial offices, warehousing, and manufacturing facilities. Private, single, and multi-family dwellings are located about 3,000 feet west of the Site. It is anticipated that the current industrial and commercial land use at the Site will continue into the future.

Groundwater Uses

The September 1988 ROD for ground water found that the shallow water bearing zones at the Site have the potential to be used as drinking water sources and are classified as Class IIB aquifers in the EPA ground water classification system. A search for residential, industrial, and agricultural water wells within a 1-mile radius of the Site of Site found three drinking water wells in the vicinity of the Site. The former private well is located immediately north of the Site WWTP. The well was used as a source of restroom water for a small commercial business. The water well was disconnected in July 2002 and replaced with a water line connected to the City of Houston water system. This well was plugged and abandoned in 2003. The ground water from this well historically had concentrations exceeding the MCL for TCE, which is 0.005 mg/L. A second, private water well is located about 900 feet north of the Site. The owner stated that the well had not been in service during the 15 years he has lived at the residence. The last private water well is located about 660 feet east of the Site. The well is currently active and provides potable water for the small commercial business operating at the same location.

2.8 Summary of Site Risks

The shallow water bearing zones at the Site (i.e., WBZ-1 through WBZ-9) are not current sources of drinking water. Residences near the Site receive their potable water from the City of Houston water supply system. However, the shallow water bearing zones are classified as Class IIB aquifers and have the potential for future use. These zones could have been used for potable water in the past.

There is no exposure resulting from use of the ground water at the Site because there is no current use. However, because the water bearing zones have the potential for future use, exposures could occur to persons using the contaminated water. Potential exposure routes for drinking water, including ingestion, dermal contact, and inhalation, could result in risk to human health from Site contaminants. A risk evaluation estimates what risks the Site poses if no action were taken. It provides the basis for taking action and identifies the contaminants and exposure pathways that need to be addressed by the remedial action. This section of the Amended ROD summarizes the results of the risk evaluation for this Site.

For carcinogens, risks are generally expressed as the incremental probability of an individual's developing cancer over a lifetime as a result of exposure to the carcinogen. Excess lifetime cancer risk is calculated from the following equation:

Risk = CDI x SF, where:

Risk = a unitless probability (e.g., 2×10^{-5}) of an individual's developing cancer.
CDI = chronic daily intake averaged over 70 years; expressed as milligrams per kilogram per day (mg/kg-day).
SF = slope factor, expressed as $(\text{mg/kg-day})^{-1}$.

These risks are probabilities that usually are expressed in scientific notation (e.g., $1x10^{-6}$). An excess lifetime cancer risk of $1x10^{-6}$ indicates that an individual has a one in 1,000,000 chance of developing cancer as a result of Site-related exposure. This is referred to as an "excess lifetime cancer risk" because it would be in addition to the risks of cancer individuals face from other causes such as smoking or exposure to too much sun. The chance of an individual's developing cancer from all other causes has been estimated to be as high as one in three. The EPA's generally acceptable risk range for Site-related exposures is 10^{-4} to 10^{-6}.

The potential for non-carcinogenic effects is evaluated by comparing an exposure level over a specified time period (e.g., lifetime) with a reference dose (RfD) derived for a similar exposure period. An RfD represents a level that an individual could be exposed to that is not expected to cause any harmful effect. The ratio of exposure to toxicity is called a hazard quotient (HQ). An HQ < one indicates that a receptor's dose of a single contaminant is less than the RfD, and that toxic non-carcinogenic effects from that chemical are unlikely. The Hazard Index (HI) is generated by adding the HQs for all Contaminant(s) of concern that affect the same target organ (e.g., liver) or that act through the same mechanism of action within a medium or across all media to which a given individual might reasonably be exposed. An HI < one indicates that, based on the sum of all HQ's from different contaminants and exposure routes, toxic non-carcinogenic effects from all contaminants are unlikely. An HI > one indicates that Site-related exposures could present a risk to human health.

The HQ is calculated as follows:

Non-cancer HQ = CDI/RfD, where:

CDI = Chronic daily intake
RfD = reference dose.

CDI and RfD are expressed in the same units and represent the same exposure period (i.e., chronic, subchronic, or short-term).

Identification of Contaminants of Concern

An average of the highest levels of the contaminants of concern in each water bearing zone was used to calculate the potential risk. Table 1a provides the list of contaminants by water bearing zone, the maximum level of ground water contamination, and the exposure point concentrations used for the risk evaluation results shown in Table 2. Table 1b shows the indoor air contaminants and concentrations.

Table 1a -Contaminants and Exposure Point Concentrations
Medium: Ground Water

Exposure Point	COC	Concentration (µg/L)		Frequency of Detection %	Exposure Point Concentration (µg/L)
		Minimum	Maximum		
WBZ-1	TCE	3.2	333,000	97	108,000
	cis-1,2-DCE	2.5	401,000	81	170,000
	VC	6.8	9,250	65	4,085
WBZ-2	TCE	2.2	262,000	83	204,800
	cis-1,2-DCE	2.1	367,000	77	34,060
	VC	2.2	14,200	46	3,740
WBZ-3A	TCE	67,500	282,000	100	174,750
	cis-1,2-DCE	1,540	3,810	100	2,675
	VC	nd	nd	--	11
WBZ-3C	TCE	2.3	25,600	83	10,253
	cis-1,2-DCE	2.1	282	48	117
	VC	4.0	182	9	67
WBZ-4	TCE	3.2	2,950	65	146
	cis-1,2-DCE	3.1	1,020	38	265
	VC	nd	nd	0	2

Table 1b -Contaminants and Exposure Point Concentrations
Medium: Indoor Air

Exposure Point	COC	Concentration Detected (ppbV)		Frequency of Detection %	Exposure Point Concentration (ppbV)
		Minimum	Maximum		
Indoor Air	TCE	4.8	5.6	23	5.6
	cis-1,2-DCE	41.9	61.5	46	61.5

Exposure Assessment

The exposure pathways include ingestion, dermal contact, and inhalation of the volatile contaminants at the Site. Dermal contact can occur while showering, washing, bathing, etc. Inhalation of volatiles results from volatilization from the water supply, or it can result from vapor intrusion into a building from contaminated soil and ground water in the area. For the risk calculations related to ground water, only the adult receptor calculation was made because the resulting estimated risk was very high, and therefore, there was no need to perform additional calculations to show a risk to human health from the Site. In addition, the MCL cleanup levels will address both adult and child.

Ground Water Risks

The steps taken to evaluate ground water risk at the Site are as follows:

- An exposure point concentration (EPC) was generated for the three contaminants (i.e., TCE, cis-1,2-DCE, and VC) in each water bearing zone (WBZ). This consisted of choosing wells which defined the most contaminated part of the plume, and performing a standard average of the contaminant concentrations in those wells.
- The most recent toxicity values were gathered from the Integrated Risk Information System (IRIS), or other sources, as necessary. TCE utilizes two different carcinogenic slope factors for inhalation: one recommended by the EPA [0.4 $(mg/kg\text{-}d)^{-1}$], and one recommended by the California EPA [0.007 $(mg/kg\text{-}d)^{-1}$].

- Risks were estimated for ingestion, inhalation, and dermal contact for an adult resident, using standard reasonable maximum exposure assumptions from the Region 6 Supplemental Risk Assessment Guidance.

- The risks were summed across exposure routes for each chemical in each WBZ. In three WBZs, the summed carcinogenic risks for TCE approached one in one, or a 100% cancer risk, due to the highly elevated sample readings. In these cases, the "one-hit equation" from the "Risk Assessment guidance for Superfund, Volume A," page 8-11, was used to estimate risk. The summarized risk evaluation results for the ground water pathway are shown in Table 2 below. A more detailed breakdown of the ground water pathway risk is also presented later, in Table 5.

Table 2 - Summary of Site Risks from Shallow Water Bearing Zones

Water Bearing Zone	Risk	
	Cancer	Non-Cancer Hazard Index
1	$9.6\text{x}10^{-1}$	13,000
2	$9.9\text{x}10^{-1}$	24,000
3A	$9.9\text{x}10^{-1}$	21,000
3C	$3.0\text{x}10^{-1}$	1,200
4	$4.3\text{x}10^{-3}$	18

The cancer slope factors used in the carcinogenic risk evaluation are shown in Table 3 below.

Table 3 - Cancer Slope Factors

Contaminants of Concern	Slope Factor $(mg/kg\text{-}d)^{-1}$		
	Oral	Inhalation	Dermal
TCE (EPA)	0.4	0.4	0.4
TCE (Cal - EPA)	0.013	0.007	0.013
cis-1,2-DCE	NA	NA	NA
VC	1.4	0.031	1.4

The non-cancer reference doses used in the non-carcinogenic risk evaluation are shown in Table 4 below.

Table 4 - Non-Cancer Toxicity Data

Contaminants of Concern	Chronic Oral RfD Value (mg/kg-d)	Chronic Inhalation RfD Value (mg/kg-d)	Chronic Dermal RfD Value (mg/kg-d)
TCE (EPA)	0.0003	0.011	0.0003
cis-1,2-DCE	0.01	0.01	0.01
VC	0.003	0.029	0.003

The risk estimation results for the ground water pathway, presented in Table 5 below, demonstrate that both the cancer (i.e., 9.9×10^{-1} for TCE) and non-cancer risks (i.e., 24,000 for TCE) are significantly higher than the acceptable risk ranges of 10^{-4} to 10^{-6} for carcinogens, and a hazard quotient of one for non-carcinogens.

Table 5 - Ground Water Risks

WBZ	Chemical	Carcinogenic Risk	Non-Carcinogenic Hazard
1	TCE	9.6×10^{-1}* to $6.4\text{x}10^{-2}$	13,000
	cis-1,2-DCE	-	2,800
	VC	$6.8\text{x}10^{-1}$	390
2	TCE	$9.9\text{x}10^{-1}$* to $1.2\text{x}10^{-1}$	24,000
	cis-1,2-DCE	-	560
	VC	$6.2\text{x}10^{-1}$	360
3A	TCE	$9.9\text{x}10^{-1}$* to $1.0\text{x}10^{-1}$	21,000
	cis-1,2-DCE	-	44
	VC	$1.7\text{x}10^{-3}$	0.1
3C	TCE	$3.0\text{x}10^{-1}$ to $6.0\text{x}10^{-3}$	1,200
	cis-1,2-DCE	-	2
	VC	$1.1\text{x}10^{-2}$	6
4	TCE	$4.3\text{x}10^{-3}$ to $8.8\text{x}10^{-5}$	18
	cis-1,2-DCE	-	4
	VC	$3.3\text{x}10^{-4}$	0.2

Key:
* Carcinogenic risk approached one in one, so the "one-hit equation" from RAGS A Page 8-11 was used to estimate combined risk.

Workplace Indoor Air Risks

Currently, there are commercial and/or industrial facilities in the vicinity of the ground water contaminant plumes. In addition to the risks associated with the use of ground water, there are risks associated with the vaporization of volatile chemicals from the contaminated ground water and soil in the area. These volatile compounds (e.g., TCE, cis-1,2-DCE, and VC) could migrate through the soil and accumulate in buildings.

To assess whether there is a threat from workplace exposure to indoor air, the indoor air sampling results from nine businesses in the vicinity of the Site were compared to the Occupational Safety and Health Administration (OSHA) "Permissible Exposure Limits" (PELs) and the National Institute for Occupational Safety and Health (NIOSH) "Recommended Exposure Limits." The OSHA Permissible Exposure Limits are average air concentrations that must not be exceeded in any eight-hour period. As discussed below in Section 2.10, PELs are ARARs for the Site. The NIOSH Recommended Exposure Limits are recommended average air concentrations for up to a ten-hour workday that should not be exceeded. None of the air samples exceeded either the OSHA or the NIOSH workplace limits.

To estimate the potential long term risk from vapor intrusion into indoor air in the workplace, air sample results for TCE, cis-1,2-DCE, and VC in indoor air were compared to screening values from the EPA Vapor Intrusion Guidance. These screening values are developed using a risk of 10^{-4} or hazard quotient of one. The commercial indoor air levels of TCE and cis-1,2-DCE from samples at 1419 South Loop West were above their screening values. Therefore, a risk evaluation was performed for the inhalation of these two chemicals using exposure factors specific to a commercial indoor worker. The steps taken to evaluate the potential risks from vapor intrusion from contaminated ground water at the Site are as follows:

- The highest detected values for TCE and cis-1,2-DCE from the two sampling events were used as exposure point concentrations.
- The most recent toxicity values were gathered from IRIS, or other sources, as necessary. TCE utilizes two different carcinogenic slope factors for inhalation: one recommended by the EPA [0.4 $(\text{mg/kg-day})^{-1}$], and one recommended by the Cal-EPA [0.007 $(\text{mg/kg-day})^{-1}$].
- Risks were estimated for inhalation using standard reasonable maximum exposure assumptions from EPA Human Health Risk Assessment Guidance. In particular, the daily inhalation rate for an indoor worker was taken from the 1997 Exposure Factors Handbook and represents eight hours of light activity work. The exposure frequency was 250 days/year, with an exposure duration of 25 years.

Table 6 below summarizes the risks associated with vapor intrusion into the workplace, based upon unremediated ground water contamination. As presented in Table 6, these risks marginally exceed the EPA's acceptable cancer risk range of 10^{-4} to 10^{-6}, and the acceptable non-cancer hazard quotient of one. However, the measured indoor air concentrations are significantly below the OSHA PELs, which are ARARs for the Site.

Table 6 - Risks from Vapor Intrusion to Indoor Air (Workplace)

Chemical	OSHA PEL (ppbV)	Concentration (ppbV)	Concentration (ug/m^3)	Risk	
				Cancer	Non-Cancer Hazard Index
TCE	100,000	5.6	30.59	3.4×10^{-4}	0.2
cis-1,2-DCE	200,000	61.5	247.84	-	1.9

Residential Indoor Air Risks

While there are no residential structures currently located at the Site, there exists the potential for future residential construction. To estimate the risk from vapor intrusion to any future residence, the highest concentration of each of the three contaminants (i.e., TCE, cis-1,2-DCE, and VC) in WBZ-1, the uppermost aquifer, was compared to risk-based screening levels from the EPA Vapor Intrusion Guidance. These screening levels help to evaluate the potential of volatile organic contaminants to contribute to residential health risks from indoor air, and they are equal to a carcinogenic risk of 10^{-4} or a non-carcinogenic hazard quotient of one. WBZ-1 was chosen for this evaluation because it is the closest to the surface and therefore has less attenuation than deeper water bearing zones. WBZ-1 also has the highest concentrations for TCE and cis-1,2-DCE. WBZ-2 contains the highest concentration of vinyl chloride (14.2 mg/L), but WBZ-1 has been evaluated for all three VOCs for consistency. The screening levels assume a conservative vapor attenuation factor of 0.001, with no consideration of soil type or depth to ground water. All three Site contaminants exceeded the screening levels as shown in Table 7 below.

Table 7 - Screening Evaluation of Residential Indoor Air Risks

WBZ (Depth in ft.)	Chemical	Endpoint	Highest Concentration (mg/L)	Screening Level (mg/L)	Screening Level Exceeded?
1 (18-24)	TCE	Cancer	333	0.0053	yes
	cis-1,2-DCE	Non-cancer	401	0.210	yes
	VC	Cancer	9.25	0.025	yes

Because the indoor air screening levels were exceeded, the highest ground water concentration of each contaminant was entered into the Johnson & Ettinger Vapor Intrusion Model in order to estimate carcinogenic risks or non-carcinogenic hazards. Assumptions entered into the model for physical parameters are presented below.

- **LF** - depth below grade to bottom of enclosed space floor = 15 cm (no basement);
- **LWT** - depth below grade to water table = 548.6 cm (18 feet; to the top of WBZ-1);
- **SCS Soil Type Directly Above Water Table** - silty clay (estimated);
- **TS** - average ground water temperature = 10° Celsius;
- **SCS Soil Type, Vadose Zone** - sandy loam (estimated, based on silty sand with 20 - 50 % fines);
- **kV** - user-defined vadose zone soil vapor permeability = 10^{-8} cm^2 (based on sandy loam)

Table 8 below summarizes the risks associated with vapor intrusion into potential residential structures. These estimated risks exceed the EPA's acceptable cancer risk range of 10^{-4} to 10^{-6}, and the acceptable non-cancer hazard quotient of one.

Table 8 - Risks from Vapor Intrusion into Indoor Air (Residential)

WBZ (depth in ft.)	Chemical	Highest Concentration (mg/L)	Risk	
			Cancer	Non-Cancer Hazard Index
1 **(18-24)**	TCE	333	$1.2x10^{-2}$	6.6
	cis-1,2-DCE	401	n/a	10
	VC	9.25	$3.9x10^{-5}$	0.1

In summary, this section of the Amended ROD describes the results of the risk evaluations for the Site. The exposure pathways include ingestion, dermal contact while showering, and inhalation of volatiles. These risk evaluations estimate the human health risks from hypothetical exposure to ground water and indoor air by future residential receptors and workers if no action is taken. It provides the basis for taking action and identifies the contaminants and exposure pathways that should to be addressed by the remedial action. As shown in the above tables, the risks for potential exposures at the Site exceed the EPA's generally acceptable carcinogenic risk range of 10^{-4} to 10^{-6}. Further, the non-carcinogenic risks exceed the EPA's generally acceptable hazard quotient of one, and could present a risk to human health. There are no potentially significant completed exposure pathways for ecological receptors.

Risk Assessment Uncertainty

There is an uncertainty inherent in risk evaluations. Estimations of exposure and risk are subject to a number of uncertainties that could lead to either an overestimate or an underestimate of risk. Assumptions made in the risk evaluation that are likely to overestimate risk include the use of a simplifying assumption that no contaminant loss would occur over the duration of the 30-year exposure. Overestimating risk can also occur through the use of conservative exposure factors, use of conservative exposure point concentrations, and the use of conservative reference doses and cancer slope factors. Factors that are likely to underestimate risk include errors associated with sampling and analysis that might result in lower sample concentrations and yield an underestimate of the true risk or hazard, and toxicity values that are not available for every chemical, for every exposure duration, or for all exposure routes. Finally, there is also uncertainty related to the assumptions used in the Johnson and Ettinger Vapor Intrusion Model and how well they relate to residences that do not currently exist.

This Amended ROD's response action is necessary to protect the public health or welfare from actual or threatened releases of hazardous substance into the environment; and pollutants or contaminants from this Site, which could present an imminent and substantial endangerment to public health or welfare.

2.9 Remedial Action Objectives

Remedial action objectives (RAOs) identify Site-specific contaminants, media of concern, potential exposure pathways, and remediation goals. The remediation goals are derived from either risk assessment findings or previously established concentration limits that protect human health and the environment and comply with applicable or relevant and appropriate requirements (ARARs). The RAOs for ground water at the Site were developed based on sampling data, the risk assessment, fate and transport modeling, and a review of the ARARs. The RAOs for the ground water operable unit, OU2, are:

- Restore the aquifer, including the source and plume areas, to drinking water standards for COCs within a reasonable time frame.
- Prevent or minimize future migration of ground water contamination.
- Reduce or eliminate further contamination of ground water from the source area.
- Prevent use of ground water as drinking water for as long as contaminant concentrations remain above drinking water levels.
- Mitigate risk from subsurface vapor intrusion from ground water to indoor air.
- Prevent residential exposure to indoor air above risk-based levels.

The September 1988 ROD provided for restoration of ground water for drinking water use using a pump and treat remedy. This ROD Amendment maintains that RAO, however, it adopts different remedial technologies for accomplishment of the objective, due to the presence of residual DNAPL and the failure of the pump and treat system to mitigate the Site.

The September 1988 ROD only provided a performance standard for TCE. In addition to TCE, the supplemental RI found significant levels of cis-1,2-DCE and VC, which exceeded the acceptable risk ranges. Therefore, this ROD Amendment provides for adding performance standards to include cleanup levels for cis-1,2-DCE and VC in ground water while retaining the September 1988 ROD's standard for TCE. The performance values will be the MCLs, which are as follows:

- <u>TCE</u> - 5 µg/L;
- <u>cis-1,2-DCE</u> - 70 µg/L; and
- <u>VC</u> - 2 µg/L.

2.10 Applicable or Relevant and Appropriate Requirements

Under CERCLA and the NCP, the ROD is required to describe the "... federal and state requirements that are applicable or relevant and appropriate to the site that the remedy will attain." 40 C.F.R. 300.400(f)(5)(ii)(A). These ARARs derive from the potential ARARs that were identified by EPA and TCEQ, which were identified as "requirements applicable to the release or remedial action contemplated based upon an objective determination of whether the requirement specifically addresses a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site." 40 C.F.R. 300.400 (g)(1). If not applicable to a specific release, these federal or state requirements might still be determined to be "relevant and appropriate to the circumstances of the release." *See* 40 C.F.R. 300.400(g)(2). *See also* CERCLA, 42 U.S.C. §9621(d)(2)(A). An ARAR could be specific to a given chemical, action, or location at a CERCLA site. The NCP defines "applicable requirements" as follows:

> *Applicable requirements* means those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environment or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable. 40 C.F.R. 300.5.

The NCP then goes on further to define "relevant and appropriate requirements":

> *Relevant and appropriate requirements* means those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate. (Emphasis Added). 40 C.F.R. 300.5.

Thus, it is clear from the NCP that state requirements must be "substantive"; and as the statute commands, they must be "more stringent" than any federal standard, requirement or limitation. 42 U.S.C. §9621(d)(2)(A)(ii). ARARs deal with the degree of cleanup, or levels and standards of control and are not procedural or administrative requirements. *See* NCP Preamble, 55 Fed. Reg. 8666, 8756 (Mar. 8, 1990). *See* also *State of Ohio v. United States Environmental Protection Agency*, 997 F.2d 1520, 1526-27 (D.C. Cir., 1993). In connection with state ARARs, the NCP also amplifies and explains the nature of "promulgated" standards or limitations, where it provides:

> Only those state *standards* that are *promulgated*, are identified in a timely manner, and *are more stringent* than federal requirements may be applicable or relevant and appropriate. For purposes of identification and notification of promulgated state standards, the term promulgated means that the standards are of *general applicability and are legally enforceable.* (Emphasis Added). 40 C.F.R. 300.400(g)(4).

If a standard is not applicable, the question of whether the standard is relevant and appropriate to the circumstances of the release is addressed by several enumerated factors, which " . . . shall be examined, where pertinent, to determine whether a requirement addresses problems or situations sufficiently similar to the circumstances of the release or remedial action contemplated, and whether the requirement is well-suited to the site, and is therefore both relevant and appropriate." 40 C.F.R. 300.400(g)(2). Finally, there is a category of other federal or state advisories, criteria, or guidance, which may be used to develop a CERCLA remedy that falls into a category called "to be considered (TBC)." 40 C.F.R. 300.400(g)(3).

ARARs pertaining to RA activities at the Site are divided into action, chemical, and location specific categories. In addition, any TBCs, potential waivers, and required agreements (permits and access covenants or agreements) are discussed.

Action Specific ARARs

Action-specific ARARs are generally activity or technology based. These ARARs (1) control remedial activities involving the design or use of certain equipment, or (2) regulate distinct actions. Action-specific ARARs for the Site, depending on the selected remedy, may include the following provisions. For on-site actions, the relevance and appropriateness of these requirements is based only upon their substantive, and not their procedural, provisions.

- **Resource Conservation and Recovery Act (RCRA) Hazardous Waste Requirements and Off-Site Disposal.** Off-site disposal of waste (including investigation derived waste/purge water) must comply with the EPA's off-site rule codified in the NCP at 40 C.F.R. 300.440, and with all current federal and state regulations for transport of waste to the receiving facility. RCRA, 42 U.S.C. §6901 *et seq.*, regulates generation, transportation, treatment, storage, and disposal of hazardous waste. Texas has an EPA authorized RCRA program. Hazardous substances identified by the EPA in ground water at the Site (i.e., 1,2 dichloroethylene [DCE], vinyl chloride [VC], and trichloroethylene [TCE]) are all "listed" hazardous wastes when discarded, pursuant to the RCRA regulations at 40 C.F.R. 33(a) and (f). RCRA standards for waste characterization (40 C.F.R. Part 261), standards for generators of hazardous waste (40 C.F.R. Part 262), transporter standards for hazardous waste (40 C.F.R. Part 263), and disposal of hazardous waste subject to land disposal restrictions (40 C.F.R. Part 268) will apply off-site, and are relevant and appropriate on-site. To the extent that regulated hazardous waste treatment, storage, or disposal (TSD) or certain recycling related activities are engaged in, then the requisite RCRA standards at 40 C.F.R. Part 264 or 266, Subparts C or H, may be applicable or relevant and appropriate, depending upon the activity and whether it is on or off-site.

- **Texas Surface Water Quality and Texas Pollutant Discharge Elimination System (TPDES) Requirements.** Certain Texas Surface Water Quality Standards, Texas Administrative Code (TAC), Title 30, Chapter 307, promulgated pursuant to the Texas Water Code, Chapter 26, V.T.C.A. Water Code §26.001 *et seq*., are ARARs that were identified by the TCEQ in connection with construction activities on any of the proposed remedial alternatives.

  30 TAC §307.4 — General Criteria: Lists narrative criteria and standards;
  30 TAC §307.5 — Antidegradation;
  30 TAC §307.6 — Toxic Materials;
  30 TAC §307.7 — Site-Specific Uses and Criteria;
  30 TAC §307.8 — Application of Standards;
  30 TAC §307.9 — Determination of Standards Attainment;
  30 TAC §307.10 — Appendices A-E: Site-specific uses and criteria for classified segments.

  In addition, certain requirements of TAC Title 30, Chapter 305, Sub-chapter O, styled "Additional Conditions And Procedures For Wastewater Discharge Permits and Sewage Sludge Permits" are ARARs for construction activities on any of the several proposed remedial alternatives. These provisions are a part of the TPDES program under V.T.C.A. Water Code §26.001 *et seq*., which is an EPA delegated program under section 402(b) of the Clean Water Act, 33 U.S.C. §1342(b). *As with all of the ARARs for the Site, for any covered on-site activity, these ARARs are only the substantive provisions and not the permitting or other procedural or administrative requirements of these TPDES rules.*

  30 TAC §305.531 — Establishing and Calculating Additional Conditions and Limitations for TPDES Permits.
  30 TAC §305.532 — Adoption of Appendices by Reference.
  30 TAC §305.534 — New Sources and New Dischargers.
  30 TAC §305.538 — Prohibitions for TPDES Permits.

- **General Air Quality Rules under the Texas Clean Air Act (TCAA).** Under the TCAA, V.T.C.A. Health & Safety Code §382.001 *et seq*., the predecessor of the TCEQ has promulgated the *General Air Quality Rules*, 30 TAC 101.1 *et seq*. The staff of TCEQ identified the following ARARs, and the EPA agrees, provided that only the substantive provisions thereof shall apply to certain on-site actions that fall within the ambit of their coverage. They are as follows.

30 TAC §101.5 — Traffic Hazard
30 TAC §101.7 — Maintenance, Start-up and Shutdown Reporting, Record keeping, and Operational Requirements.
30 TAC §101.8 — Sampling
30 TAC §101.9 — Sampling Ports

- **Clean Air Act, New Source Performance Standards and Hazardous Air Pollutants.** With respect to certain remedial action alternatives that involve actions otherwise subject to these standards, certain New Source Performance Standards (NSPS) and regulations for the emission of Hazardous Air Pollutants (HAPs) under the Clean Air Act, 42 U.S.C. §§7411, 7412, are ARARs. Specifically, these are the NSPS, 40 C.F.R. Part 60, Subpart Kb, and asbestos and other hazardous air pollutant standards at 40 C.F.R. Parts 61 and 63. These standards are also adopted under the TCAA at 30 TAC 101.20.

- **Texas Underground Injection Control Regulations.** The Texas Underground Injection Control (UIC) Regulations, *30 TAC 331*, promulgated pursuant to the Texas Injection Well Act, VTCA water Code, Chapter 27, are considered ARARs in connection with use of Surfactant Enhanced Aquifer Remediation (SEAR) as a remedial technology.

- **Certain Specific Texas Risk Reduction Program Requirements.** Although provisions of the Texas Risk Reduction Program (TRRP), 30 TAC, Chapter 350, are not generally considered ARARs, there are a few requirements of the TRRP identified as action-specific ARARs. The substantive, but not the administrative or procedural aspects, of these provisions are relevant and appropriate, though not applicable, to this remedial action. These are as follows:

  1) 30 TAC 350.33 (f)(4). Remedy B Groundwater Response Objectives concerning plume management zones for Class 2, and Class 3 aquifers. The section lists the requirements for establishment of a plume management zone (PMZ). A PMZ is relevant and appropriate for monitored natural attenuation (MNA) as a remedy, where contaminants are left in the ground water above the remediation goals.

2) **30 TAC 350.111. Use of Institutional Controls.** This section is relevant and appropriate where remedial action cleanup does not result in unrestricted use of land, which in the case of this Site would also apply to the contaminated ground water beneath and adjacent to, or emanating from, it.

3) **30 TAC 350.52. Groundwater Resource Classification.** This section lists requirements for determining the class of the aquifer. Ground water classification is necessary to determine the size of a plume management zone necessary for monitored natural attenuation.

Chemical Specific ARARs

- **National Primary Drinking Water Standards.** These standards establish acceptable contaminant levels for treatment of drinking water. CERCLA and the NCP provide that Maximum Contaminant Level Goals (MCLGs) established under the Safe Drinking Water Act (SDWA), 42 U.S.C. §300f *et seq.*, and promulgated by the EPA at 40 C.F.R. 141.50(a), shall be attained by remedial actions for ground water used for drinking, or ground water that may be a future source for potable water, where the MCLGs are relevant and appropriate to the release, 42 U.S.C. §9621(d)(2)(A); 40 C.F.R. 300.430(e)(2)(i)(B). The 1988 ROD classified the ground water units as Class IIB aquifers (EPA 1988a), thus meeting the future source test. Where these MCLGs have been set at zero, the NCP provides that the SDWA Maximum Contaminant Levels (MCLs) shall be attained where they are relevant and appropriate under the circumstances of the release, 40 C.F.R. 300.430(e)(2)(i)(C). In this case, the MCLGs for TCE and VC are set at zero, 40 C.F.R. 141.50(a). Therefore, MCLs for TCE, and VC are relevant and appropriate and are 5 and 2 μg/L, as set forth in the National Revised Primary Drinking Water Regulations under the SDWA. 40 C.F.R. 141.61(a). The MCLG for cis-1,2-DCE is the same level as the MCL at 70 μg/L and is therefore relevant and appropriate. *See* 40 C.F.R. 141.50(b), 141.61(a).

- **OSHA Permissible Exposure Limits (PELs)**. These standards are limitations on occupational exposure to airborne contaminants in the work place. They are promulgated by OSHA at 29 C.F.R. 1910.1000. These PELs are typically expressed as time-weighted average concentrations that must not be exceeded during any 8-hour shift of a 40-hour workweek. They are applicable to the selected remedy, which will comply with them.

Location Specific ARARs

Location-specific ARARs prevent damage to unique or sensitive areas, such as flood plains, historic places, wetlands, and fragile ecosystems, and restrict other activities that are potentially harmful because of where they take place. Location specific ARARs are restrictions on remedial activities solely based on the location of the remedial activity.

- **Ground Water Restoration.** The substantive provisions of the Texas Ground Water Protection Act, V.T.C.A. Water Code §§26.401- 407, are location- specific ARARs. They are relevant and appropriate, because the Site's underlying ground water is affected. This statute requires ground water to be restored, if feasible.

- **RCRA Siting Regulations.** The RCRA TSD regulations, 40 C.F.R. 264.18, prohibit placement of hazardous waste in geologically unstable areas. Because of the potential for subsurface shifting in the Houston Astrodome area, located near the Site, placement of remedial components for some alternatives will be carefully evaluated. This requirement is both an action and location-specific potential ARAR that is relevant and appropriate.

To Be Considered (TBC) Criteria

The following criteria were identified as TBC criteria.

- **Risk Based Remedial Goals and Guidance.** The primary TBC guidance for EPA risk assessment is the Risk Assessment Guidance for Superfund Vol. 1, Human Health Evaluation Manual (RAGS), Office of Emergency and Remedial Response (OERR), Washington, D.C.; EPA 540-1-89-002 (EPA 1989). Under the current draft EPA toxicity assessment for TCE (EPA 2001), cleanup to the TCE MCL of five µg/L is not currently believed to reduce the cancer risk below the one-in-ten thousand (10^{-4}) level (EPA 2004a).

  MCLs are promulgated regulations under the SDWA governing the permissible limits of TCE, DCE, and VC in drinking water at the tap. However, more recent risk-based screening levels calculated using the EPA RAGS (utilizing the methodology for the EPA Region 6 Medium Specific Screening Levels, or "MSSL") for tap water also are available to assess protection of human health and the environment. While MCLs are regulatory exposure standards that were set (here considered ARARs) taking treatment feasibility or contemporary detection limits into account, the MSSL is a guidance based screening level set at the low end, or 10^{-6}, of the acceptable risk range (i.e., 10^{-4} to 10^{-6} incremental cancer risk). Utilizing the MSSL methodology and the RAGS model, the cancer risk-based screening level for TCE in drinking water (set to the one-in-one million [10^{-6}] acceptable cancer risk level, established by the NCP as a point of departure) is 0.028 µg/L. A 10^{-5} risk level is required under Section 350.72(a) of the TRRP, 30 TAC 350.72(a), which is also a TBC guidance, which would provide for a tenfold increase in the acceptable level for individual chemicals. Under the NCP acceptable risk range, the corresponding thresholds for tap water could be as high as 100 times the MSSL screening levels, equivalent to a one-in-ten thousand (10^{-4}) cancer risk level. This approach would yield cancer risk-based concentrations of up to 2.8 µg/L TCE, without taking into account cumulative risk.

In the case of ground water, CERCLA and the NCP mandate attainment as ARARs of non-zero MCLGs, and MCLs for chemicals with zero MCLGs. 42 U.S. 9621(d)(2)(A)(ii). 40 C.F.R. 300.430(e)(2)(i)(B) and (C). For cumulative risk, where chemical specific ARARs would not be sufficiently protective, the EPA may consider the risk-based approach discussed above for establishment of its remediation goals. 40 C.F.R. 300.430(e)(2)(i)(A) and (D). For cumulative risk, the state guidance (TRRP), 30 TAC 350.72(c), provides that the carcinogenic risk level for multiple carcinogenic contaminants shall not exceed 10^{-4}, which is also the acceptable cumulative risk level under the NCP. However, for ground water, the NCP only requires attainment of the MCLG and MCL ARARs that have been identified for this Site. These are contaminant levels that would be acceptable for public drinking water from a Class I aquifer that is actually currently producing drinking water. In the instant case, the potential drinking water aquifers involved have been determined to be Class IIB. The only remaining water wells in the immediate area were shut down and plugged by the EPA in 2002, and the possibility of further use of aquifer water should be prevented during remediation and an extended operation and maintenance period by the imposition of institutional controls as part of the Site remedy. Therefore, although the EPA has considered lower risk-based levels based on TBC guidance, the EPA believes that cleaning up to the chemical specific MCLG and MCL ARAR levels for the three COCs involved will be sufficiently protective of public health and the environment.

- **Natural Attenuation Guidance.** Although not promulgated as law or regulation, the EPA guidance and TBC, Office of Solid Waste and Emergency Response (OSWER) Directive 9200.4-17P, *Use of MNA at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites* (EPA 1999) will be an important roadmap for MNA.

- **NIOSH Recommended Exposure Limits (RELs)**. These guidelines are established by the National Institute for Occupational Safety and Health for occupational exposure to airborne contaminants. See Occupational Health Guidelines for Chemical Hazards, Supp. I OHG, 1988 DHHS (NIOSH) Pub. No. 88-118.

Potential ARAR Waivers

An ARAR may be waived by the lead agency for one or more of six specified reasons in the NCP. These reasons include the scenario where an ARAR is technically impractical from an engineering standpoint, based on the feasibility, reliability, and cost of the engineering methods required, 40 C.F.R. 300.430(1)(ii)(C). When an alternative that does not attain an ARAR is chosen, the basis for waiving the requirement must be documented and explained in the ROD, in accordance with the criteria described in 40 C.F.R, 300.430(f)(5)(ii)(C). At this time, no ARAR waivers are being invoked for the Sol Lynn Site. However, there are six types of ARAR waivers for Superfund that can be invoked, should the need arise. The two potential ARAR waivers identified include the Technical Impracticability Waiver and the State ARAR Waiver described in the following:

- **Technical Impracticability Waiver.** If during the course of the RA, it becomes technically impractical to remove (from the potential drinking water aquifers) DNAPLs trapped in deep subsurface features, the EPA may, in such circumstances, waive the requirement to meet risk-based goals, SDWA MCLs, or other standards. Such a determination would be made according to the Guidance for Evaluating the Technical Impracticability of Ground Water Restoration: Interim Final, OSWER Directive 9234.2-25 (EPA 1993).

- **State ARAR Waiver** State ARARs may be waived under certain circumstances. Of the six waivers set forth in CERCLA §121(d)(4), 42 U.S.C. §9621(d)(4), only one applies exclusively to state ARARs: the inconsistent application of a state requirement in similar circumstances at other remedial actions in the state. In connection with this provision, it should be noted that many state regulations have their own waivers or exception that may be invoked at a Superfund site. The EPA guidance *CERCLA Compliance with State Requirements: CERCLA Compliance with Other Laws Manual* OSWER Directive 9234.2-05/FS(EPA 1989), or applicable superseding guidance, would pertain to any state waivers for the Sol Lynn amended ROD.

If an ARAR waiver is needed, the guiding principles will be taken from relevant EPA guidance such as *ARARs Q's & A's: General Policy, RCRA, CWA, SDWA, Post-ROD Information, and Contingent Waivers*, OSWER Directive 9234.2-01/FS-A (EPA 1991).

2.11 Description of Alternatives

Remedy alternatives were developed in the Supplemental Feasibility Study (FS) to address the contaminants found in the ground water, OU2, which pose a risk to human health and the environment. Seven ground water remediation alternatives were developed. The primary goal of each remediation alternative is to address the RAOs for OU2. However, because multiple water bearing zones and low permeability zones exist throughout the Site, all remedial technologies are limited by permeability contrasts and spatial heterogeneities. The ability to affect the entire zone of contamination, whether hydraulically, or biologically, creates difficulties with regard to restoring ground water concentrations to acceptable levels. Therefore, considerable uncertainty exists with regard to estimation of cleanup times. The more permeable water bearing zones will likely be easier to address than the low permeability zones. Nonetheless, contaminants in the low permeability zones could pose a continued threat to ground water quality until their concentrations are lowered to protective levels.

Common Elements for Remediation Alternatives

One common element for all of the remediation alternatives, except the no action alternative, is a provision for institutional controls. Institutional controls are legal and administrative measures that prevent exposure to contaminants at concentrations above health-based risk levels that remain at a Site. Usually institutional controls limit activities at or near sites. The objectives of institutional controls are to ensure the long-term protectiveness of completed remedial actions, as well as during construction and implementation. Institutional controls at the Site will supplement the remedy alternatives described below to reduce potential threats to human health and the environment. The EPA intends to work with the State of Texas to place institutional controls, such as deed notices or easements and restrictive covenants, to prevent exposure to contaminated ground water, and to prevent drilling into or through a contaminated plume, until attainment of remedial goals has been achieved. Such controls could also be needed for properties located over areas of highly contaminated ground water, in order to prevent human exposure to unacceptable contaminant levels in indoor air that might occur with residential construction.

Another common element for all of the alternatives, except the no action alternative, is monitored natural attenuation (MNA). MNA includes a variety of physical, chemical, and/or biological processes that can reduce the concentration of contaminants in ground water. These natural processes can include biodegradation (destruction), dispersion, dilution, sorption, or volatilization. The primary mechanism of TCE destruction in ground water at the Site is reductive dechlorination. The dechlorination of TCE creates cis-1,2-DCE, and the dechlorination of cis-1,2-DCE then creates VC. The presence of the TCE daughter products, cis-1,2-DCE and

VC, indicates that natural attenuation by reductive dechlorination is ongoing at the Site. Methane production and elevated chlorides in source area monitoring wells indicate reductive dechlorination is occurring. Reductive dechlorination is an anaerobic process, and regions of the water bearing zones are strongly anaerobic and reducing as indicated by dissolved oxygen (DO) levels as low as of 0 mg/L and oxidation-reduction potentials (ORP) of -307 mV. The TCE daughter products, cis-1,2-DCE and VC, can be removed by reductive dechlorination, but not as readily as TCE because they are the least oxidized. However, in addition to reductive dechlorination, cis-1,2-DCE and VC can be destroyed by a wider range of mechanisms including co-metabolic reactions and direct aerobic degradation. Regions of the water bearing zones are aerobic and oxidizing as indicated by DO levels as high as 6.5 mg/L and an ORP of +355 mV.

The ground water remediation alternatives are listed and then summarized below.

- **ALTERNATIVE 1: NO ACTION**
- **ALTERNATIVE 2: MONITORED NATURAL ATTENUATION (MNA) WITH INSTITUTIONAL CONTROLS (IC) FOR SOURCE AND DISSOLVED PHASE PLUMES**
- **ALTERNATIVE 3: PERMEABLE REACTIVE BARRIER FOR SOURCE PLUME AND MNA WITH IC FOR DISSOLVED PHASE PLUME**
- **ALTERNATIVE 4: IN SITU BIOREMEDIATION (ISB) FOR SOURCE PLUME AND MNA WITH IC FOR DISSOLVED PHASE PLUME**
- **ALTERNATIVE 5: CHEMICAL OXIDATION (CHEMOX) FOR SOURCE PLUME AND MNA WITH IC FOR DISSOLVED PHASE PLUME**
- **ALTERNATIVE 6: IN SITU BIOREMEDIATION FOR SOURCE PLUME AND PERMEABLE REACTIVE BARRIER FOR DISSOLVED PHASE PLUME**
- **ALTERNATIVE 7: IN SITU CHEMICAL OXIDATION FOR SOURCE PLUME AND PERMEABLE REACTIVE BARRIER FOR DISSOLVED PHASE PLUME**

Table 9 below presents a summary of the costs and estimated time to reach the remediation goals of the seven alternatives. The costs include "capital costs" and "operations and maintenance" costs. Capital costs include initial construction costs such as modifications to the treatment plant, and operation and maintenance costs are those necessary to continue the remedy until the cleanup goals are achieved.

Table 9 - Remedial Alternatives Summary

	Alternative	Costs			Time to Obtain RAOs (Years)
		Remedial Action	Present Worth O&M	Total Present Worth	
1	**No Action**	$0	$0	$0	na
2	**MNA with IC for Source and Dissolved Plume**	$1,200,000	$515,000	$1,715,000	30
3	**Permeable Reactive Barrier for Source and MNA with IC for Dissolved Plume**	$2,996,000	$721,000	$3,717,000	30
4	**ISB for Source and MNA with IC for Dissolved Plume**	$3,015,000	$515,000	$3,530,000	30
5	**In-Situ CHEMOX for Source and MNA with IC for Dissolved Plume**	$2,900,000	$820,000	$3,720,000	30
6	**ISB for Source and Permeable Reactive Barrier for Dissolved Plume**	$8,415,000	$1,060,000	$9,475,000	30
7	**In-Situ CHEMOX for Source and Permeable Reactive Barrier for Dissolved Plume**	$8,300,000	$980,000	$9,280,000	30

ALTERNATIVE 1: NO ACTION

The no-action alternative, required by the NCP (§ 300.430 [e][6]), is the baseline alternative against which the effectiveness of all other remedial alternatives is judged. Under this alternative, no remediation activities will be conducted at the Site. Likewise, no attempts will be made to further control access to the Site. This alternative would result in no change in the ground water contaminant levels because no treatment would be included in this alternative. No monitoring or institutional controls would be in place to protect human health and the environment. Any reduction in ground water contaminant concentrations would be from natural dispersion, physical attenuation, and degradation processes.

ALTERNATIVE 2: MONITORED NATURAL ATTENUATION (MNA) WITH INSTITUTIONAL CONTROLS FOR SOURCE AND DISSOLVED PHASE PLUMES

This alternative will involve ground water monitoring to observe the progress of natural attenuation and institutional controls to prevent exposures as long as necessary to protect human health. A ground water monitoring plan, including a sampling schedule, must be developed prior to implementing this alternative. The data collected during these sampling events will provide information on ground water contaminant concentration trends. Evaluation of data will determine whether natural attenuation is occurring. Should the analysis indicate otherwise, more aggressive contingency measures could be triggered. This alternative will have minimal operation and maintenance requirements. Five year reviews will be conducted as required by the NCP to determine if contaminants that remain are causing unacceptable risk to human health or the environment.

ALTERNATIVE 3: PERMEABLE REACTIVE BARRIER FOR SOURCE PLUME AND MNA WITH INSTITUTIONAL CONTROLS FOR DISSOLVED PHASE PLUME

Permeable Reactive Barriers (PRB) are designed to intercept the flow of contaminated ground water, and react with contaminants that pass through them, rendering them innocuous. Permeable Reactive Barriers have been used to remediate ground water contaminated with chlorinated organics. Zero-valent iron serves as a reducing agent, itself being oxidized while reducing the contaminant through dechlorination. PRBs are a long-term remedy and are effective for several years. At the Site, a PRB would be used to remediate source contamination, and MNA with institutional controls would be used to mitigate the solute plume. The MNA with institutional controls features are as discussed for Alternative 2.

The PRB would be installed on the downgradient side of the source area to destroy contaminants as they migrate out of the source contamination zone. The PRB would be installed using drilling and Deep Aquifer Remediation Tools (DART) technologies to minimize surface disturbance.

The iron filings might need to be replaced periodically, otherwise, operation and maintenance activities would be minimal. Five year reviews will be conducted as required by the NCP to determine if contaminants that remain are causing unacceptable risk to human health or the environment.

ALTERNATIVE 4: IN-SITU BIOREMEDIATION FOR SOURCE PLUME AND MNA WITH INSTITUTIONAL CONTROLS FOR DISSOLVED PHASE PLUME

This alternative is the EPA's selected remedy for the Site. In-situ bioremediation (ISB) involves the breakdown of contaminants by biologically mediated metabolic reactions under both aerobic and anaerobic conditions. It involves the addition of amendments potentially including a substrate or carbon source for cell growth, an electron donor, nutrients, and TCE degrading microorganisms. The chlorinated contaminants present at the Site can be completely degraded to ethene and hydrogen chloride under the proper conditions.

A treatability study will be conducted during the remedial design to identify and compare possible treatment solutions and amendments, determine the most effective delivery strategies, and gather other necessary design information. Any necessary ISB amendments are typically injected in the water bearing zones using either direct push methods or by drilling. Unless a different strategy is approved in the remedial design, the location of the injection treatments would likely be determined by Site wells showing the highest contaminant levels, and focused on the source area south of I-610. The treatment strategy would be refined as necessary during the remedial design based on the treatability study work.

It is possible the ISB treatment could require re-application, depending on the effectiveness demonstrated in testing and practice. In the event that the treatments do not prove effective, the EPA will review the remedy's effectiveness and will consider modifying or changing the selected remedy for the Site to one of the contingent remedies, including construction of a PRB for source area containment (Alternative 3), implementation of the ChemOx approach (Alternative 5), or another remedy in accordance with the NCP and EPA guidance (e.g., an Explanation of Significant Differences, or a ROD amendment as appropriate).

To implement ISB in the source area, the existing pump and treat ground water system will be converted to an ISB system. Extraction, treatment, and discharge of ground water to publicly owned treatment works could be utilized for hydraulic control of the ISB system. Additional injection and/or extraction wells might be required as determined during the remedial design phase. Furthermore, modification of existing equipment might be required for nutrient addition and preparation of microorganism amendments. ISB has intensive monitoring as part of the operation and maintenance requirements. Five year reviews will be conducted as required by the

NCP to determine if contaminants that remain are causing unacceptable risk to human health or the environment.

ALTERNATIVE 5: CHEMICAL OXIDATION FOR SOURCE PLUME AND MNA WITH INSTITUTIONAL CONTROLS FOR DISSOLVED PHASE PLUME

Alternative 5 consists of injecting chemical oxidants, such as potassium permanganate or hydrogen peroxide, into the source area to facilitate the direct abiotic oxidation of the chlorinated ethene residual DNAPL present at the Site. The solute plume would be addressed by MNA with institutional controls as discussed under Alternative 2. Chemical oxidation for the dissolved phase plume is not considered implementable because of the physical limitations caused by Site proximity to I-610 and its feeder roads.

To implement chemical oxidation for source remediation, the existing ground water pump and treat system will be converted to a chemical oxidant delivery system. Additional injection and/or extraction wells could be required as determined in the remedial design. Expansion of the existing equipment compound might be required to facilitate addition of DNAPL separation equipment, batch mixing tanks and transfer pumps. Batch injections of the chemical oxidant will occur quarterly. Chemical oxidation has intensive operations and maintenance requirements. Five year reviews will be conducted as required by the NCP to determine if contaminants that remain are causing unacceptable risk to human health or the environment.

ALTERNATIVE 6: IN SITU BIOREMEDIATION FOR SOURCE PLUME AND PERMEABLE REACTIVE BARRIER FOR DISSOLVED PHASE PLUME

Alternative 6 includes ISB for source remediation and the installation of a PRB for dissolved phase plume remedy. DART wells used to construct the PRB will be screened across WBZ-1, WBZ-2, and WBZ-3. WBZ-4 contaminants will be addressed by MNA. Zero valent iron will be placed in the wells as the reactive media. As the ground water flows through the iron media making up the wall a reaction takes place that breaks down the contaminants.

The purpose of combining the ISB with a PRB is to reduce the chance for off-site contaminant migration. Additionally, if source treatment proves impracticable, the PRB would continue to provide protectiveness to off-site areas. However, construction of the PRB would require road closure of Englemohr Avenue for an extended period of time to allow for the DART wells to be installed. The features of Alternative 6 are discussed in Alternative 3 and Alternative 4.

ALTERNATIVE 7*: *IN SITU CHEMICAL OXIDATION FOR SOURCE PLUME AND PERMEABLE REACTIVE BARRIER FOR DISSOLVED PHASE PLUME

Alternative 7 includes ChemOx for source removal and the installation of a PRB for the dissolved phase plume remedy. DART wells used to construct the PRB will be screened across WBZ-1, WBZ-2, and WBZ-3. WBZ-4 contaminants will be addressed by MNA. Zero valent iron will be placed in the wells as the reactive media. As the ground water flows through the iron media making up the wall a reaction takes place that breaks down the contaminants.

The purpose of combining chemical oxidation with a PRB is to reduce the chance for off-site contaminant migration. Additionally, if complete source removal proves impracticable, the PRB would continue to provide protectiveness to off-site areas. However, construction of the PRB would require road closure of Englemohr Avenue for an extended period of time to allow for the DART wells to be installed. The features of Alternative 7 are discussed in Alternative 3 and Alternative 5.

2.12 Comparative Analysis of Remedy Alternatives

The EPA has established nine evaluation criteria to address the statutory requirements of CERCLA. The criteria can be classified into three categories: threshold criteria, primary balancing criteria, and modifying criteria. This section evaluates each potential RA alternative by these criteria.

Threshold Criteria:

Threshold criteria are requirements that each remediation alternative must achieve to be eligible for selection as a permanent remedy. The two threshold criteria are as follows:

- Overall Protection of Human Health and the Environment: The overall protection of human health and the environment is evaluated for each alternative on the basis of the alternative's ability to provide adequate protection by reducing, controlling, or eliminating the risk of exposure to contaminants through treatment, engineering controls, and/or institutional controls.

- Compliance with ARARs: Section 121(d) of CERCLA and the NCP, Section 300.430(f)(1)(ii)(B), require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate Federal and State requirements, standards, criteria, and limitations (unless they are waived). This criterion evaluates each alternative's compliance with location, chemical, and action specific ARARs.

Primary Balancing Criteria

The five balancing criteria are used to compare and evaluate the major tradeoffs among alternatives that fulfill the two threshold criteria. The balancing criteria are:

- Long Term Effectiveness and Permanence: Remediation alternatives are reviewed and evaluated under this criterion to assess the potential for risk, in the form of treatment residuals and untreated wastes, that would remain at the Site following implementation of the alternative. Likewise, the evaluation of each alternative with respect to this criterion requires assessment of the adequacy and suitability of controls that could be used to manage those residuals or untreated wastes remaining after Site remediation. This evaluation also includes an assessment of the reliability of remedy components, and the potential need for redoing components that were implemented during the original Site remediation such as caps, slurry walls, or on-site treatment systems over the life of the Site.

- Reduction of Toxicity, Mobility, or Volume Through Treatment: Remediation alternatives are evaluated for effectiveness at achieving the statutorily driven preference for alternatives that permanently and significantly reduce toxicity, mobility, or volume of the hazardous substances as their principal element. The evaluation includes the level to which the alternative will destroy or treat contaminants, the permanence of the treatment, and the type and volume of treatment residuals that will remain subsequent to treatment.
- Short Term Effectiveness: Remedial alternatives are evaluated under this criterion with respect to the immediate threat of risk to human health and the environment during implementation of that alternative. This risk threat is not only evaluated for the surrounding community, but for the workers at the Site conducting the remediation and the expected environmental impacts as well.

- Implementability: Each alternative is evaluated with respect to the technical and administrative feasibility of implementation, as well as the availability of necessary equipment and services. This criterion includes such items as the ability to obtain services, capacities, equipment, and specialists necessary to construct components of the alternative; the ability to operate and monitor the permanence and effectiveness of the technologies; and the ability to coordinate with and obtain necessary approvals from other relevant agencies.

- Cost: Detailed cost estimates are derived from current information, including vendor quotes; conventional cost-estimating guides; and costs associated with similar remediation projects. The actual cost of the project will depend on labor and material costs, Site conditions, competitive market conditions, the final project scope, and the implementation schedule at the time the remedial activities are initiated. Costs expected to be incurred over the life of the project are compiled, then distilled to a common comparative year through a process known as present worth analysis. A "discount rate," published by the Office of Management and Budget, is used to evaluate how much money would need to be set aside, during the common base year, to cover the costs expected to be incurred over the life of the project. Because some alternatives are more capital-intensive, with more costs toward the beginning of the project, and other alternatives can have more extended treatment times and greater operation and maintenance costs, present worth analysis provides a means to compare each in a common format.

Modifying Criteria

The two modifying criteria are used in the final evaluation of remedy alternatives. Evaluation of these two criteria will be based on comments on the remedial investigation, the feasibility study, and the proposed plan received during the public comment period. The modifying criteria are:

- State Acceptance: This assessment reflects the state's (or support agency's) preferences or concerns about remedy alternatives.
- Community Acceptance: This assessment reflects the community's preferences or concerns about remedy alternatives.

Below is a comparison of the remediation alternatives in order of the nine evaluation criteria that are presented in Table 10.

1. *Overall Protection of Human Health and the Environment*

This criterion addresses the way in which a remediation alternative would reduce, eliminate, or control the risks posed by the Site to human health and the environment. The method used to achieve an acceptable level of protection could include the use of treatment technologies, engineering controls, and/or institutional controls to limit the future use of the Site.

Alternatives 4 and 5 provide aggressive measures for source removal, not just source control, as well as MNA to remediate dissolved plume contamination. Alternatives 6 and 7 also provide aggressive measures for source removal, but in addition, include more aggressive measures for plume treatment (i.e., PRB). All of the aggressive source removal alternatives are considered protective, because they effectively prevent the potential for future human contact with, or ingestion of, Site ground water contaminants. The current lack of receptors for the ground water ingestion pathway allows establishment of a deliberate, but less aggressive approach to dissolved plume cleanups. In this circumstance, the EPA believes that MNA could prove to be an effective technology to address the dissolved plume contamination. MNA is therefore a component for addressing the dissolved plume in four remedial alternatives, numbers 2, 3, 4, and 5. The no-action alternative (number 1) is not protective because at least some protective devices, such as IC or long term ground water monitoring, must be in place to ensure that potential future receptors are prevented from contact with contaminated water.

A MNA remedial response is likely insufficient to address source zone residual DNAPL contamination in a time frame comparable to more aggressive remedies. Therefore, the use of MNA in Alternative 2 to address both the solute plume and the DNAPL source might not be sufficiently protective. On the other hand, Alternative 3 couples a PRB for source control with MNA for the solute plume to prevent future migration of contaminants out of the source area into downgradient plume areas. However, with Alternative 3, the residual DNAPL would remain in place and the PRB would have to be maintained for a long time.

Table 10 - Comparison of Remedial Action Alternatives

Alternative	Protection of Human Health & Environment	Meet ARARs	Long Term Effectiveness & Permanence	Reduction of Toxicity, Mobility, or Volume	Short Term Effectiveness	Implementation	Present Worth Cost
Alternative 1: No Action	No risk reduction. The present lack of receptors means no current risk to human health or the environment. But, the no-action alternative will not ensure elimination of future pathways. The state and extent of the plume will be unknown because of lack of monitoring.	Does not comply for plume area because MCLs cannot be determined without some form of ground water monitoring.	Least effective. Because dechlorination is occurring in the ground water, natural attenuation should eventually ensure the permanence of this alternative. However, the risks posed to potential down gradient receptors will be unknown, as will the time frame to achieve MCLs of the contaminants.	Any reduction in mobility, toxicity, or volume of contaminated media would occur only through natural processes. Before degradation to innocuous compounds, TCE degradation will result in VC, which is more toxic. A reduction in mobility is not anticipated. The volume is expected to increase for several decades before it begins to decrease.	Continued risk through no action. Because implementing the no-action alternative at Sol Lynn involves no disturbance of contaminated media it poses no short-term risk to human health or the environment.	Nothing to construct and operate.	$ 0

Table 10 - Comparison of Remedial Action Alternatives

Alternative	Protection of Human Health & Environment	Meet ARARs	Long Term Effectiveness & Permanence	Reduction of Toxicity, Mobility, or Volume	Short Term Effectiveness	Implementation	Present Worth Cost
Alternative 2: MNA with Institutional Controls	Minimal risk reduction only to extent that ICs are enforced, but there is no current ground water ingestion. An area would be created to prevent new water wells. Risk from exposure to contaminated ground water should abate over time as a result of biological and geochemical mechanisms. No reduction of potential vapor intrusion into buildings.	Reduction of concentrations to MCLs in the source area by MNA is unlikely within a reasonable time frame. Therefore, MNA for the dissolved plumes should be coupled with aggressive source control measures.	The remedy will be protective only as long as institutional controls are implemented to prevent exposure. The ability of natural processes to reduce contamination has been proved to some degree through the presence of TCE daughter products like 1,2-DCE and VC. But, as long as there is a residual DNAPL source, cleanup to MCLs within a reasonable time frame is unlikely. Also, the effectiveness of MNA for the dissolved plumes must be demonstrated during the first several years of implementation.	Same as Alternative 1.	Short-term risks to Site workers or community residents will be minimal, because the possibility of exposure to contaminated ground water would exist only during sampling events. The passive nature of this alternative removes the possibility of short term risks to residents and travelers along the transportation routes that can be an issue with more active remedial alternatives.	Easily implementable. Will have to establish institutional controls. Nothing to construct and operate.	$1,715,000

Table 10 - Comparison of Remedial Action Alternatives

Alternative	Protection of Human Health & Environment	Meet ARARs	Long Term Effectiveness & Permanence	Reduction of Toxicity, Mobility, or Volume	Short Term Effectiveness	Implementation	Present Worth Cost
Alternative 3: Permeable Reactive Barrier for Source Area, MNA with Institutional Controls for Dissolved Plume	The PRB would isolate the source zone from downgradient ground water, and eliminate sources of contaminants to dissolved plumes. The PRB in conjunction with institutional controls will result in the overall protection of human health and environment. Does not reduce potential vapor intrusion into buildings.	This alternative reduces transport off-site, but does not reduce contamination in the source area. Material removed during PRB installation could trigger hazardous waste disposal requirements under RCRA. This alternative should result in achievement of MCLs in the dissolved plumes over time.	Risks related to treatment residuals will occur at the time of construction and once every five years during iron filings replacement. Risks associated with untreated residual contamination will be unchanged in the source area. Residual contamination passing the PRB would be addressed by MNA in the dissolved plumes.	This alternative will isolate the source, and thereby reduce contamination moving off-site. The PRB consists of lines of DART wells screened across WBZ-1, WBZ-2, and WBZ-3. WBZ-4 contaminants will be addressed by MNA . Zero valence iron will be placed in the DART wells as the reactive media. The line of wells will be installed down gradient of the source area. As the ground water flows through the iron media, a reaction takes place that breaks down the chlorinated chemicals.	Contact by construction workers could occur during installation. Potentially greater concern is the very limited space for construction of the wells. The presence of high-speed traffic will be a danger. A well-maintained traffic plan will be required at all times. Contaminant migration off-site during construction will be restricted by the use of engineering controls such as silt fences, dust control measures, and the use of lined roll-off boxes for the placement of drilling cuttings.	Implementation will be somewhat difficult because of minimal space available for drilling numerous DART wells and handling drilling wastes. Operation will require compliance with licensing of zero valent iron technology.	$3,716,740

Table 10 - Comparison of Remedial Action Alternatives

Alternative	Protection of Human Health & Environment	Meet ARARs	Long Term Effectiveness & Permanence	Reduction of Toxicity, Mobility, or Volume	Short Term Effectiveness	Implementation	Present Worth Cost
Alternative 4: ISB for Source Area, MNA with Institutional Controls for Dissolved Plume	Provides high degree of overall protection. ISB is expected to result in achieving contaminant reduction in the source area. The reduction of residual DNAPL in the source area will reduce migration of contaminants to off-site areas. Reduces potential vapor intrusion into buildings.	Because reductive dechlorination is occurring in ground water, and this alternative would substantially augment naturally occurring processes, the ability of this alternative to reduce contamination is very good. ISB will reduce contaminant mass in source area. Implementation of this alternative should result in achievement of MCLs, although the presence of DNAPL in the source area is a challenge to meeting ARARs there.	ISB will have long term effectiveness by reduction of contaminant mass in the source area. The microcosm study showed that microbes in some areas of the Site are capable of breaking down chlorinated hydrocarbons. ISB is dependent on hydraulic injection of fluids, and will affect water bearing zones more than low permeability zones. Contamination following treatment in the low permeability zones could pose a reduced threat to ground water quality. This risk would be addressed by MNA.	Bioremediation will reduce toxicity through the breakdown of contaminants. Implementation of this alternative will eliminate the mobility of source area contaminants via control of the ISB flood. Discharge of a fraction of the extracted and treated water to the publically owned wastewater treatment works will ensure positive hydraulic control. The future growth of the plume will be reduced by contaminant destruction. This alternative will result in reduction in volume of contaminated ground	ISB will involve injection and extraction of ground water. Therefore, risk to workers and community would be posed by spills of contaminated water. Risks can be mitigated with proper safety measures, isolation of equipment, and minimization of biological amendment usage. The contaminated plume will not pose human risk because there currently are no known receptors, nor will any develop in the process of implementing ISB as a result of institutional controls.	ISB is considered to be implementable. Existing injection and extraction wells could be retrofitted to serve as amendment and nutrient supply wells. Equipment necessary to implement the ISB remedy is readily available. If additional wells are required, this remedy would require access to properties and right-of-way agreements for drilling. Also, additional wells would require installation of supplemental piping, pumps, electrical hookups, and other associated equipment.	$3,530,000

Table 10 - Comparison of Remedial Action Alternatives

Alternative	Protection of Human Health & Environment	Meet ARARs	Long Term Effectiveness & Permanence	Reduction of Toxicity, Mobility, or Volume	Short Term Effectiveness	Implementation	Present Worth Cost
Alternative 5: Chemical Oxidation for Source Area, MNA with Institutional Controls for Dissolved Plume	Provides high degree of overall protection. Would result in achieving MCLs in the source area through abiotic destruction of contaminants. The reduction of DNAPL in the source area will reduce migration of contaminants off-site. Reduces potential vapor intrusion into buildings.	ChemOx will reduce the contaminant mass in the source area. Implementation of this alternative should result in achievement of MCLs over time, although the presence of residual DNAPL in the source area is a challenge.	ChemOx is an emerging technology. ChemOx is dependent on hydraulic injection of oxidizing fluids, and will treat water bearing zones more thoroughly than low permeability zones. Residual contaminants in the low permeability zones could pose a long term threat to ground water quality in the water bearing zones. The risk associated with untreated residual contamination at the conclusion of active ChemOx treatment would be addressed by MNA.	ChemOx is the direct abiotic chemical oxidation of chloroethenes. ChemOx will result in the reduction of toxicity through the breakdown of contaminants. Implementation of this alternative will eliminate the mobility of source area contaminants by hydraulic control during chemical oxidant batch floods. The future growth of the plume will be mitigated through contaminant destruction. This alternative will result in reduction in volume of contaminated ground water.	Remedial action will involve injection and extraction of strong oxidants. A secure chemical storage area must be maintained. Risk to workers and community would be posed by spills. Risks can be mitigated with proper safety measures, isolation of equipment, and minimization of chemical usage. The contaminated plume itself will not pose human risk because there currently are no receptors nor will any develop due to implementation of institutional controls.	Potassium permanganate or hydrogen peroxide are chemical oxidants that will be pumped into the water zones in batches until tracer (e.g., bromide) returns are seen in extraction wells. Between batch ChemOx floods, positive hydraulic control will be maintained by discharging a fraction of extracted water to the publically owned wastewater treatment works during the batch floods.	$3,720,000

Table 10 - Comparison of Remedial Action Alternatives

Alternative	Protection of Human Health & Environment	Meet ARARs	Long Term Effectiveness & Permanence	Reduction of Toxicity, Mobility, or Volume	Short Term Effectiveness	Implementation	Present Worth Cost
Alternative 6: ISB for Source Area, Permeable Reactive Barrier for Dissolved Plume	Provides high degree of overall protection. See Alternative 4 for source plume discussion. This combination of technologies would be effective at controlling off-site migration of Site contaminants. Reduces potential vapor intrusion into buildings.	See Alternatives 3 and 4.	See Alternatives 3 and 4.	See Alternative 4. This alternative will isolate the dissolved plume, and thereby help to control the further migration of contaminants. Dissolved contaminants downgradient of the PRB will be addressed by MNA (see Alternative 2). Site contaminants flowing through the PRB will be rendered innocuous by undergoing dechlorination through reaction with the zero valent iron in the DART wells. The volume of dissolved plume contaminants will decrease with time as the source area is treated with ISB.	See Alternative 2, 3 and 4. Risks related to treatment residuals will occur at the time of construction and Once every five years during iron filings replacement in the PRB.	See Alternative 2, 3 and 4. Implementation will be somewhat more difficult due to closure of Englemohr Avenue to install DART wells for the PRB.	$9,475,000

Table 10 - Comparison of Remedial Action Alternatives

Alternative	Protection of Human Health & Environment	Meet ARARs	Long Term Effectiveness & Permanence	Reduction of Toxicity, Mobility, or Volume	Short Term Effectiveness	Implementation	Present Worth Cost
Alternative 7: Chemical Oxidation for Source Area, Permeable Reactive Barrier for Dissolved Plume	Provides high degree of overall protection. See Alternative 5 for the source area discussion. This combination of technologies would be effective at controlling off-site migration of Site contaminants. Reduces potential vapor intrusion into buildings.	See Alternatives 2, 3, and 5.	See Alternatives 3 and 5.	See Alternative 5. This alternative will isolate the dissolved plume, and help to control the migration of contaminants. Dissolved contaminants downgradient of the PRB will be addressed by MNA (see Alternative 2). Site contaminants flowing through the PRB will be rendered innocuous by dechlorination through reaction with the zero valent iron in the DART wells. The volume of dissolved plume contaminants will decrease with time as the source area is treated with ChemOx.	See Alternative 2, 3 and 5. Risks related to treatment residuals will occur at the time of construction and once every five years during iron filings replacement in the PRB.	Implementation will be somewhat more difficult due to closure of Englemohr Avenue to install DART wells for the PRB.	$9,280,000

2. *Compliance with ARARs*

Compliance with the Applicable or Relevant and Appropriate Requirements (ARARs) assures that a remedy will meet all the appropriate Federal, State, and local requirements. The requirements may specify maximum concentrations of contaminants that can remain at a site. ARARs may also cover design or performance requirements for treatment technologies, or may could address potential activity restrictions because of the Site location.

The National Primary Drinking Water Standards are health-based standards for public drinking water system. The drinking water standards are known as Maximum Contaminant Levels, or MCLs. The benchmark ARAR for comparing alternatives is the restoration of ground water to the MCLs for TCE, cis-1,2-DCE, and VC. The MCLs are ARARs for the Site because the ground water may be used as a future drinking water source.

All ARARs are considered achievable for all alternatives with the exception of the no-action alternative (Alternative 1). The ability of MNA to restore solute plume ground water quality to MCLs should be demonstrated during the first several years of implementation. MNA appears promising, particularly in conjunction with aggressive source zone remedies; however, insufficient data presently exist to conclusively establish the effectiveness of MNA. Likewise, the ability of source zone remedies to restore ground water quality to MCLs in the area of residual DNAPL is uncertain; however, their implementation is important for the success of MNA for solute plume restoration to MCLs within a reasonable time frame.

3. *Long Term Effectiveness and Permanence*

This criterion concerns the residual risk that might remain following implementation of a remedy alternative. It also refers to the ability of an alternative remedy to reliably protect human health and the environment over time following completion of the remedy.

Because there is residual DNAPL in the source zone, the most aggressive alternatives rank the highest with regard to long term effectiveness. These include Alternative 4, ISB for the source area with MNA for the dissolved plumes; Alternative 5, ChemOx for the source area with MNA for the dissolved plume; Alternative 6, ISB for the source area with PRB for the dissolved plume; and Alternative 7, ChemOx for the source area with PRB for the dissolved plume.

ISB and ChemOx (Alternatives 4 and 5) rely on hydraulic means of delivery, and are therefore likely to be more successful in water bearing zones and less so in low permeability zones. The potential for significant levels of residual contaminants in low permeability zones following active remediation is high with these technologies. However, they should contain and control future migration of contaminants from the source during implementation, and Alternatives 6 and 7 add the benefit of a PRB to the ISB and ChemOx technologies for assurance against downgradient migration of contaminants during and after active remediation of the source zone. Nonetheless, any contaminants remaining in low permeability zones at the close of active remediation will pose a long-term threat to ground water quality.

ISB appears promising based on the results of the microcosm study conducted in 2002, which showed complete dechlorination of a number of amended microcosms. Dechlorinating bacteria are present in some areas of the Site, although not all, and injection of dechlorinating microorganisms will probably be required. Because reductive dechlorination is occurring in contaminated ground water at the Site, and the intent of the ISB treatment alternative is to substantially augment naturally occurring microbial processes in the source area, the long term effectiveness and permanence of the ISB alternative is good.

The long-term effectiveness and permanence of the following alternatives are considered poor: Alternative 1, no-action alternative; Alternative 2, MNA (with respect to source removal); and Alternative 3, PRB with MNA. The no-action alternative is not considered effective and would leave considerable residual contamination in the source zone, as would MNA for source zone contamination.

Although the PRB with MNA (Alternative 3) will prevent migration of contaminants out of the source zone into downgradient areas, this alternative does nothing to remove residual DNAPL in the source zone, and the PRB would be maintained until source zone contaminants naturally attenuate. Therefore, residual contamination would have comparable fate as with the no-action alternative and MNA for source removal. Long-term PRB effectiveness at remediating ground water contamination is still being evaluated. Preliminary data indicates the technology is an efficient means of achieving ground water cleanups, but existing PRBs have been operational for only about seven years. Because of this, the ability of this technology to meet the required process efficiencies and performance specifications is probable, but not assured.

The long term effectiveness and permanence of MNA will be confirmed by monitoring. Additionally, monitoring of the existing plumes will provide a means to refine ground water models and provide sufficient time for more substantive remediation methods to be used should the plumes begin to reach a point where they become threats to human health or the environment.

4. ***Reduction of Toxicity, Mobility, or Volume Through Treatment***

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of a remediation technology. Factors considered include the nature of the remediation alternative, the amount of the hazardous material destroyed by the remediation alternative, how effectively it reduces the toxicity, mobility, or volume of waste through treatment, and the type and amount of contamination that will remain after treatment.

The amount of contaminant material to be destroyed is presently not well known at the Site, particularly in the source area. This uncertainty results from the lack of observation of DNAPL during the field investigations, yet DNAPL is likely present at the Site. For all the alternatives evaluated, the types of anticipated TCE breakdown products (i.e., cis-1,2-DCE and then VC) are comparable. The VC will in turn degrade into chloride, ethene, and ethane. To the extent that VC is formed through the reductive dechlorination process and not further degraded, the toxicity could increase.

The treatment processes evaluated for the Site include PRB for dissolved plume contamination, and a variety of processes for source zone residual DNAPL cleanups. Alternative 4, using ISB for source area remediation, takes advantage of biological degradation to reduce the toxicity and volume of contaminated ground water. Implementation of the ISB alternative will eliminate the mobility of source area contaminants by hydraulic control of the ISB flood. Discharge of a fraction of the extracted and treated water to the publically owned wastewater treatment works will ensure positive hydraulic control. The future growth of the plume will be reduced by contaminant destruction in the source area. Implementation of this alternative will result in reduction in volume of contaminated media. Both ISB and ChemOx (Alternatives 4 and 5) should result in significant reduction in contaminant volume in the water bearing zones, however, because these methods rely on hydraulic delivery and recovery of fluids, their effectiveness in the lower permeability zones is uncertain.

The PRB (Alternative 3) should significantly reduce contaminant migration from the source area; however, it will not reduce contamination within the source area. Therefore, the PRB is considered source control rather than source removal. The zero valent iron filings proposed for the PRB could need replacing as a result of biological growth, scaling, or both. Therefore, the long-term operation of this technology will likely include iron filing media replacement. Because the DART method of emplacement is untested, filings replacement and DART well redevelopment every five years is assumed. Long-term ground water monitoring is required to confirm the effectiveness of this alternative.

MNA is not considered a treatment by the EPA, and will not reduce the volume of contamination in the source zone (Alternative 2) in a reasonable time frame. Furthermore, MNA will do little to mitigate the migration of contaminants to downgradient, off-site areas from the source zone.

Alternatives 6 and 7, ISB and ChemOx for the source area, with PRB for the solute plumes, provides added assurance against downgradient migration of residual contaminants via the PRB. A PRB for the solute plume would prove effective in reducing toxicity, mobility, and volume to the goal of MCLs, especially because aggressive source control measures would be implemented with this process.

MNA, although not considered a treatment by the EPA, may prove effective in reducing toxicity to the goal of MCLs for the dissolved plumes (Alternatives 2 through 5), particularly if aggressive source control measures are undertaken. Nonetheless, the efficacy of MNA must be thoroughly evaluated over the first several years of implementation to confirm its effectiveness. Dissolved contaminants will continue to migrate on a limited basis, as they have thus far. The toxicity of Site contaminants will be reduced, either through biotransformation or geochemical mechanisms over long periods of time. The volume of contaminated ground water is expected to increase before it begins to decrease. However, with aggressive source control measures, the volume and mass of dissolved plume contamination should stabilize and begin to decline.

In summary, on the basis of reduction of toxicity, mobility, or volume, Alternatives 6 and 7 are the most aggressive at treating both the source and solute plumes. ISB and ChemOx both provide significant reduction of toxicity and volume in the water bearing zones. The source plume PRB provides assurance against off-site migration of contaminants, but nothing to reduce TMV in the source zone. Finally, MNA is considered unacceptable for the source area based on poor reduction of toxicity, mobility, or volume. Both ISB for the source area and PRB for the solute plume; and ChemOx for the source area and PRB for the solute plumes provide significant reduction of toxicity, mobility, and volume in the water bearing zones. They also provide added assurance against downgradient off-site migration of residual contaminants.

5. ***Short Term Effectiveness:***

Short-term effectiveness is determined by the level of protection of the community and workers during the remedial actions, by any environmental impacts, and the time until the remedial action objectives are achieved. Alternative 1, no-action alternative, and Alternative 2, MNA, pose virtually no risk to the community or workers during implementation with the exception of well drilling and construction and sampling activities conducted during implementation of the MNA remedy. These risks are considered low. ISB (Alternatives 4 and 6) and ChemOx (Alternatives 5 and 7), would employ the existing remediation infrastructure to the extent possible. Construction activities would be far less intense than for a PRB in the source area and would also pose less worker risk. Operation of treatment systems would include handling chemicals and strong oxidants that could pose a threat to the community in the event of a mishap. Nonetheless, safety measures and controls should reduce this risk considerably.

Alternative 3, PRB with MNA, poses risks to the community and workers during construction. A traffic plan and feeder road easement are required to implement the remedy. Construction activities and waste handling pose a short-term threat to the community.

None of the alternatives pose a significant risk to the environment that cannot be managed with readily available engineered controls. Potential environmental impacts include dust generation, silt runoff, unauthorized discharge to a publically owned wastewater treatment plant, untreated discharges to injection wells, and air emissions. All of these risks are considered manageable with appropriate planning, design, and controls.

Because MNA for the solute plume is a component of Alternatives 2, 3, 4, and 5, the time until RAOs are achieved is long for these alternatives (greater than 20 years). Therefore, comparison of the alternatives based on cleanup times is discussed in terms of the time required for source removal. With this in mind, a qualitative ranking of alternatives with regard to source removal, in order of the shortest to longest time frames, is:

- Alternatives 4, 5, 6, and 7—ISB, ChemOx, ISB/PRB, ChemOx/PRB, respectively (five years)

- Alternatives 1, 2, and 3—no-action alternative, MNA, and PRB, respectively (20+ years)

Because the no-action, MNA, and PRB alternatives (Alternatives 1 through 3, respectively) provide no aggressive means of residual DNAPL removal from the source zone, a minimum time frame of 20 plus years is assigned for comparison purposes. All other alternatives should provide source removal in a reasonable time frame within the context of the overall approach (i.e., considering MNA as the solute plume remedy).

6. ***Implementability:***

Implementability relates to the ease with which a remedy alternative can be put in place. Factors including availability of materials, necessary equipment, maturity of the remediation process, and availability of services are considered.

All alternatives evaluated are considered implementable. The no-action alternative (Alternative 1) and MNA (Alternative 2) require no construction other than possible additional MWs for MNA. PRB (Alternative 3) would likely require access to the feeder road easement for implementation. ISB (Alternative 4) and ChemOx (Alternative 5) would require modification of the existing remediation system; however, the existing well field and conveyance systems would be utilized. Finally, ISB/PRB and ChemOx/PRB (Alternatives 6 and 7) would not only require modification of the existing remediation system, they would also require road closure of Englemohr Avenue for an extended period of time to allow for installation.

Implementation of PRB (with zero valent iron) would require licensing agreements because of the proprietary nature of this technology. All alternatives require long-term ground water monitoring.

ISB, ChemOx, ISB/PRB and ChemOx/PRB are all proven technologies; however, delivery of remediation fluids by hydraulic means in a complex layered system is challenging. Significant specialty subcontractor roles would be involved in the ISB alternative. All of the technologies are readily available.

7. ***Cost:***

Costs include capital costs necessary for design and construction, as well as long term costs related to operation and maintenance of the remediation technology. The cost of a remediation alternative is generally calculated as a present worth cost, which is the total cost of the alternative, including current and future costs, expressed in terms of today's dollar value.

Costs for the Site remediation alternatives were estimated for both the remediation action period, typically years one through 10, and the operation and maintenance (O&M) phase, generally year 11 and beyond. The costs are based on an MNA duration for the dissolved plume of generally 20 years; but, because the actual performance of MNA remains to be demonstrated, this should be considered a minimum time frame. A discount rate of 7% was used for the present worth calculations.

The total estimated present worth costs for the alternatives vary from $0 for the no-action alternative (Alternative 1) to $9.5 million for ISB source/PRB plume (Alternative 6) as shown in Table 11. MNA for source zone and solute plume (Alternative 2) has a present worth cost of $1.7 million. The costs for the more aggressive source zone treatments, with either MNA or PRB for the dissolved plume, can be summarized as follows:

- Alternatives 3, 4, and 5 (PRB, ISB, and ChemOx for the source area, respectively), and each with MNA for the solute plume, have present worth costs of $3.5 to $3.7 million.
- The present worth cost for ISB for the source area and PRB for the plume (Alternative 6) is about $9.5 million.

- The present worth cost for ChemOx for the source area and PRB for the plume (Alternative 7) is about $9.3 million.

Table 11 - Remediation Alternatives Cost Summary

Alternative	Capital Cost	Remedial Action Duration (years)	O&M Costs	O&M Period (years)	Discount Rate	Total Present Worth Cost
1: No Action	$0	none	$0	none	7%	$0
2: MNA	$1,200,000	10	$515,000	20	7%	$1,715,000
3: PRB Source & MNA Plume	$2,996,000	10	$721,000	20	7%	$3,717,000
4: ISB Source & MNA Plume	$3,015,000	10	$515,000	20	7%	$3,530,000
5: ChemOx Source & MNA Plume	$2,900,000	5	$820,000	25	7%	$3,720,000
6: ISB Source & PRB Plume	$8,415,000	10	$1,060,000	20	7%	$9,475,000
7: ChemOx Source & PRB Plume	$8,300,000	5	$980,000	25	7%	$9,280,000

8. *State Acceptance*

State acceptance addresses whether the State concurs with, opposes, or has no comment on the preferred remediation alternative. The TCEQ has reviewed a draft of this Amended ROD. The TCEQ concurs with the EPA's selected remedy and has provided a letter of concurrence which is provided in Appendix A.

9. *Community Acceptance*

The EPA acknowledges that the community within the area of a Superfund site is the principal beneficiary of all remediation actions performed. The EPA also recognizes its responsibility to inform interested citizens of the nature of environmental problems at a site, as well as potential solutions, and to learn what the community's preferences are regarding these sites.

The Amended Proposed Plan for the Sol Lynn Site was released for public review and comment in April 2004. The public comment period began on April 8, 2004, and ended on May 7, 2004. A public meeting was held in Houston, Texas near the Site on April 15, 2004, to provide the local community with an opportunity to hear a description of the Site conditions and the EPA's proposed remedy, and provide an opportunity for the public to make either written and/or verbal comments on the Amended Proposed Plan. A court reporter was present to record a transcript of the meeting.

There were no questions raised during the public meeting, and only one comment was received. The comment recognized that property in the area has been significantly impacted by chemicals at the Site, and expressed the hope that the EPA will be able to move forward as soon as possible to "get this behind all of us." Likewise, there were no public comments on the remedy alternatives received during the public comment period. However, there was one question received that asked for clarification regarding the sampling locations for the planned indoor air sampling at commercial locations in the area.

2.13 Principal Threat Waste

The NCP establishes an expectation that the EPA will use treatment to address the principal threats posed by a site wherever practicable. At a Superfund site, the principal threat concept applies to source materials, which are hazardous substances, pollutants, or contaminants that act as a reservoir for supplying contamination to ground water, surface water, or air. Source material can also act as a source for direct exposure. In general, principal threat wastes are those source materials considered to be highly toxic or highly mobile, which generally cannot be contained in a reliable manner or would present a significant risk to human health or the environment should exposure occur.

The likely presence of DNAPL and the highly contaminated ground water in the source areas of the water bearing zones are considered principal threat wastes because the contaminants (i.e., TCE, cis-1,2-DCE, and VC) are found at concentrations that pose a significant risk to human health, and because these materials act as a reservoir for further migration to and contamination of ground water.

Alternative 1, No Action, would not address the principal threats at the Site. While Alternative 2, MNA, would warn people of the contamination through the use of institutional controls, the risks would only be reduced to the extent that the controls were monitored and enforced over a very long period of time. Further, the use of institutional controls would not satisfy the preference for treatment. Alternative 3, which includes a permeable reactive barrier down gradient of the source area, would contain the principal threat wastes and provide treatment as the material migrated from the source areas, but would do nothing to treat the principal threats within the source area. All of the remaining remedy alternatives (numbers 4, 5, 6, and 7) would significantly reduce the risks posed by the principal threat wastes through treatment, either by ISB or by chemical oxidation.

2.14 Selected Remedy

Summary of the Rationale for the Selected Remedy

The selected remedy for ground water is Alternative 4, ISB for the source area, and MNA for the dissolved phase ground water plume. It is the EPA's current judgment that the Selected Remedy identified in this ROD is necessary to protect public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

ISB would consist of augmenting and stimulating the naturally occurring reductive dechlorination processes at work on the Site. Alternative 4 is selected because:

- The microcosm studies conducted in 2002 showed significant potential for the ISB technology;
- The ISB process satisfies the requirement to provide treatment of the principal threat wastes;
- The present worth cost of Alternative 4 is in the lower tier of alternatives evaluated
- MNA can be used for the dissolved ground water plumes in conjunction with the source area treatment by ISB.
- In addition, this alternative readily allows undertaking additional remedial actions as necessary. For example, PRBs can be added to the water bearing zones downgradient from the source area if necessary; or ChemOx can be implemented if ISB proves insufficient in treating the source area. Any additional remedial action would be implemented in accordance with the NCP and EPA guidance (e.g., an Explanation of Significant Differences, or a ROD amendment as appropriate).

The contamination to be addressed at the Site includes the source area, where residual TCE DNAPL and high concentrations of dissolved TCE, cis-1,2-DCE, and VC exist. The dissolved phase ground water plumes requiring cleanup are present in WBZ-1 through WBZ-4. Because control of the source area is required for the MNA remedy to be effective for the ground water plume, Alternatives 1 (no action) and 2 (MNA for source remediation) would not be effective components of the remediation approach due to the very long cleanup times expected. Alternatives 6 (ISB for source and PRB for the plume) and 7 (ChemOx for the source and PRB for the plume) address both the source area and solute plumes, but these technologies were not selected based on their high costs and the level of effort required for the extended road closures necessary (i.e., for installation of DART wells along Englemohr Avenue). The remaining alternatives consist of two general approaches: (1) source control measures to reduce or eliminate additional contaminant additions to the downgradient solute plumes (Alternative 3); and (2) source treatment measures via in-situ techniques that rely on hydraulic delivery (Alternatives 4 and 5).

Source control via PRB (Alternative 3) is not considered an effective remedy for source zone contamination at the Site because it does not reduce contamination within the source area. Furthermore, the potential for vapor intrusion into buildings in the area will not be reduced because the source area contamination will not be reduced. However, the PRB, if properly designed and maintained, will reduce contaminant additions to downgradient ground water plumes, thereby allowing MNA for the dissolved contamination to perform effectively. A drawback of this approach is that the PRB must be maintained for a very long time, until natural attenuation processes sufficiently reduce residual DNAPL within the source area. Nonetheless, Alternative 3 is in the lower tier of cost options for the alternatives ($3.7 million), and if institutional controls are maintained, it is an appropriate contingency strategy if ISB ultimately proves unsuccessful.

The in-situ source treatment alternatives, including ISB and ChemOx, are based on hydraulic injection of treatment materials. These approaches utilize existing equipment at the Site (i.e., wells, pipelines, water treatment plant, existing power supply, etc.). However, expansion of the well field could be required and will be evaluated during the remedial design. ChemOx is a proven technology for abiotic destruction of chlorinated contaminants, but it would virtually sterilize the Site during implementation and stop, for a period of time, the natural reductive dechlorination processes currently in progress. Following ChemOx treatment, reversion to ISB via reductive dechlorination in the source area would require considerable effort. For these reasons, ChemOx (Alternative 5) is an additional contingency alternative for source area treatment that the EPA may consider in the event ISB proves insufficient in achieving the remedial action objectives.

Description of the Selected Remedy

The components of the selected remedy, Alternative 4, are described below.

In-Situ Bioremediation (ISB) for the source area. ISB is a process that relies on microbial degradation of the chlorinated contaminants at the Site. The microorganisms require a substrate, or carbon source, for cell growth and an electron donor to complete the oxidation-reduction chemical reaction that these microbes use to create energy for life. The Site contaminants act as electron acceptors to complete the other half of the oxidation-reduction reaction. Nutrients could also be required, if not already present in sufficient quantities, to support microbial cell growth. The enhanced ISB planned for the Site is considered an "innovative technology" as a result of the limited number of sites that have used this treatment, as well as its application to an area of DNAPL contamination.

The performance goal for all contaminants in the source areas is to achieve MCLs for COCs, by reduction of DNAPL through employment of ISB. This will prevent future migration of the contaminant plume.

The existing packed tower aeration and the granular activated carbon ground water pump, treat, and re-injection system will be converted to an ISB system as needed. Utility hookups to city water and sewer are required. The existing equipment compound will be expanded as appropriate for addition of batch tanks and a transfer pump for nutrient addition and preparation of amendments. A portion of the treated extracted ground water will be discharged to a publicly owned wastewater treatment plant to provide hydraulic control of ISB system. Additional injection and/or extraction wells could be required as determined during the remedial design.

ISB amendments could include dechlorinating microorganisms, electron donor material, and substrate and nutrients for cell growth and to facilitate anaerobic conditions throughout source area. There are a number of ISB process options relating to the particular substrate used. One potential substrate is Hydrogen Release Compound (HRC™). HRC™ is a proprietary polylactate ester, which has been formulated to result in the slow release of lactic acid and a low level supply of hydrogen upon contact with ground water. Lactic acid occurs naturally in milk products and some foods. The lactic acid acts as a substrate, and the hydrogen is the electron donor necessary for cell growth and reductive dechlorination. One feature of HRC™ in contrast to other substrates is that it is designed to release hydrogen over a longer time period, requiring less frequent re-application. Other potential substrate amendments include lactate, molasses, refined sugars, and edible vegetable oils. Necessary nutrients could include nitrogen and phosphorus.

The type of ISB amendments, and design factors for injection, will be determined based on a pilot scale treatability study conducted during the remediation design. At a minimum, the purpose of the treatability study will be:

- Identification and comparison of possible delivery strategies and methodologies for addressing delivery into the DNAPL and high contaminate concentration zones. Potential alternatives for amendment injection include wells or by using direct push equipment;
- Identification and comparison of possible treatment solutions and reagents; and
- Gathering of other appropriate design information.

The ISB treatments will be targeted on the source areas where DNAPL and/or high contaminant concentrations exist, generally south of I-610. The ISB amendments will be injected throughout the DNAPL and high contaminant concentration areas except where access is not practicable, such as any source areas that extend underneath I-610. Provisions will be made for the addition of new wells for amendment addition, extraction, and/or monitoring should future conditions warrant it. Ground water monitoring in the source area will be ongoing in accordance with an approved sampling plan.

The existing pump and treat facility will remain in operation during the ISB remedial action to facilitate hydraulic control of the ISB system and to reduce or prevent contaminants from migrating out of the source area and feeding the downgradient ground water plumes. The treated ground water will be discharged to a publically owned wastewater treatment plant.

An annual evaluation of the ISB program will be completed for the first three years, and thereafter as determined by the EPA to be necessary. This evaluation could result in adjustments, as necessary, to ISB amendment injection locations, type of materials, frequency, and quantity to maintain optimum contaminant degradation. If the EPA determines that ISB will not achieve the remedial action objectives for the source area, or unacceptable migration of a contaminant is occurring, the EPA may consider selection of an appropriate contingency action as necessary to protect human health and the environment.

Monitored Natural Attenuation (MNA) for the dissolved contaminant ground water plumes downgradient of the source areas. The ground water monitoring well network will be expanded as needed, and the wells will be monitored in accordance with an approved monitoring plan developed during the remedial design. The monitoring data will be used to evaluate plume stability, and to support verification of the MNA processes and contaminant destruction over time. Contaminant fate and transport modeling will be conducted throughout implementation as new data become available to verify the effectiveness of remedy. MNA will remain in operation until the EPA confirms that cleanup levels are met and maintained. If the EPA determines that

MNA will not achieve the remedial action objectives for the contaminated ground water in the dissolved plumes, the EPA may consider selection of an appropriate contingency action as necessary to protect human health and the environment that is consistent with the remedy alternatives discussed in this ROD. Any contingent remedy could also include a TI Waiver for the drinking water ARARs.

Institutional Controls in the form of restrictive covenants are in place in much, if not all, of the source area, and will be applied where not in place, in order to prevent exposure to contaminated ground water during treatment of the source area. Institutional controls will also be implemented in connection with a plume management zone for the dissolved ground water plume to prevent future use of ground water within the affected area until the ground water cleanup levels are achieved by MNA. Finally, institutional controls would be employed to prevent the construction of residential structures in areas that could be adversely impacted by vapor intrusion into indoor air. Additional indoor air sampling will be done during the remedial design to confirm previous sampling due to the potential for seasonal variability in results. The institutional controls will be determined, but could include a combination of deed notices, easements, and restrictive covenants.

Five Year Reviews will be completed for as long as contaminants remain above the drinking water standards. The effectiveness of the MNA remedial technology as well as updated estimates of cleanup time will be evaluated during the 5-year reviews. If it appears, the MNA remediation technology is not effective, alternative remediation technologies will be evaluated.

An operation and maintenance (O&M) plan for the Site will be implemented. It will include a schedule for ground water monitoring in addition to activities necessary to ensure that the institutional controls are being followed and that they are effective and protective. The O&M schedule will be coordinated with the five year reviews.

Summary of the Estimated Remedy Costs

The estimated capital and operating costs for the selected remedy, Alternative 4, are presented in Appendix B. The information in this cost estimate is based on the best available information regarding the anticipated scope of the remediation alternative. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design of the remediation alternative. Changes would be documented in the form of a memorandum in the Administrative Record file, an Explanation of Significant Difference (ESD), or a ROD amendment, depending upon their scope and significance. These are order of magnitude engineering cost estimates that are expected to be within +50 percent to -30 percent of the actual cost.

Expected outcomes of the Selected Remedy

Completion of the ISB treatments may free the properties in the area for further development for commercial uses, with an exception for the locations of the retained ground water monitoring wells. Ground water use in the source area and the ground water plume areas will be restricted during the time that the remedy is implemented, including MNA.

The primary expected outcome for contaminated ground water, outside of the source area, following completion of Alternative 4 is reduction of contamination to below the cleanup levels, or MCLs, for TCE, cis-1,2-DCE, and VC. The expected outcome could be achieved within 30 years following remedy implementation. However, because multiple water bearing zones and low permeability zones exist throughout the Site, the remediation technology is limited by permeability contrasts and areal variations. The ability to affect the entire zone of contamination creates difficulties with regard to restoring ground water concentrations to acceptable levels. Therefore, substantial uncertainty exists regarding the estimation of cleanup times, and the length of time required for cleanup could well be more than 30 years.

A combination of monitoring and institutional controls will be used to prevent exposure to contaminated ground water in the source area until the cleanup levels (i.e., MCLs) are achieved. For contaminated water bearing zones outside the source area, implementation of a PMZ with institutional controls will prevent future use of the ground water there until the cleanup levels have been achieved. A successful remediation program should restore the ground water to beneficial uses and release of the property for unrestricted reuse.

2.15 Statutory Determinations

Under its legal authorities, the EPA's primary responsibility at Superfund sites is to undertake remedial actions that achieve adequate protection of human health and the environment. In addition, Section 121 of CERCLA establishes several other statutory requirements and preferences. These specify that, when complete, the selected remedial action must comply with applicable or relevant and appropriate environmental standards established under federal and State environmental laws unless a waiver is justified. The selected remedy must also be cost-effective and utilize permanent solutions and alternative treatment technologies to the maximum extent practicable. Finally, the statute includes a preference for remedies that employ treatment that permanently and significantly reduces the volume, toxicity, or mobility of hazardous wastes as their principal element. The following sections discuss how the selected remedy, Alternative 4, addresses these statutory requirements and preferences.

Protection of Human Health and the Environment

The Selected remedy will adequately protect human health and the environment through ISB treatment, MNA, and institutional controls. The source areas will be treated with an ISB process to reduce the amount of contaminants that are sources for the ground water plumes. Contaminant mass reduction in the source areas will also reduce the potential for vapor intrusion into buildings in the area. MNA will be used for the area of dissolved ground water contaminant plumes downgradient from the source area. These remedies are not expected to cause unacceptable short term risks or cross media impacts.

If the EPA determines ISB will not achieve the remedial action objectives, the EPA may consider selection of an appropriate contingency action in accordance with remedies in this ROD.

MNA is protective of human health because:

- Notices will be placed in property deeds warning potential property purchasers of contaminated ground water in the plume area downgradient of the source, and would remain in place until the ground water is returned to adequate quality for unlimited use;
- Monitoring will continue until it has been demonstrated that ARARs have been achieved;
- MNA is expected to achieve cleanup levels within a reasonable time frame;
- The EPA will review the remedy if monitoring data shows that a contaminant threatens water supply wells or cleanup levels will not be met.

Because these remedies will result in contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure, a statutory five-year review will be conducted within five years of the commencement of this remedial action, and continued thereafter until the RAOs are achieved to ensure that the remedy continues to provide adequate protection of human health and the environment.

Compliance with ARARs

Remedial actions selected under CERCLA must comply with all ARARs under federal environmental laws or, where more stringent than the federal requirements, State or State subdivision environmental or facility siting laws. Applicable or relevant and appropriate requirements are identified on a site-specific basis from information about site-specific chemicals, specific actions that are being considered, and specific features of the site location. Only the substantive provisions of ARARS, and not the permitting or other procedural or administrative requirements, are applicable or relevant and appropriate. A detailed discussion and analysis of the ARARs for this Site that have been identified by the EPA and the TCEQ is contained above in Section 2.10 of this ROD Amendment.

This ROD Amendment modifies the ground water remedy selected in the September1988 ROD. However, this ROD Amendment will neither modify the remedy, nor affect the ARARs selected for the March 1988 ROD for Site soil remediation.

The selected remedy of ISB for the source area, and MNA for the ground water plume, will comply with all Federal and any more stringent State ARARs that are applicable or relevant and appropriate to the Site. Table 12 below (Applicable or Relevant and Appropriate Requirements) summarizes how the selected remedy, Alternative 4, will comply with location, chemical, and action specific ARARs for the Site.

Table 12 - Applicable or Relevant and Appropriate Requirements (ARARs)

Standard or Criteria	Citation	Description	Status	Discussion
Chemical Specific ARARs				
National Primary Drinking Water Standards	Safe Drinking Water Act, 42 U.S.C. §300f et seq.; 40 CFR 141.50(a)	Maximum Contaminant Level Goals (MCLG) and Maximum Contaminant level (MCL). For the Site, the MCLGs, or the MCLs if the MCLGs are 0, are TCE - 5 µg/L; cis-1,2-DCE - 70 µg/L; and VC - 2 µg/L.	Relevant and Appropriate	The selected remedy will comply with this ARAR. These levels are considered relevant and appropriate for ground water aquifers potentially used for drinking water. The ground water units are classified as Class IIA aquifers.
OSHA Permissible Exposure Limits (PELs)	29 C.F.R. 1910.1000	Rule on Permissible Exposure Limits (PELs) for specific chemicals in the workplace indoor air, including Site COCs.	Applicable	The selected remedy will comply with this ARAR.

Table 12 - Applicable or Relevant and Appropriate Requirements (ARARs)

Standard or Criteria	Citation	Description	Status	Discussion
NIOSH Recommended Exposure Limits (RELs)	Occupational Health Guidelines for Chemical Hazards, Supp. I OHG, 1988 DHHS (NIOSH) Pub. No. 88-118.	Recommended Exposure Limits for specific chemicals in the work place indoor air, including Site COCs.	To Be Considered	NIOSH Guidance.
		Action Specific ARARs		
Resource Conservation and Recovery Act (RCRA),	42 U.S.C. §6901 et seq.; 40 C.F.R. 300.440	Hazardous substances identified by the EPA in the ground water at the Site (cis-1,2-DCE, VC, and TCE) are "listed" hazardous wastes under RCRA regulations at 40 CFR 261.33(a) and (f). RCRA standards for waste characterization (40 CFR Part 261), standards for generators of hazardous waste (40 CFR Part 262), standards for transporting hazardous waste (40 CFR Part 263), standards for treatment, storage, and disposal facilities (40 CFR Part 264), and disposal of hazardous waste subject to land disposal restrictions (40 CFR Part 268) will apply.	Applicable or Relevant and Appropriate	Texas has an EPA authorized RCRA program. The selected remedy will comply with this ARAR, including off-site disposal of waste (including investigation derived waste/purge water), which is also regulated by the NCP off-site Rule at 40 CFR 300.440.

Table 12 - Applicable or Relevant and Appropriate Requirements (ARARs)

Standard or Criteria	Citation	Description	Status	Discussion
Texas Risk Reduction Program	30 TAC 350.33(f)(4)	Requirements for establishment of a plume management zone (PMZ).	Relevant and Appropriate	The selected remedy will comply with this ARAR, which is relevant only to Monitored Natural Attenuation.
Texas Risk Reduction Program	30 TAC 350.52	Requirements for determining the class of an aquifer. Aquifer classification is necessary to establish size of PMZ for MNA.	Relevant and Appropriate	The selected remedy will comply with this ARAR.
Texas Risk Reduction Program	30 TAC 350.111	Requirements for the use of Institutional Controls when cleanup does not result in unrestricted use.	Relevant and Appropriate	The selected remedy will comply with this ARAR.
US DOT Regulations for Transport of Hazardous Materials	49 CFR Parts 171 and 172	Regulates transportation of Dept. of Transportation (DOT) defined hazardous materials	Applicable	All DOT defined hazardous materials will be handled as required by this ARAR.
Clean Air Act	42 U.S.C. §§7411, 7412	New Source Performance Standards (NSPS) and regulations for the emission of Hazardous Air Pollutants (HAPs) under the Clean Air act	Applicable	The selected remedy will comply with this ARAR.
Texas Surface Water Quality Standards	TAC, Title 30, Chapter 307: §307.4 through §307.10	Regulations related to construction activities	Applicable	The selected remedy will comply with this ARAR.

Table 12 - Applicable or Relevant and Appropriate Requirements (ARARs)

Standard or Criteria	Citation	Description	Status	Discussion
Texas Additional Conditions & Procedures For Wastewater Discharge Permits & Sewage Sludge Permits	TAC Title 30, Chapter 305, Sub-chapter O: §305.531; §305.532; §305.434; §305.538	Regulations related to wastewater and sewage sludge permits for construction activities	Applicable	The selected remedy will comply with this ARAR (substantive provisions only).
Texas Clean Air Act (TCAA)	30 TAC §101.1, §101.5, §101.7, §101.8, §101.9	Regulations relating to traffic hazard, maintenance, start-up and shutdown reporting, record keeping, and operational requirements, sampling, and sampling ports.	Applicable	The selected remedy will comply with this ARAR.
Texas Injection Well Act	30 TAC 331	Regulations relating to control of underground injection	Relevant and Appropriate for surfactant injection	If surfactant injection is used at the Site, then the remedy will comply with this ARAR.
Risk Assessment Guidance	"Risk Assessment Guidance for Superfund, Vol. 1 (EPA, 1989)	Guidance on the completion of a risk assessment.	To Be Considered	EPA Guidance
Texas Risk Reduction Program	30 TAC 350.72(a), (c)	TRRP risk assessment procedures for determining individual and cumulative risk.	To Be Considered	TCEQ Procedures

Table 12 - Applicable or Relevant and Appropriate Requirements (ARARs)

Standard or Criteria	Citation	Description	Status	Discussion
Natural Attenuation Guidance	"Use of MNA at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites" (EPA 1999)	Guidance on the use of MNA to restore ground water	To Be Considered	EPA guidance
Location Specific ARARs				
Texas Ground Water Protection Act	Water Code §§26.401-407	Requires ground water to be restored, if feasible.	Relevant and Appropriate	The selected remedy will comply with this ARAR.
RCRA TSD Siting Rule	40 C.F.R. 264.18	Regulation governing location of TSD facilities in connection with certain geological and meteorological conditions.	Relevant and Appropriate	The selected remedy will comply with this ARAR.
Natural Attenuation Guidance	Use of MNA at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites (EPA 1999)	Guidance on the use of MNA to restore ground water	To Be Considered	NA

Cost Effectiveness

The Selected Remedy, Alternative 4, is cost effective because the remedy's costs are proportional to its overall effectiveness (see 40 CFR §300.430(f)(l)(ii)(D)). This determination was made by evaluating the overall effectiveness of those alternatives that satisfied the threshold criteria (i.e., that are protective of human health and the environment and comply with all Federal and any more stringent State ARARs, or as appropriate, waive ARARs). Cost-effectiveness is determined by evaluating three of the balancing criteria (long-term effectiveness and permanence; reduction of toxicity, mobility or volume through treatment; and short-term effectiveness). Overall effectiveness is then compared to cost to ensure that the remedy is cost effective.

The projected net worth costs including 30 years for the selected remedy is $3.5 million, which is the least costly, except for Alternative 2, of all the alternatives considered. However, unlike the selected remedy, Alternative 2 does nothing to treat the DNAPL source area, which is a principal threat waste.

Alternative 3 and Alternative 5, which are contingent remedies for the selected remedy, have roughly the same projected net worth costs, at $3.7 million, as the selected remedy. Alternative 3, while providing treatment of the contaminated ground water as it migrates through the permeable reactive barrier, does not provide treatment within the source area, and the barrier would have to be maintained and replenished for a long time. Neither would Alternative 3 provide any near term reduction in the potential for vapor intrusion into overlying Site structures. Alternative 5 does provide direct ChemOx treatment within the source are, but would sterilize the water bearing zones and stop the ongoing natural reductive dechlorination processes. If necessary, reestablishment of reductive dechlorination in the source area would require considerable effort.

The remaining alternatives, Numbers 6 and 7, while effectively reducing the risk and providing a more aggressive remedy for the contaminated ground water plumes, are both much more expensive, more than $9 million, than the selected remedy. Further, both of these alternatives would have implementation issues related to the road closure of Englemohr Avenue for an extended period of time to allow for the DART wells to be installed.

Utilization of Permanent Solutions and Alternative Treatment Technologies or Resource Recovery Technologies to the Maximum Extent Practicable

The EPA has determined that the selected remedy, Alternative 4, ISB treatment for the source area and MNA outside of the source area, represents the maximum extent to which permanent solutions and treatment technologies can be used in a cost-effective manner for ground water at the Site. Of the alternatives evaluated, the EPA has determined that the selected remedy provides the best balance of tradeoffs in terms of the nine criteria used for remedy selection. In particular, this remedy represents the best balance between long-term effectiveness and permanence, reduction of toxicity, mobility or volume through treatment, implementability, short-term effectiveness, and cost.

The selected remedy for the source area does result in treatment of contaminants through the ISB process. Source area DNAPL contamination is expected to degrade overtime through this enhanced biological action, and should restore the source area to drinking water standards.

Preference for Treatment as a Principal Element

Although contaminated ground waters generally are not considered to be principal threat wastes, DNAPLs are viewed as principal threat wastes because of their potential to be sources of toxic contaminants to ground water. For this reason, the EPA expects to remove or treat source area DNAPLs to the MCLs.

Five-Year Review Requirements

Section 121(c) of CERCLA and NCP §300.430(f)(5)(iii)(C) provide the statutory and legal bases for conducting five-year reviews. Because this amended remedy will result in hazardous substances remaining in the ground water above levels that allow for unlimited use and unrestricted exposure, the EPA will conduct a statutory review within five years after initiation of the remedial action to ensure that the remedy is, or will continue to be, protective of human health and the environment.

2.16 Documentation of Significant Changes from Preferred Alterative of the Proposed Plan

The Proposed Plan for the Site, released for public comment in April 2004, identified Alternative 4 as the EPA's preferred alternative. The selected remedy, Alternative 4, remains unchanged, consisting of ISB for the source removal, MNA for the dissolved plumes, and institutional controls.

PART 3: RESPONSIVENESS SUMMARY

3.1 Stakeholder Comments and EPA Responses

The public comment period for the Proposed Plan began on April 8, 2004, and closed on May 7, 2004. A notice of the Amended Proposed Plan, the public comment period, and the date and location for a public meeting was published in the Houston Chronicle on April 7, 2004. This notice was also published in Spanish in a Spanish language newspaper, the EL Dia, on April 8, 2004. In addition, a fact sheet regarding the public meeting and proposed remedy was mailed to 40 members of the community on April 12, 2004.

The public meeting was attended by one community member. There were no questions and only one comment during the public meeting. The comment recognized that property in the area has been significantly impacted by chemicals at the Site, and expressed the hope that the EPA will be able to move forward as soon as possible to "get this behind all of us." Likewise, there were no public comments on the remedy alternatives received during the public comment period. However, there was one question received that asked for clarification regarding the sampling locations for the planned indoor air sampling at commercial locations in the area. A transcript of the public meeting is included in the Administrative Record.

3.2 Technical and Legal Issues

No technical or legal issues were raised by the stakeholders during the public comment period.

PART 4: REFERENCE LIST

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