FINAL

RECORD OF DECISION
LHAAP-46, PLANT 2 AREA, GROUP 4
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

Prepared for

U.S. Army Corps of Engineers
Tulsa District
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Acronyms and Abbreviations

2,3,7,8-TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
µg/L	micrograms per liter
ARARs	applicable or relevant and appropriate requirements
AT123D	Analytical Transient One-, Two-, Three-Dimensional
BERA	Baseline Ecological Risk Assessment
BHHRA	Baseline Human Health Risk Assessment
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CFR	Code of Federal Regulations
cm/s	centimeters per second
COC	chemical of concern
COEC	chemical of ecological concern
COPC	chemical of potential concern
CWA	Clean Water Act of 1972
DCE	dichloroethene
DNAPL	dense non-aqueous phase liquid
ECOP	Environmental Condition of Property
EPC	exposure point concentration
ESD	Explanation of Significant Differences
FFA	Federal Facility Agreement
FR	Federal Register
FS	Feasibility Study
ft^2	square feet
GW-Ind	groundwater medium-specific concentration for industrial use
HEAST	Health Effects Assessment Summary Tables
HI	hazard index
HQ	hazard quotient
IRIS	Integrated Risk Information System
Jacobs	Jacobs Engineering Group, Inc.
LHAAP	Longhorn Army Ammunition Plant
LTM	long-term monitoring
LUC	land use control
MARC	Multiple Award Remediation Contract
MCL	maximum contaminant level
mg/kg	milligrams per kilogram
MNA	monitored natural attenuation

Acronyms and Abbreviations (continued)

MOA	memorandum of agreement
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priorities List
O&M	operation and maintenance
PCB	polychlorinated biphenyl
Plexus	Plexus Scientific Corporation
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RD	remedial design
RFA	RCRA Facility Assessment
RfD	reference dose
RI	remedial investigation
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
Shaw	Shaw Environmental, Inc.
STEP	Solutions to Environmental Problems, Inc.
SVOC	semivolatile organic compound
TAC	Texas Administrative Code
TCE	trichloroethene
TCEQ	Texas Commission on Environmental Quality
TDLR	Texas Department of Licensing and Regulation
U.S. Army	U.S. Department of the Army
USACE	U.S. Army Corps of Engineers
USAEHA	U.S. Army Environmental Hygiene Agency
USATHAMA	U.S. Army Toxic and Hazardous Material Agency
USC	U.S. Code
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
UTL	upper tolerance limit
VC	vinyl chloride
VOC	volatile organic compound

1.0 Declaration

1.1 Site Name and Location

Longhorn Army Ammunition Plant-46 (LHAAP-46), Plant 2 Area, Group 4

Longhorn Army Ammunition Plant
Karnack, Texas

Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS), U.S. Environmental Protection Agency (USEPA) Identification Number: TX6213820529.

1.2 Statement of Basis and Purpose

This decision document presents the selected remedy for LHAAP-46, the Plant 2 Area, located at the Longhorn Army Ammunition Plant (LHAAP) in Karnack, Texas. The 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), Code of Federal Regulations (CFR) Title 40 §300.

The remedy selection was based on the Administrative Record for this site, including the remedial investigation (RI) (Jacobs Engineering Group, Inc. [Jacobs], 2002), baseline human health risk assessment (BHHRA) report (Jacobs, 2003), installation-wide baseline ecological risk assessment (BERA) report (Shaw Environmental, Inc. [Shaw], 2007a), feasibility study (FS) (Shaw, 2009), Proposed Plan (U.S. Department of the Army [U.S. Army], 2010), and other related documents contained in the Administrative Record for LHAAP-46.

This document is issued by the U.S. Army, the lead agency for this installation. The USEPA (Region 6) and the Texas Commission on Environmental Quality (TCEQ) are the regulatory agencies providing technical support, project review and comment, and oversight of the U.S. Army cleanup program. The USEPA and TCEQ concur with the selected remedy.

1.3 Assessment of the Site

The response action selected in this Record of Decision (ROD) is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances, pollutants, or contaminants from this site which may present an unacceptable risk to human health and the environment.

1.4 Description of the Selected Remedy

The final selected remedy for LHAAP-46 protects human health and the environment by preventing human exposure to trichloroethene (TCE)-contaminated groundwater and preventing TCE-contaminated groundwater from migrating into nearby surface water. No principal threat source material has been identified at LHAAP-46. The remedy includes the components described below.

- Monitored natural attenuation (MNA) will be implemented to verify that the TCE plume is stable and will not migrate to nearby surface water at levels that may present an unacceptable risk to human health and the environment. MNA will return groundwater to its potential beneficial use, wherever practicable.
  - Performance objectives will be evaluated after 2 years of MNA. During those 2 years, monitoring will be quarterly. If MNA is found to be ineffective, a contingency remedy to enhance MNA will be implemented. If MNA is found to be effective, it will be continued, and monitoring will be semiannual for 3 years. In subsequent years, monitoring will be annual until the next five-year review. The monitoring and reporting associated with this remedy will be used to track the effectiveness of MNA and will continue every 5 years until cleanup levels are achieved. Based on calculated attenuation rates for LHAAP-46, groundwater cleanup levels are expected to be met through natural attenuation in approximately 23 years. Considering the lithologic variability, particularly the lateral and vertical change from sand to clay, the times to maximum contaminant level (MCL) may vary.
- Land use control (LUC) in the impacted area will ensure the protection of human health by restricting the use of groundwater to environmental monitoring and testing only. The LUC will remain in place until the MCLs are met.

The remedial design (RD) will cover the specific LUC and implementation details. The MNA performance monitoring plan will also be presented in the RD. Within 90 days of the signing of the ROD, the U.S. Army will prepare and submit the RD to USEPA consistent with the schedule of Section XVI of the Federal Facility Agreement (FFA). The U.S. Army, USEPA, and the Texas Water Commission (currently known as TCEQ) entered into the FFA for remedial activities at LHAAP on December 30, 1991. The U.S. Army will be responsible for implementation, maintenance, periodic inspection, and enforcement of the LUC in accordance with the RD. Although the U.S. Army may transfer these responsibilities to another party through property transfer agreement or other means, the U.S. Army will remain ultimately responsible for: (1) CERCLA §121(c) five-year reviews; (2) notification of the appropriate regulators of any known LUC deficiencies or violations; (3) access to the property to conduct any necessary response; (4) reservation of the authority to change, modify, or terminate the LUC and any related transfer or lease provisions; and (5) ensuring that the LUC objectives are met to protect the integrity of the selected remedy.

Army and regulators will consult to determine appropriate enforcement actions should there be a failure of an LUC objective at these sites after they have been transferred. The Army shall consult with TCEQ and obtain USEPA concurrence prior to termination or significant modification of an LUC, or land use change inconsistent with the LUC objectives and use assumptions of the remedy. In the event that TCEQ and/or EPA and the U.S. Army agree with respect to any modification of the selected remedy, including the LUC component of the selected remedy, the remedy will be changed consistent with the FFA and 40 CFR 300.435(c)(2) and 40 CFR 300.430(f)(4)(iii).

The management strategy at LHAAP is to approach each site separately to address human health issues and to approach the sites by sub-area to address ecological risk. Thus, the implementation of this remedy at LHAAP-46 is independent of any other remedial action at LHAAP to address human health issues. To address ecological risk, LHAAP-46 was grouped with several other sites as part of the Industrial Sub-Area. Because no chemicals exceeded ecological thresholds of concern in the Industrial Sub-Area, no action is needed at LHAAP-46 to address ecological risk (Shaw, 2007a).

1.5 Statutory Determinations

The selected remedy does not satisfy the statutory preference for treatment as a principal element of the remedy. Although the final selected remedy is not intended to address the statutory preference for treatment to the maximum extent practicable, the final selected remedy offers, within a reasonable time frame and at a lower cost, a similar level of protection to human health and the environment than those remedy alternatives which satisfy the preference for treatment. In addition, no source materials constituting principal threats will be addressed within the scope of this action. In addition, the remedy offers long-term effectiveness through the implementation of the LUC, which would minimize the potential risk posed by the contaminated groundwater. Further, evaluation of MNA including routine monitoring of the attenuation until MCLs are met would document the effectiveness of the selected remedy. The selected remedies are easily and immediately implementable and cost less than the other alternatives considered for LHAAP-46, with the exception of Alternative 1 (No Action).

The selected remedy of MNA would reduce the toxicity, mobility, or volume of contaminants in the groundwater through a passive remedial action. There is no known principal threat material or contaminant source in the LHAAP-46 groundwater.

Because hazardous substances, pollutants, or contaminants remain at the site above levels that allow for unlimited use and unrestricted exposure, a five-year review will be conducted every five years to ensure protection of human health and the environment under CERCLA §121(c), U.S. Code (USC) Title 42 §9621(c). In accordance with 30 Texas Administrative Code (TAC) §335.566, a notification will be recorded in Harrison County records stating that the site is

suitable for nonresidential use and that a restriction of groundwater usage to environmental monitoring and testing is in place until the MCL is achieved. Although the U.S. Army may later pass these procedural responsibilities to the transferee by property transfer agreement, the U.S. Army shall retain ultimate responsibility for remedy integrity, per the FFA and CERCLA §121.

1.6 ROD Data Certification Checklist

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

- Current and reasonably anticipated future land use assumptions and current and potential future beneficial uses of groundwater as identified in the baseline risk assessment and ROD **(Section 2.6**).
- Potential land and groundwater use that will be available at the site as a result of the selected remedy **(Section 2.6)**.
- Chemicals of concern (COCs) and their respective concentrations **(Section 2.7)**.
- Baseline risk represented by the COCs **(Section 2.7)**.
- Cleanup levels established for COCs and the basis for these levels **(Section 2.8)**.
- Absence of source materials constituting principal threats that need to be addressed at this site **(Section 2.11)**.
- Key factor(s) that led to selecting the remedy **(Section 2.12)**.
- Estimated capital, annual operation 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)**.

1.7 Authorizing Signatures

As the lead agency, the United States Army issues this ROD for LHAAP-46 which documents the final selected remedy. The undersigned is the appropriate approval authority for this decision.

Thomas E Lederle 23 Sep 2010
(Name) *(Date)*
Thomas E. Lederle
Industrial Branch Chief
Base Realignment and Closure Division
United States Army

The United States Environmental Protection Agency approves the selected remedy as provided in the ROD for LHAAP-46.

9-30-10
(Name) *(Date)*
for Samuel Coleman, P.E.
Director
Superfund Division
United States Environmental Protection Agency
Region 6

2.0 Decision Summary

2.1 Site Name, Location, and Description

LHAAP-46, Plant 2 Area, Group 4

Longhorn Army Ammunition Plant
Karnack, Texas

Comprehensive Environmental Response, Compensation, and Liability Information System USEPA Identification Number: TX6213820529

Lead Agency: U.S. Army, Department of Defense
Support Agencies: USEPA Region 6, TCEQ

Source of Cleanup Money: U.S. Army, Department of Defense

Site type: Industrial facility

The former LHAAP is an inactive, government-owned, formerly contractor operated and maintained, Department of Defense facility located in central east Texas (see **Figure 2-1**) in the northeast corner of Harrison County. LHAAP is approximately 14 miles northeast of Marshall, Texas, and approximately 40 miles west of Shreveport, Louisiana. The former U.S. Army installation occupied 8,416 acres between State Highway 43 at Karnack, Texas, and the southwestern shore of Caddo Lake. The facility can be accessed via State Highways 43 and 134.

LHAAP was placed on the Superfund National Priorities List (NPL) on August 9, 1990. Activities to remediate contamination began in 1990. After its listing on the NPL, the U.S. Army, the USEPA, and the Texas Water Commission (currently known as the TCEQ) entered into a CERCLA Section 120 FFA for remedial activities at LHAAP. The FFA became effective December 30, 1991. LHAAP operated until 1997 when it was placed on inactive status and classified by the U.S. Army Armament, Munitions, and Chemical Command as excess property. The majority of LHAAP has been transferred by the U.S. Army to the U.S. Fish and Wildlife Service (USFWS) for management as the Caddo Lake National Wildlife Refuge.

LHAAP-46, also known as the Plant 2 Area, is located in the north-central portion of LHAAP. The site is shown on **Figure 2-2** and covers approximately 190 acres.

2.2 Site History and Enforcement Activities

2.2.1 History of Site Activities

LHAAP was established in December 1941 and had three plants that manufactured a variety of ammunition and explosives at various times, among other industrial activities. LHAAP-46 is the current designation of the former Plant 2 Area. Construction of facilities for producing JB-2 propellant fuel at Plant 2 began in 1944, but construction was halted in 1945 with the end of World War II. Plant 2 was used to produce pyrotechnic ammunition, such as photoflash bombs, simulators, hand signals, and tracers for 40 mm ammunition from 1952 to 1956. Plant 2 was reactivated to produce pyrotechnic and illuminating devices from 1964 to 1997. LHAAP, including Plant 2, operated until 1997 when it was placed on inactive status and classified by the U.S. Army Armament, Munitions, and Chemical Command as excess property.

2.2.2 History of Investigative Activities

As part of the Installation Restoration Program, the U.S. Army began an environmental investigation in 1976 at LHAAP followed by installation wide assessments/investigations that included the following:

- In 1980, U.S. Army Toxic and Hazardous Material Agency (USATHAMA, 1980) conducted a record search to assess the impact of the LHAAP installation activities including usage, storage, treatment, and disposal of toxic and hazardous materials on the environment, and defined conditions that may have adversely affected human health and the environment.
- Contamination Survey – In 1982, as part of the LHAAP contamination survey, Environmental Protection Systems collected six groundwater samples for laboratory analyses. Subsequently, in 1987, as part of the Resource Conservation and Recovery Act (RCRA) permit application process, and as a continuation of the contamination survey, U.S. Army Environmental Hygiene Agency (USAEHA) identified, described, and evaluated all solid waste management units at LHAAP (USAEHA, 1987). Units requiring further sampling, investigation, and corrective action were delineated.
- RCRA Facility Assessment (RFA) – In 1988, a preliminary RFA was conducted by the U.S. Army (Maley, 1988). Waste at the various sites was characterized, but no samples were collected.

Several investigations to determine the nature and extent of contamination in the soil, groundwater, surface water, and sediments at LHAAP-46 were conducted and are listed below. Samples were analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), metals, explosive compounds, perchlorate, pesticides, polychlorinated biphenyls (PCBs), and/or dioxins/furans, depending on the focus of the investigation. For some of the earlier investigations, LHAAP sites were organized into groups, and LHAAP-46 was

included in Group 4. The group designation was de-emphasized as the complexities of the individual sites became greater. The following summarizes the investigations at LHAAP-46.

- **Multi-phase investigation of Group 4 sites**: Between 1992 and 2001, numerous investigations were conducted in a phased approach by Jacobs, U.S. Army Corps of Engineers (USACE), and BCM Engineers, Inc. Activities included installation of 24 monitoring wells and analysis of groundwater, surface water, sump contents, soil, and sediment samples. The results are documented in the RI report for Group 4 sites (Jacobs, 2002).

- **Plant-wide perchlorate investigation**: The investigation was conducted by Solutions to Environmental Problems, Inc. (STEP) in 2000 through 2002 (STEP, 2005). Groundwater samples were collected from five wells.

- **Baseline Human Health Risk Assessment**: The BHHRA (Jacobs, 2003) used data from the investigations conducted through 2001 including the plant-wide perchlorate investigation results up to that time. The report concluded that the soil at LHAAP-46 required no action because the associated carcinogenic risk and non-carcinogenic hazard were acceptable. Groundwater was found to pose acceptable carcinogenic risk but unacceptable non-carcinogenic hazard.

- **Phase II Environmental Site Assessment**: Media investigated in 2003 included soil and groundwater (Plexus Scientific Corporation [Plexus], 2005).

- **Baseline Ecological Risk Assessment**: The BERA (Shaw, 2007a) determined that LHAAP-46, as a part of the Industrial Sub-Area, did not have chemicals of ecological concern (COECs). The evaluation was based on environmental investigations from 1993 to 2006.

- **Data gaps**: Additional investigations were conducted by Shaw in 2004 after the BHHRA was finalized to further delineate the extent of groundwater contamination identified during previous sampling events. The results of the 2004 investigation were presented in the Data Gaps Report (Shaw, 2007b).

- **Sumps report**: The 146 sumps/waste rack sumps across LHAAP were grouped together and were designated as LHAAP-35/36. Sixty of these sumps/waste rack sumps were located on LHAAP-46. All sumps were removed from the site in the mid-1990s, and it was determined that no further action is necessary for sump-related soil (Shaw, 2008).

- **Feasibility Study (FS)**: The FS (Shaw, 2009) was based on the available results from previous investigations. In addition, it included sampling results from Building 407 soil and ash samples in 2006, natural attenuation and geochemical evaluations based on 2007 results, monitoring well sampling for volatile organic compounds (VOCs) in 2008, and details of new intermediate zone well installations.

2.2.3 History of CERCLA Enforcement Activities

Due to releases of chemicals from facility operations, LHAAP was placed on the Superfund NPL on August 9, 1990. Activities to remediate contamination associated with the listing of LHAAP as a Superfund site began in 1990. After being listed on the NPL, the U.S. Army, the USEPA, and the Texas Water Commission (currently known as the TCEQ) entered into a CERCLA Section 120 FFA for remedial activities at LHAAP. The FFA became effective December 30, 1991.

The FS for LHAAP-46 (Shaw, 2009) was issued in October 2009, and the Proposed Plan (U.S. Army, 2010) was issued in January 2010.

2.3 Community Participation

The U.S. Army, USEPA, TCEQ, and the Restoration Advisory Board have provided public outreach to the surrounding community concerning LHAAP-46 and other environmental sites at LHAAP. The outreach program has included fact sheets, media interviews, site visits, invitations to attend quarterly technical and regulatory review meetings, and public meetings consistent with its public participation responsibilities under Sections 113(k)(2)(B), 117(a), and 121(f)(1)(G) of CERCLA.

The Final Proposed Plan (U.S. Army, 2010) for the selection of the remedy for LHAAP-46 was released to the Administrative Record file and made available to the public for review and comment on January 25, 2010. The initial 30-day public comment period for the Proposed Plan also began on January 25, 2010. An open house was held on January 26, 2010. The initial notice of availability of the Proposed Plan and other related documents in the Administrative Record was published in the *Marshall News Messenger* and *The Shreveport Times* on two dates in both publications: January 17 and 24, 2010. A notice of a 30-day extension of the public comment period and announcement of the March 9, 2010, public meeting was published in the *Marshall News Messenger* on February 21 and 28, 2010, and in *The Shreveport Times* on February 22 and 28, 2010. The public comment period for the Proposed Plan was held from January 25 to March 25, 2010, which includes the 30 day extension. The newspaper and media notices for the meetings are provided in **Appendix A**. The transcript for the meeting on March 9, 2010 is part of the Administrative Record. Significant comments are addressed in the Responsiveness Summary, which is **Section 3.0** of this ROD.

Currently, the Administrative Record can be found locally at the information repository maintained at the following location:

Location: Marshall Public Library
300 S. Alamo
Marshall, Texas, 75670

Business Hours: Monday – Thursday 10:00 a.m. – 8:00 p.m.
Friday – Saturday 10:00 a.m. – 5:00 p.m.

2.4 Scope and Role of Response Action

The recommended action at LHAAP-46 will prevent potential risks associated with exposure to contaminated groundwater. Although groundwater at Longhorn is not currently being used as drinking water, nor may it be used in the future based on its reasonably anticipated use as a national wildlife refuge, when establishing the remedial action objectives (RAOs) for this response action, the U.S. Army has considered the NCP's expectation to return usable groundwaters to their potential beneficial uses wherever practicable and has also considered the State of Texas designation of all groundwater as potential drinking water, unless otherwise classified, and consistent with 30 TAC 335.563(h)(1). The U.S. Army intends to return the contaminated shallow groundwater zone at LHAAP-46 to its potential beneficial uses, which for the purposes of this ROD is considered to be attainment of the Safe Drinking Water Act (SDWA) MCLs to the extent practicable, and consistent with 40 CFR 300.430(e)(2)(i)(B&C). If a return to potential beneficial uses is not practicable, the NCP expectation is to prevent further migration of the plume, prevent exposure to the contaminated groundwater, and evaluate further risk reduction.

The preferred remedial action will also ensure containment of the plume to prevent potential impact to surface water. The potential exists for contaminated shallow groundwater to migrate to surface water, which could ultimately affect Caddo Lake, a source of drinking water.

In addition, the preferred action will include groundwater monitoring to demonstrate that the plume is not migrating at levels that present a potential impact to nearby surface water bodies and to verify that contaminant levels are being reduced to drinking water standards (MCLs) when the LUC may be terminated.

2.5 Site Characteristics

2.5.1 Conceptual Site Model

Figure 2-3 illustrates the overall conceptual site model for LHAAP-46 and presents those pathways that are being considered for remediation. Pathways that are likely to have a negligible impact are not being considered for remediation.

All sumps have been removed at LHAAP-46. Analytical results from samples of sump contents and soil near the sumps did not indicate that they were likely sources of contamination.

The original sources of contamination at LHAAP-46 were most likely spills resulting from the variety of support services that occurred in the area. The spills would have resulted in minor soil contamination that would migrate, depending on the contaminants, through overland flow via

surface runoff or through leaching to the groundwater. Overland flow does not currently appear to be contributing to a migration of contaminants, as the ditch surface water did not contain any VOCs, SVOCs, explosives, pesticides, or PCBs. Likewise, the sediment data do not show detections of VOCs, SVOCs, explosives, or pesticides. Some metals were detected in the surface water and sediment at low concentrations that occur naturally.

Metals and VOCs have been detected in the groundwater at elevated concentrations, but there is no associated soil contamination to indicate that contaminants are currently leaching from the soil to the groundwater. However, use of groundwater by a hypothetical future maintenance worker is a potential pathway that should be remediated.

Modeling calculations were completed to assess the potential for the COCs present in shallow groundwater at LHAAP-46 to migrate toward and discharge into Goose Prairie Creek. The modeling concluded that contaminants present in the shallow groundwater at LHAAP-46 will not adversely impact Goose Prairie Creek surface water (Shaw, 2007c).

2.5.2 Overview of the Site

The size of LHAAP-46 is approximately 190 acres. The surface features at the site are a mixture of asphalt-paved roads, parking areas, building foundation remnants, old buildings, and overgrown wooded and grassy vegetation-covered areas. There are no notable subsurface features. The topography in this area is relatively flat with the surface drainage flowing east into tributaries of Goose Prairie Creek, which eventually flows into Caddo Lake. The lake is a source of drinking water for several neighboring communities in Louisiana. LHAAP-46 has no known areas of archaeological or historical importance.

2.5.3 Geology and Hydrogeology

The soils at LHAAP-46 consist primarily of silty clay with thin lenses of sand. The first saturated sand layer encountered when drilling was designated as the shallow zone, the next was designated as the intermediate zone, followed by the deep zone. The three zones are separated by clay or silty clay layers of variable thicknesses that are generally not laterally continuous for large distances. At wells LHSMW23 and LHSMW26 there is no apparent separation between the shallow and intermediate zones at these wells and the zones appear to be interconnected. These wells have been designated as shallow/intermediate zone wells and they will be used in the discussions of both the shallow and intermediate zone.

Groundwater is present within a shallow saturated sand zone, which varies from 3 to 5 feet thick (Jacobs, 2002). Groundwater elevations were measured by Shaw in November/December 2007. The shallow zone groundwater elevation contours based on these data are shown on **Figure 2-4**. Depth to groundwater in the shallow zone is approximately 11 to 23 feet below ground surface (bgs) with groundwater flow to the east (Jacobs, 2002; Shaw, 2009). The hydraulic

conductivities in the shallow zone wells varied from 2.5×10^{-5} to 1.9×10^{-3} centimeters per second (cm/s) (Jacobs, 2002).

Groundwater is also present in an intermediate zone and a deep zone. **Figure 2-5** shows measured groundwater elevations and groundwater contours for the intermediate wells based on the data collected in November/December 2007. Depth to groundwater in the intermediate zone is approximately 23 to 30 feet bgs. Groundwater flows to the northeast according to the November/December 2007 groundwater elevation measurements. Hydraulic conductivities in three intermediate zone wells varied from 4.5×10^{-4} to 9.5×10^{-4} cm/s.

Groundwater in the deep zone is approximately 33 feet bgs with flow to the east or northeast, based on the November/December 2007 groundwater elevation measurements. The hydraulic conductivity in the deep zone was measured at 1.4×10^{-3} cm/s (Jacobs, 2002). With only one deep zone well at LHAAP-46, the groundwater flow direction was extrapolated from wells at multiple LHAAP sites, and thus no specific figure for the deep zone at LHAAP-46 has been prepared.

2.5.4 Sampling Strategy

Several sampling events were conducted at LHAAP-46 from 1992 to 2008, as outlined in **Section 2.2.2** on site investigations. In the early investigations, soil samples were collected from throughout the site to determine the areas of contamination. Subsequent investigations focused on the areas where contamination was found, performing additional soil, groundwater, and sediment sampling and installing monitoring wells to delineate the contamination. Samples were analyzed for various analytes including VOCs, SVOCs, metals, explosives, perchlorate, pesticides, and dioxins/furans. In the area of the contaminant plume, groundwater samples were also analyzed for indicators of conditions that promote natural attenuation (biodegradation), such as sulfide, methane, and chloride.

2.5.5 Nature and Extent of Contamination

Based on the risk assessment and subsequent evaluations, it was determined that the COCs for this site are dissolved TCE and the daughter products cis-1,2-dichloroethene (DCE) and vinyl chloride (VC) in the shallow and intermediate groundwater zones. **Figures 2-6** and **2-7** present the current TCE plumes for the shallow and intermediate zones, respectively, as defined by the MCL of 5 micrograms per liter (µg/L). The figures also show historical data. The COCs are toxic and carcinogenic. No principal threat source material (such as dense non-aqueous phase liquid [DNAPL]) was identified or suspected to exist at LHAAP-46.

The shallow zone plume is roughly centered on well LHSMW19, and has a lateral extent of approximately 210,000 square feet (ft^2), and a vertical extent of approximately 3 feet. Assuming a total porosity of 0.3, the calculated volume of contaminated groundwater is 1.41 million

gallons. During the February 2007 sampling event, the highest concentration of TCE detected was 85.5 µg/L at LHSMW19. The plume's edge is defined by the MCL of 5 µg/L. Wells surrounding LHSMW19 were below the MCL, thus LHSMW19 is currently the only well within the plume boundaries as shown in **Figure 2-6**. During the 2007 sampling event, the maximum concentration for cis-1,2-DCE was an estimated 1.5 µg/L at LHSMW18 (which is below the MCL of 70 µg/L), and VC was not detected (detection limit of 0.32 µg/L).

The intermediate zone plume is roughly centered on well 46WW02, which is approximately 200 feet east of LHSMW19. In this zone, the lateral extent of contamination is approximately 700,000 ft^2, and the vertical extent is approximately 5 feet. Assuming a total porosity of 0.3, the calculated volume of contaminated groundwater is 7.85 million gallons. The highest concentration of TCE detected was 31.2 µg/L on October 28, 2008 at 46WW02. Currently there are two wells, 46WW02 and 46WW05, within the plume boundary, as shown in **Figure 2-7**. COCs in the surrounding wells were below the MCL. During the 2008 sampling event, the maximum concentration for cis-1,2-DCE was 1.72 µg/L at 46WW05 (which is below the MCL of 70 µg/L), and VC was not detected (detection limit of 0.32 µg/L).

Modeling calculations were completed to assess the potential for the COC present in shallow groundwater at LHAAP-46 to migrate toward and discharge to Goose Prairie Creek. The modeling concluded that contaminants present in the shallow groundwater at LHAAP-46 will not adversely impact Goose Prairie Creek surface water (Shaw, 2007c). The results were obtained by using the transport model Analytical Transient One-, Two-, and Three-Dimensional Simulation of Waste Transport in the Aquifer System (AT123D). AT123D assumes the aquifer to be homogeneous and isotropic. It accounted for advection, dispersion, adsorption, and chemical degradation.

2.6 Current and Potential Future Land and Resource Uses

2.6.1 Current and Future Land Uses

LHAAP is located near the unincorporated community of Karnack, Texas. Karnack is a rural community with a population of 775 people. The incorporated community of Uncertain, Texas, population 205, is located to the northeast of LHAAP on the edge of Caddo Lake and is a resort area and an access point to Caddo Lake. The industries in the surrounding area consist of agriculture, timber, oil and natural gas production, and recreation.

LHAAP has been an industrial facility since 1942. Production activities and associated waste management activities continued until the facility was determined to be in excess of the U.S. Army's needs in 1997. The plant area has been relatively dormant since that time. LHAAP is surrounded by a fence (except on the border with Caddo Lake), and current security measures at

the LHAAP preclude unlimited public access to areas within the fence. The fence now represents the Refuge boundary. Approved access for hunters is very limited.

The reasonably anticipated future use of LHAAP-46 is as a national wildlife refuge. This anticipated future use is based on a Memorandum of Agreement (MOA) (U.S. Army, 2004) between the USFWS and the U.S. Army. That memorandum of agreement (MOA) documents the transfer process of the LHAAP acreage to USFWS to become the Caddo Lake National Wildlife Refuge. Presently the Caddo Lake National Wildlife Refuge occupies approximately 7,000 acres of the 8,416-acre former installation. In accordance with the National Wildlife Refuge System Administration Act of 1966 and its amendments (16 USC 668dd), the land will remain as a national wildlife refuge unless there is a change brought about by an act of Congress, or the land is part of an exchange authorized by the Secretary of the Interior.

2.6.2 Current and Future Surface Water Uses

Surface water on LHAAP currently supports wildlife and aquatic life. While humans may have limited access to some surface water during annual hunts, there is no routine human use of surface water on LHAAP. The surface water does not carry adequate numbers and size of fish to support either sport or subsistence fishing. During the summer months, the surface waters cease flowing and/or dry up. Surface water discharges into Caddo Lake. Caddo Lake is a large recreational area that covers 51 square miles and has a mean depth of 6 feet. The watershed of the lake encompasses approximately 2,700 square miles. It is used extensively for fishing and boating. Caddo Lake is a drinking water supply for multiple cities in Louisiana including Vivian, Oil City, Mooringsport, South Shore, Blanchard, Shreveport, and Bossier City.

The anticipated future uses of surface water are the same as the current uses.

2.6.3 Current and Future Groundwater Uses

Groundwater in the drinking water aquifer (250-430 feet bgs) under and near LHAAP is currently used as a drinking water source. The drinking water aquifer should not be confused with the deep zone groundwater, which begins at approximately 33 ft bgs. There are currently five active water supply wells near LHAAP. One well is located in and owned by Caddo Lake State Park. The well is completed to a depth of 315 feet and has been in use since 1935. A second well owned by the Karnack Water Supply Corporation services the town of Karnack and is located approximately 2 miles southeast of town. This well is approximately 430 feet deep and has been in use since 1942. The Caddo Lake Water Supply Corporation has three wells located both north and northwest of LHAAP. These wells are identified as Caddo Lake Water Supply Corporation Wells 1, 2, and 3 and are all hydraulically upgradient of LHAAP (Jacobs, 2002). Because of the large distance between these wells and LHAAP, water removal from these wells is not expected to affect groundwater flow at the site. In addition, there are several

livestock and domestic wells located in the vicinity of LHAAP with depths averaging approximately 250 feet.

There are three water supply wells located on LHAAP, and all three supply water to buildings currently in use at the installation. None of the water supply wells are associated with or in imminent danger from the localized contaminated groundwater at LHAAP-46. One well is located at the Fire Station/Security Office. A second well is located approximately 0.35 mile southwest of the Fire Station/Security Office. The third well is located north of the administration building, near the entrance to LHAAP. The distances from these wells to the middle of LHAAP-46 are approximately 0.65 mile, 1 mile, and 1.9 miles, respectively. Two additional wells previously supplied water to the installation, but these have been plugged and abandoned. The wells are not currently used for drinking water at LHAAP, although they may supply water for non-potable uses.

Although the anticipated future use of the facility as a wildlife refuge may not include the use of the groundwater at LHAAP-46 as a drinking water source, the State of Texas designates all groundwater as potential drinking water, unless otherwise classified, and consistent with 30 TAC 335.563(h)(1). To be conservative, a hypothetical industrial use scenario was evaluated for risk. The future industrial scenario for LHAAP assumes limited use of groundwater as a drinking water source.

2.7 Summary of Site Risks

The BHHRA and BERA estimate the risks posed by the site if no action were taken. These assessments provide the basis for taking action and identify the contaminants and exposure pathways that need to be addressed by the remedial action.

2.7.1 Summary of Human Health Risk Assessment

This section is based on the conclusions presented in the *Final Baseline Human Health and Screening Ecological Risk Assessment for the Group 4 Sites* (Jacobs, 2003), in the *Data Gaps Investigations* (Shaw, 2007b), and in additional data collected in preparation of the *Final Feasibility Study, LHAAP-46* (Shaw, 2009). The risk assessment used data from the investigations conducted through 2001 including the plant-wide perchlorate investigation. Results from the later investigations did not change the overall outcome of the risk assessment. During the risk assessment, soil and groundwater data were used to calculate the aggregate risk, which was then compared to the USEPA target risk range of 1×10^{-4} to 1×10^{-6} for the excess lifetime carcinogenic risk and to a hazard index (HI) of 1 for non-carcinogenic hazards. If there is no unacceptable risk associated with a medium, and a cleanup level is not exceeded, then the medium is not identified in this ROD for remediation. The conceptual site model that is

associated with the risk assessment was introduced in **Section 2.5.1**, and is presented as **Figure 2-3**.

2.7.1.1 Identification of Chemicals of Potential Concern

The BHHRA identified chemicals of potential concern (COPCs) for LHAAP-46 and evaluated the carcinogenic risk and non-carcinogenic hazard for each. **Table 2-1** summarizes the risk assessment data for the COPCs, including minimum and maximum detected concentrations, frequency of detection, and exposure point concentrations (EPCs). Analytical results for various congeners of dioxins and furans are expressed as toxic equivalents of 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD).

2.7.1.2 Exposure Assessment

The Jacobs risk assessment (Jacobs, 2003) presented the human health risks and hazards to a hypothetical future maintenance worker under an industrial scenario for soil and groundwater.

For soil, reasonable exposure pathways according to the conceptual site model are: incidental ingestion of the surface soil (0 to 2 feet bgs), dermal contact with the surface soil, inhalation of particulates, and inhalation of VOCs from the soil (0 to 7 feet bgs). The BHRRA found VOC levels in the soil at 0 to 7 feet bgs to be non-detect; this exposure pathway did not add to carcinogenic risk or non-carcinogenic hazard. Therefore, it was not included in the summary tables (**Tables 2-1, 2-4,** and **2-5**). For groundwater, reasonable exposure pathways are ingestion of groundwater, dermal contact while showering with contaminated groundwater, and inhalation of VOCs while showering with contaminated groundwater.

2.7.1.3 Toxicity Assessment

The carcinogenic and non-carcinogenic toxicity assessments from the BHHRA are summarized in **Tables 2-2** and **2-3**, respectively. The toxicity data assumes that exposure would be chronic to be conservative. Sources for the data include the Integrated Risk Information System (IRIS) and Health Effects Assessment Summary Tables (HEAST).

2.7.1.4 Risk Characterization

Characterization of the carcinogenic risk and non-carcinogenic hazard are summarized in **Tables 2-4** and **2-5**, respectively. 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 carcinogenic risk is calculated from the following equation:

$$\text{Risk} = \text{CDI} \times \text{SF}$$

where: risk = unitless probability of an individual 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. An excess lifetime carcinogenic risk of 1×10^{-6} indicates that an individual experiencing the reasonable maximum exposure estimate has a 1 in 1,000,000 chance of developing cancer as a result of site-related exposure. This is referred to as an "excess lifetime carcinogenic risk" because it would be in addition to the risks of cancer that individuals face from other causes such as smoking or exposure to too much sun. The chance of an individual developing cancer from all other causes has been estimated to be as high as one in three. USEPA's generally acceptable risk range for site-related exposures is 1×10^{-4} to 1×10^{-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 may be exposed to that is not expected to cause any deleterious effect. The ratio of exposure to toxicity is called a hazard quotient (HQ). An HQ < 1 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 HI is generated by adding the HQs for all COCs 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 may reasonably be exposed. An HI < 1 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 > 1 indicates that site-related exposures may present a risk to human health.

The HQ is calculated as follows:

$$\text{Non-carcinogenic HQ} = \text{CDI/RfD}$$

where: CDI = chronic daily intake
RfD = reference dose

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

The carcinogenic risks for soil and groundwater are 1.67×10^{-5} and 4.05×10^{-5}, respectively (Jacobs, 2003). Both media are within the acceptable range. The hazard indices for soil and groundwater are 0.12 and 31, respectively. The latter value is outside of the acceptable range.

Therefore, the remedial action focuses on the groundwater. The major contributors to the non-carcinogenic hazard in groundwater were three metals which account for approximately 87% of the total groundwater non-carcinogenic hazard. The three metals are thallium, antimony, and manganese, which had groundwater HQ values of 24, 1.5, and 1.4, respectively. Other chemicals did not have an HQ that exceeded 1. Also, the maximum detected concentrations of the following COPCs exceeded their MCL concentrations (Jacobs, 2002 and 2003): antimony, arsenic, beryllium, cadmium, chromium, lead, thallium, TCE, and bis(2-ethylhexyl)phthalate.

The BHHRA included an uncertainty analysis which identified factors that would cause values used in the risk assessment to be over or underestimated. The analysis concluded that the risks and HIs are overestimated, making the BHHRA a conservative evaluation. The analysis listed eight factors that would lead to overestimations, four that would lead to underestimations, and five that could lead to either over or underestimations.

2.7.1.5 Evaluation of COPCs

To further evaluate the occurrence of the COPCs, a data gap investigation was conducted (Shaw, 2007b) and additional investigations were conducted when preparing the FS (Shaw, 2009). While these investigations did not change the overall outcome of the earlier BHHRA, they concluded there was a single relevant COPC that needed to be targeted by the remedial action, which is TCE. Since TCE has degradation or daughter products, the daughter products, DCE and VC are also considered COPCs. **Table 2-6** is a summary of the justifications for which of the COPCs should be classified as COCs. The list of COPCs in **Table 2-6** excludes compounds that were detected but considered to be insignificant and not in need of further evaluation. Specifically, compounds were excluded if they resulted in a groundwater HQ below 0.1 and had a maximum detection below the MCL. In the evaluation of COPCs, reasons for not considering a COPC as a COC include: the elevated concentration during BHHRA sampling was due to using a non-low flow sampling technique, absence of the COPC from recent sampling, elevated concentration due to well corrosion, the COPC is naturally occurring, the COPC's contribution to the HI is low, and/or the chemical was detected in the laboratory blank. In **Table 2-6**, the maximum detected concentrations indicated is the maximum from all investigations including those after the BHHRA. The following subsections evaluate the COPCs. **Table 2-7** presents the outcome of the evaluation, which is the list of COCs that require remediation.

Metals

The maximum concentration of aluminum in groundwater (80,000 µg/L) was from LHSMW16 in 1994 and exceeded the LHAAP perimeter well groundwater background value (13,400 µg/L). Aluminum was detected in 80 of the 105 groundwater samples analyzed between 1994 and 2007. The maximum concentration of aluminum in the 2007 groundwater samples was 1,360 µg/L. The geochemical evaluation presented in Appendix B of the Final FS (Shaw, 2009) concluded

that aluminum in the groundwater is primarily the result of suspended clay particles. Thus, aluminum is not considered a COC at LHAAP-46.

Groundwater samples were analyzed for antimony between 1994 and 2007. The maximum antimony concentration was 63 µg/L in LHSMW27 in 1996. That was an estimated result because the detection limits were elevated in the 1996 sampling round. In 1998, the detection limits were not elevated, and antimony was detected only in 46WW01 at a concentration of 8 µg/L. Even though this concentration is above the MCL value of 6 µg/L, this concentration is less than the LHAAP perimeter well groundwater background 95% upper tolerance limit (UTL) value of 11.5 µg/L (Shaw, 2007d). Antimony was detected in 4 of 107 groundwater samples at LHAAP-46, and antimony was not detected in the 2007 samples. Due to lack of detection in the 2007 sampling round, and 1998 results below background, antimony is not considered a COC for LHAAP-46.

The maximum concentration of arsenic in groundwater (20 µg/L) that exceeded the MCL (10 µg/L) was detected in LHSMW17 in 1998. Other arsenic results that exceeded the MCL were found at LHSMW12 and 46WW02 in 1998 and at LHSMW22, LHSMW23 and LHSMW24 in 1996. There is no evident pattern to the arsenic detected in the groundwater at LHAAP-46. The most recent (2007) arsenic concentrations were all less than the MCL. The geochemical evaluation identified no definite conclusions about arsenic, but noted that the detected concentrations were all estimated. The most recent samples were collected with low flow sampling methods and showed consistently lower arsenic concentrations than earlier samples. This suggests that elevated arsenic concentrations in earlier samples were associated with suspended solids caused by the sample collection method. Thus, arsenic is considered an artifact of turbid samples collected during historic sampling rounds and is not retained as a COC at LHAAP-46.

The maximum concentration of barium in groundwater (1,400 µg/L) was from LHSMW16 in 1994 and did not exceed the MCL (2,000 µg/L). The LHAAP perimeter well groundwater background value (1,990 µg/L) was less than the MCL, but greater than the highest barium concentration at LHAAP-46. Barium was detected in 84 of the 107 groundwater samples analyzed between 1994 and 2007. The most recent 2007 barium sample concentrations were all less than 50 µg/L. Thus, barium is not considered a COC at LHAAP-46.

The maximum concentration of beryllium in groundwater (76 µg/L) was from LHSMW27 in August 1996, and exceeded the MCL (4 µg/L). In 1998, the beryllium concentration from this well was 0.9 µg/L, below the MCL. Two other detectable concentrations of beryllium were slightly above the MCL in 1998, 5.4 µg/L at LHSMW17 and 6.5 µg/L at LHSMW12. There is no evident pattern to beryllium in the groundwater at LHAAP-46. Beryllium was detected in 19

of 90 groundwater samples at LHAAP-46, mostly from 1998. Beryllium was not detected in the 2007 samples. Thus, beryllium is not considered a COC for LHAAP-46.

The maximum concentration of cadmium in groundwater was 20 µg/L from LHSMW27 in 1996 and exceeded the MCL (5 µg/L). In 1998, the concentration at LHSMW27 was 0.8 µg/L, which is below the MCL. No other cadmium results exceeded the MCL. Cadmium was detected in 19 of 107 groundwater samples at LHAAP-46. The most recent (2007) cadmium concentrations were all less than the MCL. Since the only detection above the MCL was not reproducible, cadmium is not considered a COC for LHAAP-46.

The maximum concentration of chromium in groundwater (4,700 µg/L) was from LHSMW15 in 1998, and exceeded the MCL (100 µg/L). Five wells exceeded the MCL in 1994, one well exceeded the MCL in February 1996, six wells exceeded the MCL in August 1996, ten wells exceeded the MCL in 1998, and four wells exceeded the MCL in 2007. Eight of the ten wells that had chromium concentrations that exceeded the MCL in 1998 were sampled in 2007. All eight wells had detectable concentrations of chromium. Four of the wells had unfiltered results that were above the MCL, but filtered results ranged from 5.26 to 57.6 µg/L and were all lower than the MCL. Comparison of dissolved versus total chromium concentrations from 2007 showed most of the chromium as filterable particulates, not dissolved. The geochemical evaluation suggests that the stainless steel material of the monitoring wells is the source of chromium in groundwater at LHAAP-46. A similar occurrence has been observed at other sites, e.g., LHAAP-12 and LHAAP-53. Detectable chromium concentrations associated with filterable particulates are expected as the stainless steel of the wells degrades over time. Thus, the chromium in groundwater samples at LHAAP-46 is from high filterable particulates in the samples, and chromium is not considered a COC at LHAAP-46.

The maximum concentration of lead in groundwater (673 µg/L) was from LHSMW23 in August 1996, and exceeded the MCL (15 µg/L). The anomalously high lead concentrations observed in 1996 were not duplicated in 1998 or 2007. The geochemical evaluation suggests that any previously present lead contamination has attenuated, and an ongoing source is not present at the site. Thus, lead in groundwater is not considered a COC at LHAAP-46.

Although the risk assessment reported that the maximum concentration of manganese, 6,500 µg/L from LHSMW18 in 1994, is a contributor to the groundwater non-carcinogenic HI (1.4), this maximum manganese concentration is less than the LHAAP perimeter well groundwater background value (95% UTL) of 7,820 µg/L (Shaw, 2007d). The most recent manganese samples from 2007 had a maximum concentration of 3,790 µg/L from LHSMW22. The geochemical evaluation concluded that manganese detected in the site samples is most likely natural. Thus, manganese is not considered a COC for LHAAP-46.

The maximum concentration of nickel in groundwater (3,670 µg/L) was from LHSMW22 in 2007 and exceeded the LHAAP perimeter well groundwater background value (211 µg/L). Nickel was detected in 69 of the 87 groundwater samples analyzed between 1996 and 2007. The geochemical evaluation concluded that nickel in the groundwater is local contamination as a result of corrosion of the stainless steel monitoring wells. Thus, nickel is not considered a COC at LHAAP-46.

The maximum concentration of silver in groundwater (120 µg/L) was from LHSMW15 in 1998. Silver was detected in 5 of the 107 groundwater samples analyzed between 1994 and 2007. Silver was not detected in the most recent (2007) round of sampling. Thus, silver is not considered a COC at LHAAP-46.

The maximum concentration of strontium in groundwater (12,000 µg/L) was from LHSMW25 in 1998. Strontium was detected in 82 of the 87 groundwater samples analyzed between 1994 and 1998. Strontium was not tested in 2007. The HQ associated with the strontium was 0.20. Due to the low HQ, strontium is not considered a COC at LHAAP-46.

The maximum thallium concentration of 200 µg/L was detected in LHSMW27 in 1996. The other three thallium concentrations higher than 90 µg/L were also from 1996. These high concentrations of thallium were not reproducible in subsequent rounds of sampling. The 2007 samples of thallium had a maximum concentration of 5.43 µg/L at LHSMW24, which is above the MCL value of 2 µg/L. However, the geochemical evaluation concludes the thallium concentrations in the groundwater are most likely natural. Thus, thallium is not considered a COC for LHAAP-46.

The maximum concentration of vanadium in groundwater (140 µg/L) was from LHSMW17 in 1998. Vanadium was detected in 11 of the 87 groundwater samples analyzed between 1996 and 2007. Vanadium was detected in only one 2007 sample with a concentration of 9.24 µg/L at LHSMW22, which would have an HQ of less than 0.1. Thus, vanadium is not considered a COC at LHAAP-46.

In summary, metals are not considered to be COCs at LHAAP-46.

Volatile Organic Compounds

TCE and its daughter products are considered COCs at LHAAP-46 in the shallow and intermediate zone groundwater. In the shallow zone, the plume of TCE centers around LHSMW19. The shallow zone plume boundary is decreasing, and it currently encloses fewer wells than it did in the past. The maximum concentration detected for this TCE plume was 85.5 µg/L from LHSMW19. In the intermediate zone, the plume of TCE centers around 46WW02. The maximum concentration detected was 31.2 µg/L at 46WW02. TCE has not been detected in the deep groundwater zone (46WW03). **Figure 2-6** and **Figure 2-7** show the extent of TCE in

the shallow and intermediate zones, respectively. Tabulated analytical results can be found in the FS (Shaw, 2009), Appendix A, *Preliminary Evaluation of Natural Attenuation*.

As biodegradation daughter products of TCE, which is a COC, cis-1,2-DCE and VC are considered COCs regardless of the extent of their presence at the current time. The maximum concentration of cis-1,2-DCE in groundwater (9.8 µg/L) was from LHSMW18 in 1998 and was less than the MCL (70 µg/L). The most recent concentrations from 2007 ranged from nondetect to an estimated 1.5 µg/L. The maximum concentration of VC in groundwater (0.71 µg/L) was from LHSMW18 in 1998 and was less than the MCL (2 µg/L). VC was not detected in the 2007 samples.

Semivolatile Organic Compounds

The maximum concentration of bis(2-ethylhexyl)phthalate in groundwater (27 µg/L) was from 46WW02 in November 1998 and exceeded the MCL (6 µg/L). Two other samples, from 46WW03 in November 1998 and LHSMW11 in 1994 also exceeded the MCL. The most recent results (November 1998) for bis(2-ethylhexyl)phthalate ranged from nondetect to 27 µg/L. In the May 1998 sample round, bis(2-ethylhexyl)phthalate was also found in the laboratory blank. It is likely that the November 1998 samples could have also been impacted by laboratory contamination. Bis(2-ethylhexyl)phthalate is not considered a COC in the groundwater at LHAAP-46 since there were only sporadic detections and the chemical is a common laboratory contaminant.

Perchlorate

Perchlorate was detected in 9 of the 40 groundwater samples analyzed between 2000 and 2007. Perchlorate was not detected in the 2007 samples. Since perchlorate has no MCL, the detected perchlorate results were compared to TCEQ's groundwater medium-specific concentration for industrial use (GW-Ind) developed under the Risk Reduction Rules, Standard 2, in accordance with 30 TAC 335.558 and 335.559(d)(2). The maximum concentration of perchlorate in groundwater was 30 µg/L at 46WW04 in 2001. This value is well below the GW-Ind value (72 µg/L); thus, perchlorate is not considered a COC at LHAAP-46.

2.7.2 Summary of Ecological Risk Assessment

The ecological risk for LHAAP-46 was addressed in the installation-wide BERA (Shaw, 2007a). The BERA provides a process that evaluates the likelihood that adverse ecological effects may occur, or are occurring, as a result of exposure to one or more stressors. A stressor is any physical, chemical, or biological entity that can induce an adverse ecological response. The BERA for LHAAP focuses only on chemical stressors.

Ecological risk does not exist unless:

- The stressor has the inherent ability to cause adverse effects
- It co-occurs with or contacts an ecological component (i.e., organism, population, community, or ecosystem) long enough and at sufficient intensity to elicit an adverse effect

For the BERA, the entire installation was divided into three large sub-areas (i.e., the Industrial Sub-Area, Waste Sub-Area, and Low Impact Sub-Area) for the terrestrial evaluation. Each of the individual sites at LHAAP was grouped into one of these sub-areas based on commonalities of historic use, habitat type, and spatial proximity to each other. Conclusions for individual sites and the potential for detected chemicals to adversely affect the environment are made in the context of the overall conclusions of the sub-area in which the site falls.

LHAAP-46 lies within the Industrial Sub-Area, and the BERA concluded that no chemicals exceeded ecological thresholds of concern in the Industrial Sub-Area (Shaw, 2007a). Thus, there are no COECs at LHAAP-46. Therefore, no action is needed at LHAAP-46 for the protection of ecological receptors.

2.7.3 Basis of Action

The remedial action selected in this ROD is necessary to protect public health or welfare or the environment from actual or threatened releases of hazardous substances, pollutants, or contaminants into the environment. The conclusion reached by the FS investigation and subsequent investigations is that the COCs for groundwater at LHAAP-46 are TCE, DCE, and VC. There are no COCs for soil. **Table 2-7** presents the cleanup levels for the COCs. A SDWA MCL has been determined for each of the COCs, therefore these MCLs will be used as the cleanup levels.

The human health risk assessment, which was based on the reasonably anticipated future use as a national wildlife refuge, does not address unrestricted use. Although not part of the remedy, limited monitoring in the form of five-year reviews will be conducted to certify proper land use and, in accordance with 30 TAC 335.566, a notification will be recorded in the Harrison County records stating that the site is suitable for nonresidential use.

2.8 Remedial Action Objectives

The RAOs for LHAAP-46, which address contamination associated with the media at the site and take into account the future uses of LHAAP surface waters, land, and groundwater, are:

- Protection of human health by preventing human exposure to the contaminated groundwater;

- Protection of human health and the environment by preventing contaminated groundwater from migrating into nearby surface water; and
- Return of groundwater to its potential beneficial uses as drinking water, wherever practicable.

The above RAO recognizes USEPA's policy to return all groundwater to beneficial uses, based on the non-binding programmatic expectation in the NCP and is consistent with the NCP regulations requiring the lead agency, the U.S. Army in this case, to establish RAOs specifying contaminants and media of concern, potential exposure pathways, and remediation goals.

2.9 Description of Alternatives

Three alternatives (including No Action) are proposed. This section introduces the remedy components, identifies the common elements and distinguishing features of each alternative, and describes the expected outcomes of each.

2.9.1 Description of Remedy Components

Alternative 1 – No Action Alternative

As required by the NCP, the no action alternative provides a comparative baseline against which the action alternatives can be evaluated. Under this alternative, groundwater would be left "as is" without implementing any additional monitoring, containment, removal, treatment, or other mitigating actions. No actions would be implemented to reduce existing or potential future exposure to human receptors, although natural attenuation would be ongoing.

Estimated Capital Present Worth Cost: $0
Estimated O&M Present Worth Cost: $0
Estimated Duration: --
Estimated Total Present Worth Cost: $0

Alternative 2 – Monitored Natural Attenuation with Land Use Control

The major components of the MNA remedy with a contingency remedy for the impacted groundwater include the following.

- MNA to return groundwater to its potential beneficial use, wherever practicable
  - Performance objectives to evaluate the MNA remedy performance after two years
  - A contingency remedy to reach the RAOs if MNA is found to be ineffective
- LUC to restrict access to the contaminated groundwater until the cleanup levels are reached

- Long-term monitoring (LTM) semiannually for three years, annually until the next five-year review, then once every five years to evaluate remedy performance and determine if plume conditions remain constant, improve, or worsen until cleanup levels are reached

Estimated Capital Present Worth Cost: $60,500
Estimated O&M Present Worth Cost: $460,700
Estimated Duration: 30 years
Estimated Total Present Worth Cost: $521,200

Alternative 3 – In Situ Bioremediation, MNA, and LUC

The components of the in situ bioremediation action include:

- Injecting microbial cultures and nutrients into the subsurface at predetermined locations
  - Sampling wells to monitor effectiveness
- LUC and LTM until the cleanup levels are reached

Estimated Capital Present Worth Cost: $379,000
Estimated O&M Present Worth Cost: $365,000
Estimated Duration: 15 years
Estimated Total Present Worth Cost: $744,000

2.9.2 Common Elements and Distinguishing Features of Each Alternative

Common Elements of Alternatives 2 and 3

Common elements of Alternatives 2 and 3 are described below.

MNA—MNA is a passive remedial action that relies on natural biological, chemical, and physical processes to reduce the mass and concentrations of groundwater COCs under favorable conditions. The natural attenuation evaluation indicates that MNA is a feasible technology for the groundwater at LHAAP-46 (Shaw, 2009). Monitoring activities associated with MNA would assure the protection of human health and the environment by documenting the return of the groundwater to its potential beneficial use as a drinking water supply, by documenting reduction of the contaminant mass and protection of surface water through containment of the plume.

LUC—The LUC would be implemented to support the RAOs. The U.S. Army would be responsible for long-term implementation, maintenance, inspection, reporting, and enforcement of the LUC. The U.S. Army will provide details of the LUC long-term implementation and long-term maintenance actions in the RD for the site. The LUC would prevent human exposure to residual groundwater contamination presenting an unacceptable risk to the hypothetical future maintenance worker and ensure that there is no withdrawal or use of groundwater beneath the

sites for anything other than environmental monitoring and testing. The groundwater restriction LUC would be maintained until the concentrations of contaminants and by-product (daughter) contaminants in groundwater had been reduced to levels below their respective cleanup levels. In addition, the Texas Department of Licensing and Regulation (TDLR), responsible for notifying well drillers of groundwater restrictions, would be notified and a notification of the LUC with the Harrison County Courthouse would include a map showing the areas of groundwater restriction at the site, in accordance with 30 TAC 335.566.

In order to transfer this property (LHAAP-46), an Environmental Condition of Property (ECOP) document would be prepared and the Environmental Protection Provisions from the ECOP would be attached to the letter of transfer. The ECOP would include the LUC for groundwater as part of the Environmental Protection Provisions. The property would be transferred subject to the LUC identified in the ECOP. These restrictions would prohibit or restrict property uses that might result in exposure to the contaminated groundwater (e.g., drilling restrictions). The U.S. Army and regulators will consult to determine appropriate enforcement actions should there be a failure of an LUC objective at these sites after they have been transferred. The U.S. Army shall consult with TCEQ and obtain USEPA concurrence prior to termination or significant modification of an LUC, or land use change inconsistent with the LUC objectives and use assumptions of the remedy. In the event that TCEQ and/or USEPA and the U.S. Army agree with respect to any modification of the selected remedy, including the LUC component of the selected remedy, the remedy will be changed consistent with the FFA and 40 CFR 300.435(c)(2) and 40 CFR 300.430(f)(4)(iii).

Inspection/Long-Term Groundwater Monitoring—Alternatives 2 and 3 include inspection and long-term groundwater monitoring activities. Monitoring would be continued as required to evaluate the effectiveness of the remedy, to demonstrate compliance with applicable or relevant and appropriate requirements (ARARs) and RAOs, and to support five-year reviews.

Distinguishing Features of Alternative 3

Distinguishing features of Alternative 3 are discussed below.

Alternatives 2 and 3 are similar in that they both depend on MNA processes. Existing biological activity is the biggest component of natural attenuation. Alternatives 2 and 3 are anticipated to provide verifiable long-term reliability. These two alternatives comply with all ARARs, whereas Alternative 1 would not. For Alternative 2, a plan for a contingency action of in situ bioremediation will be in place in case MNA alone is insufficient. The estimated time to reach cleanup goals for these two alternatives is 23 and 15 years, respectively.

Alternative 3 involves active treatment, whereas Alternative 2 does not. In comparison to Alternative 2, Alternative 3 would: 1) require more design and implementation time, including

the time to conduct a treatability study of in situ bioremediation; 2) have more action-specific ARARs, such as those related to drilling work; and 3) have a greater cost, especially capital cost. Alternative 3 is further described below.

Areas to be treated—In situ bioremediation is proposed for an area of the shallow zone centered around the shallow monitoring well LHSMW19, and for an area of the intermediate zone centered around the intermediate monitoring well 46WW02. These two wells are the ones most highly impacted by TCE. Contaminated groundwater is present in shallow thin sand lenses that occur in a formation consisting primarily of clay to silty clay. Separate plumes in the shallow and intermediate zones are assumed.

Injecting microbial cultures and nutrients into the subsurface at predetermined locations— Bacteria present in the groundwater can use chlorinated solvents as electron acceptors. Electron donors may include a wide variety of nutrients: sugars (molasses), alcohols (methanol, ethanol), volatile acids (acetate, lactate), and/or wastes (food processing, manure). The COCs at LHAAP-46 can degrade under anaerobic conditions, but microorganisms, mechanisms, and redox requirements differ. Bioaugmentation additives, appropriate nutrients, and other materials would be injected into the subsurface. This form of bioremediation combines the injection of microbial cultures capable of degrading the contaminants with a carbon source to provide adequate conditions for the proliferation of the dechlorinating organisms. For costing purposes, it is assumed that the bioaugmentation material will be injected into both the shallow (20 feet bgs) and intermediate zone (40 feet bgs) using direct-push technology within the plumes, targeting areas with higher concentrations.

Sampling wells to monitor effectiveness—Monitoring for contaminants would be performed to assess the effectiveness of the treatment. Anticipated remediation times may be short with appropriate contact of the contaminant and the injected materials. Assuming first order anaerobic degradation rates and reasonable half-lives for the COCs, the COCs within the treated areas could be reduced to their respective cleanup levels in approximately two years. However, it is anticipated that COCs will remain in the plumes outside the treated areas and will attenuate to levels below MCLs over time. Additional monitoring is recommended for up to 15 years after reduction of the COCs at the two biotreated areas or until cleanup levels are attained. Annual reports will be prepared during the first 10 years to document the program.

2.9.3 Expected Outcomes of Each Alternative

Alternative 1 would allow the site to remain a hazard to human health, since it simply leaves the site as is. Alternatives 2 and 3 have very similar outcomes – the main difference is in the time required to reach the MCLs, 23 or 15 years, respectively. The similar outcomes are considered to be attainment of the SDWA MCLs to the extent practicable, and consistent with 40 CFR 300.430(e)(2)(i)(B&C). In addition, the monitoring activities associated with MNA would

assure the protection of human health and the environment by documenting the return of the groundwater to its potential beneficial use as a drinking water supply, by documenting reduction of the contaminant mass and protection of surface water through containment of the plume. Until that time, the LUC will restrict the use of the site's groundwater to environmental monitoring and testing.

2.10 Summary of Comparative Analysis of Alternatives

Nine criteria identified in the NCP §300.430(e)(9)(iii) are used to evaluate the different remediation alternatives individually and against each other in order to select a remedy. This section profiles the relative performance of each alternative against the nine criteria, noting how it compares to the other options under consideration. The nine evaluation criteria are discussed below. **Table 2-8** summarizes the comparative analysis of the alternatives.

2.10.1 Overall Protection of Human Health and the Environment

Overall protection of human health and the environment addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled through treatment, engineering controls, and/or institutional controls.

The three alternatives provide varying levels of human health protection. Alternative 1, no action, does not confirm achievement of the RAO for the return of groundwater to its potential beneficial use as a drinking water since there is no monitoring involved. Alternative 1 also provides the least protection of all the alternatives; it provides no reduction in risks to human health or the environment because no measures would be implemented to eliminate the pathway for human exposure to the groundwater contamination.

Alternatives 2 and 3 both satisfy the RAOs for LHAAP-46. Alternatives 2 and 3 also provide confirmation that human health and the environment will be protected because the monitoring will be conducted to ensure that MNA is returning the contaminated shallow groundwater zone at LHAAP-46 to its potential beneficial uses as a drinking water, wherever practicable, and to document that the plumes are contained and prevented from impacting surface water at levels that could present a risk to human health and the environment. Furthermore, the LUC would protect human health by preventing access to the contaminated groundwater until contaminants in the groundwater attain the SDWA MCLs for all contaminants above the MCLs and attain the MCLs for all contaminants by-products (daughter contaminants) above the MCLs.

2.10.2 Compliance with ARARs

Section 121(d) of CERCLA and NCP §300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites attain legally applicable or relevant and appropriate Federal and State requirements, standards, criteria, and limitations, which are collectively referred to as "ARARs"

unless such ARARs are waived under CERCLA Section 121(d)(4). The ARARs that pertain to this ROD are discussed in **Section 2.13.2**.

Because contaminated groundwater has the potential to discharge to surface water features that flow to Caddo Lake, a drinking water supply, chemical specific ARARs for surface water consumption are appropriate and relevant. Specifically, Texas surface water quality standards are set forth in 30 TAC 307.6(d)(1) for TCE (5 µg/L), cis-1,2-DCE (70 µg/L), and VC (2 µg/L) for LHAAP-46. These standards are equivalent to the MCLs for the contaminants.

Alternative 1 does not comply with chemical-specific ARARs because no additional remedial action would be implemented. Alternatives 2 and 3 return the contaminated shallow groundwater zone at LHAAP-46 to its potential beneficial use as drinking water, wherever practicable, which for the purposes of this ROD is considered to be attainment of the relevant and appropriate SDWA MCLs to the extent practicable, and consistent with 40 CFR 300.430(e)(2)(i)(B&C). If a return to potential beneficial uses is not practicable, these alternatives would still meet the NCP expectation to prevent further migration of the plume, prevent exposure to the contaminated groundwater, and evaluate further risk reduction. Alternative 2 does comply with surface water ARARs because modeling results indicate MNA will reduce the TCE concentrations in groundwater to the MCL prior to discharge as base flow into surface water and monitoring would be used to confirm it. Alternative 3 also complies with surface water chemical specific ARARs because active remedial processes will reduce contaminant levels in groundwater to levels below water quality standards prior to discharge as base flow into surface water.

Location-specific and action-specific ARARs would not apply to Alternative 1 since no remedial activities would be conducted. Alternatives 2 and 3 comply with all location-specific and action-specific ARARs.

2.10.3 Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once cleanup levels have been met. This criterion includes the consideration of residual risk that will remain onsite following remediation, and the adequacy and reliability of controls.

For Alternative 1, contaminant removal would occur by natural attenuation processes, but the long-term effectiveness and permanence would be unknown because of the absence of monitoring. Also, no controls would be implemented to prevent access to contaminated groundwater.

Alternatives 2 and 3 are remedial actions that would permanently reduce contaminant levels in the groundwater over time and return the groundwater to its potential beneficial use as drinking water wherever practicable, with Alternative 3 taking the least amount of time. The LUC would prevent human exposure to the groundwater until cleanup levels are achieved.

Natural attenuation processes are effectively controlling plume migration at LHAAP-46 and have stabilized the size of the plume. Based on predictive analysis, natural attenuation is expected to continue to be successful at the site. However, when performance is based on predictive analysis, contingency measures should be included in the decision document (USEPA, 1999). Therefore, Alternative 2 includes a contingency remedy of in-situ bioremediation.

Alternative 3 would also control plume migration through contaminant reduction by in situ bioremediation. Until a treatability study is conducted, some uncertainty exists regarding the ability of in situ bioremediation to effectively reduce concentrations further and enhance natural attenuation. However, in situ bioremediation is expected to be effective for the contaminants at this site. Should in situ bioremediation be considered ineffective after implementation, the remedy may need to be reevaluated. Alternatives 2 and 3 rely on the LUC for the protection of human health until the MCLs are achieved. Monitoring activities associated with MNA would assure the protection of human health and the environment by documenting the return of the groundwater to its potential beneficial use as a drinking water supply, by documenting reduction of the contaminant mass and protection of surface water through containment of the plume.

2.10.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy.

Alternative 1 has the potential to reduce the mass and concentration of contaminants through natural attenuation processes, although the progress would be unmonitored and undocumented. Alternative 2 would use MNA to permanently reduce the mass and concentration of contaminants and, therefore, the volume, toxicity, and mobility of the contaminants. Alternative 3 would use in situ bioremediation to achieve the same reductions in contamination that are expected from Alternative 2. MNA is a passive remedial action, and bioremediation is an active treatment process.

Biological activity would generate daughter products that may temporarily increase toxicity or mobility of the contaminant plume. Alternatives 2 and 3 include monitoring so that daughter products would be quantified, documented, and evaluated. The same biological activities would also consume the daughter products, and it is anticipated that these concentrations would be reduced to levels below their associated MCLs.

Since there is no known residual source of groundwater contamination in the soils at LHAAP-46, achievement of cleanup levels in groundwater would be expedited under Alternative 3 by implementing in situ bioremediation in areas of highest contaminant concentrations in the groundwater. It is noted that monitoring for contaminants would be performed to assess the effectiveness of the treatment. Also, it is anticipated that COCs will remain above MCLs in the plume outside the treated areas and will continue to attenuate to levels below MCLs over time.

2.10.5 Short-Term Effectiveness

Short term effectiveness addresses the period of time needed to implement the remedy and any adverse impacts that may be posed to workers, the community, and the environment during construction and operation of the remedy until cleanup levels are achieved.

Because Alternative 1 does not involve any remedial measures, no short-term risk to workers, the community, or the environment would exist. The activities associated with Alternative 2 would have little potential for short-term risk to workers or the environment, other than the negligible risks to workers associated with the exposure to contaminants during groundwater monitoring activities. Alternatives 2 and 3 involve potential short-term risks to workers associated with exposure to contaminated groundwater and operation of drilling/construction equipment.

Alternatives 2 and 3 both contain the LUC as an element of their remedies and would provide almost immediate protection through implementation of the LUC that prohibits installation of wells for any purposes other than environmental monitoring and testing. The time period to achieve groundwater cleanup levels is the most significant difference between Alternatives 2 and 3. Alternative 3 is expected to take less time to achieve RAOs. The implementation of Alternative 2 would require more time than Alternative 3.

2.10.6 Implementability

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other governmental entities are also considered.

Under the no action alternative, no remedial action would be taken. Therefore, no difficulties or uncertainties would be associated with its implementation. Alternative 2 is easily implemented from a technical standpoint because no construction activities would be performed, although the U.S. Army would be responsible for long-term maintenance and enforcement of the LUC, long-term evaluation of MNA, long-term sampling; and long-term maintenance and operation of sampling equipment.

Alternative 3 is also technically implementable, although less so than Alternative 2 because of the uncertainties associated with the ability of in situ bioremediation to effectively lower

contaminant levels and to enhance natural attenuation in the complex hydrogeologic conditions of the site. Alternative 3 would be somewhat more difficult to implement than Alternative 2 from a technical standpoint due to the specialized expertise required to design and construct the in situ bioremediation treatment elements.

Administratively, all of the alternatives are implementable.

2.10.7 Cost

Cost estimates are used in the CERCLA process to eliminate those remedial alternatives that are significantly more expensive than competing alternatives without offering commensurate increases in performance or overall protection of human health or the environment. The cost estimates developed are preliminary estimates with an intended accuracy range of –30 to +50 percent. Final costs will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final scope, final schedule, final engineering design, and other variables.

Costs developed are capital costs (including fixed-price remedial construction) and long-term O&M costs (post-remediation). Overall 30-year present worth costs are developed for each alternative assuming a discount rate of 2.8 percent.

The progression of present worth costs from the least expensive alternative to the most expensive alternative is as follows: Alternative 1, Alternative 2, and Alternative 3. No costs are associated with Alternative 1 because no remedial activities would be conducted.

Alternative 2 has the lowest present worth and capital costs of the action alternatives. The highest capital cost is associated with Alternative 3 primarily due to the activities associated with the injection phase of in situ bioremediation. The selection of Alternative 2 over Alternative 3 saves 30% in total present worth cost. The capital present worth cost of Alternative 3 is 6 times higher than Alternative 2.

2.10.8 State/Support Agency Acceptance

The USEPA and TCEQ have reviewed the Proposed Plan, which presented Alternative 2 as the preferred alternative. Comments received from the USEPA and TCEQ during the Proposed Plan development have been incorporated. Both agencies concur with the selected remedial action.

2.10.9 Community Acceptance

Community acceptance is an important consideration in the final evaluation of the selected remedy. Public comments were received during the 60-day public comment period, including written comments sent to the U.S. Army and verbal comments made at the January 26, 2010 and March 9, 2010 public meetings. The public expressed some reservations about the proposed plan, especially about the proximity of the plume to public drinking water wells outside LHAAP.

This concern was addressed in the March 9, 2010 public meeting with further explanation that the water wells are upgradient of the plume. Responses to this and other concerns have been provided and can be found in the Responsiveness Summary (**Section 3.0** of the ROD), in the transcript of the March 9, 2010 meeting, and in the U.S. Army's response to written comments which has been filed in the Administrative Record.

2.11 Principal Threat Wastes

LHAAP-46 has no known principal threat wastes (e.g., source materials such as DNAPLs).

2.12 The Selected Remedy

2.12.1 Summary of Rationale for the Selected Remedy

Alternative 2, MNA and LUC, is the preferred alternative for LHAAP-46 and is consistent with the intended future use of the site as a national wildlife refuge. This alternative is selected because it satisfies the RAOs for the site through the groundwater use restriction LUC, which will ensure protection of human health by preventing human exposure to contaminated groundwater, and MNA, which will return the contaminated water to its potential beneficial use as drinking water, wherever practicable. The LUC will remain in place until MCLs are met. Furthermore, MNA will ensure protection of human health and the environment by documenting that the contaminated groundwater remains localized and is not migrating into nearby surface water bodies at levels that exceed MCLs. The LTM and reporting associated with the MNA remedy will continue until primary COC and daughter product MCLs are attained. Based on a preliminary natural attenuation evaluation and groundwater modeling, MCLs are expected to be met through natural attenuation in approximately 23 years for TCE (Shaw, 2009). Considering the lithologic variability, particularly the lateral and vertical change from sand to clay, the times to MCL may vary by an order of magnitude. The groundwater flow rates are within the normal range for the formation material at these sites. Thus, no adverse impact is expected to the surface water during the time it would take natural attenuation to reduce contaminant concentrations to MCLs. The selected alternative offers a high degree of long-term effectiveness, can be easily and immediately implemented, and costs significantly less than Alternative 3.

The performance of MNA will be evaluated after two years of performance monitoring using data from eight quarterly sampling events and from historical sampling events of the prior ten years. The performance objectives will be included in the RD. If it is found that the performance objectives for that two-year period are not being met, a contingency remedy of in situ bioremediation (see Alternative 3 description for basic elements) will be implemented after approval of the RD for the contingency remedy. If MNA is found to be effective, the monitoring program will be continued as follows: 3 years of semiannual monitoring, then annual monitoring

until the next five-year review, and finally LTM every 5 years until the cleanup levels are reached.

Based on the information currently available, the U.S. Army believes that the preferred alternative provides the best balance of tradeoffs among the other alternatives with respect to the CERCLA §121(b) criteria used to evaluate remedial alternatives. The preferred alternative will 1) be protective of human health and the environment; 2) comply with ARARs; 3) be cost-effective; 4) utilize a permanent solution; and 5) does not utilize an active treatment as a principal element.

Although the selected remedy is not intended to address the statutory preference for treatment to the maximum extent possible, the final selected remedy offers, within a reasonable time frame and at a lower cost, a similar level of protection to human health and the environment than the remedy alternative which satisfies the preference for treatment. In addition, no source materials constituting principal threats have been identified at the site; therefore, none will be addressed within the scope of this action.

The U.S. Army will present details of the LUC implementation plan, the groundwater monitoring plan, and the MNA remedy implementation in an RD for LHAAP-46.

2.12.2 Description of the Selected Remedy

The selected remedy, Alternative 2, was outlined in **Section 2.9**; that description is expanded in the following discussion. The remedy may change somewhat as a result of the RD and construction processes. Changes to the remedy described in the ROD will be documented using a technical memorandum in the Administrative Record, an Explanation of Significant Differences (ESD), or a ROD amendment.

The major components of the MNA remedy with a contingency remedy for the impacted groundwater include:

- *MNA to reduce concentrations in groundwater to MCLs.* Historic data suggest that natural attenuation of COCs is occurring at the site; however, additional data collection is necessary to fully evaluate natural attenuation. Monitoring wells will be sampled for eight consecutive quarters to evaluate and confirm the occurrence of natural attenuation in conjunction with historical data. Data from the eight quarterly events will be combined with historic data to evaluate the effectiveness of various natural physical, chemical, and biological processes in reducing contaminant concentrations.

    - *Performance objectives to evaluate the MNA remedy performance after two years. Each of the general performance objectives must be met as indicated below. If the criteria are not met to illustrate that MNA is an effective remedy, the contingency action would be initiated. If MNA is effective, a baseline will be*

established from the data to this point in time. Specific evaluation criteria will be developed in the RD. The MNA evaluation will be based on the USEPA lines of evidence (USEPA, 1999) and the anaerobic screening (USEPA, 1998) as follows:

- MNA potential based on evaluation biodegradation screening scores using USEPA guidance
- Plume stability (i.e., the plume concentrations are decreasing in the majority of performance wells, and the plume is not expanding in area as demonstrated with compliance wells).
- MNA Process Evaluation demonstrated based on an attenuation rate calculated with empirical performance monitoring data, and MNA Process Demonstration based on the presence of daughter products and bacterial culture counts.

- *A contingency remedy involving in situ bioremediation to reach the RAOs if MNA is found to be ineffective.* The contingency remedy will use elements of in situ bioremediation from Alternative 3 to address the ineffective aspects of MNA. The area and the elements of the contingency remedy would be selected based on the entire data set available. If the contingency remedy is implemented, it will be documented in an ESD.
- *Initiate LTM.* If MNA is determined to be effective, monitoring will be conducted to evaluate the remedy performance and determine if the plume conditions remain constant, improve or worsen after the baseline is established. Monitoring will continue after the initial eight quarters at a frequency of semiannual for three years, then annually until the next five-year review. The performance monitoring plan will be developed in the RD and will be based on USEPA guidance (USEPA, 2004).
- Continue LTM every five years to evaluate remedy performance and determine if plume conditions remain constant, improve, or worsen. The baseline of the plume for future five-year reviews will be established as part of the MNA evaluation program. The initial LTM plan will be developed during RD.

- LUC to restrict access to the contaminated groundwater to environmental monitoring and testing until groundwater is returned to its potential beneficial use as a drinking water. LUC implementation details will be included in the RD. The boundary of the LUC would be the site boundary as shown on **Figure 2-7**; this is sufficient to include all of the plume.

The U.S. Army would be responsible for implementation, maintenance, inspection, reporting, and enforcement of the LUC. Although the U.S. Army may later pass these procedural responsibilities to the transferee by property transfer agreement, the U.S. Army shall retain ultimate responsibility for: (1) CERCLA 121(c) five-year reviews; (2) notification of the appropriate regulators of any known LUC deficiencies or violations; (3) access to the property to

conduct any necessary response; (4) reservation of the authority to change, modify or terminate the LUC and any related transfer or lease provisions; and (5) ensuring that the LUC objectives are met to protect the integrity of the selected remedy. In the event that TCEQ and/or USEPA and the U.S. Army agree with respect to any modification of the selected remedy, including the LUC component of the selected remedy, the remedy will be changed consistent with the FFA and 40 CFR 300.435(c)(2) and 40 CFR 300.430(f)(4)(iii).

LUC implementation and maintenance actions would be described in the RD for LHAAP-46. The selected LUC will prevent human exposure to chlorinated solvents-contaminated groundwater through the restriction of groundwater use. The groundwater restriction component of the LUC shall be maintained until the concentrations of contaminants and by-product (daughter) contaminants have been reduced to below their respective MCLs under the SDWA to allow unrestricted use and unlimited exposure at LHAAP-46. The LUC would be included in the property transfer documents. In addition, the TDLR responsible for notifying well drillers of groundwater restrictions would be notified and a recordation of the area of groundwater restriction would be filed in the Harrison County Courthouse.

Monitoring activities associated with the LUC and MNA would be undertaken to ensure that groundwater is not being used, and to demonstrate containment of the plume and the eventual reduction of contaminates to levels below MCLs.

Long-term operational requirements under this alternative would include maintenance of the LUC. The need for continued monitoring will be evaluated every five years during the reviews. Sampling frequency and analytical requirements will be presented in the RD for LHAAP-46.

2.12.3 Cost Estimate of the Selected Remedy

Table 2-9 presents the present worth analysis of the cost for the selected remedy, Alternative 2. The information in the table is based on the best available information regarding the anticipated scope of the remedial alternative. The quantities used in the estimate are for estimating purposes only. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedial alternative. Major changes may be documented in the form of a memorandum in the Administrative Record file, an ESD, or a ROD amendment. This is an order-of-magnitude engineering cost estimate that is expected to be within –30 to +50 percent of the actual project cost.

The total project present worth cost of this alternative is approximately $521,200, using a discount rate of 2.8%. The capital cost is estimated at $60,500. The total O&M present value cost is estimated at approximately $460,700. The O&M cost includes evaluation of MNA, maintenance of the LUC, and LTM through Year 30. The LTM would support the required five-year reviews.

2.12.4 Expected Outcomes of the Selected Remedy

The purpose of this response action is to attain the RAOs stated in **Section 2.8** of this document. The cleanup levels for the COCs in the groundwater are the Federal SDWA MCLs, to satisfy the chemical-specific ARAR (**Table 2-7**).

The expected outcome of the selected remedy is that the TCE plume in the groundwater, and any plumes of daughter products, would be reduced to the MCLs. MCLs for TCE, cis-1,2-DCE, and VC are 5, 70, and 2 µg/L, respectively. Achievement of the cleanup levels is anticipated to be completed in 23 years, although for cost estimating purposes, it is assumed that five-year reviews will continue until Year 30. When the groundwater is satisfactory, the LUC will be removed. In the short-term (prior to the groundwater achieving MCLs), the site will be made part of a national wildlife refuge operated by USFWS, and is expected to continue as such in the long-term (after the groundwater achieves MCLs).

In addition, the monitoring activities associated with MNA would assure the protection of human health and the environment by documenting the return of the groundwater to its potential beneficial use as a drinking water supply, by documenting reduction of the contaminant mass and protection of surface water through containment of the plume. Until that time, the LUC will restrict the use of the site's groundwater to environmental monitoring and testing.

2.13 Statutory Determinations

Under CERCLA §121 and the NCP, the U.S. Army must select remedies that are protective of human health and the environment, comply with ARARs (unless a statutory waiver is justified), are cost effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ treatment that permanently and significantly reduce the volume, toxicity, or mobility of hazardous wastes as a principal element and a bias against off-site disposal of untreated wastes. The following sections discuss how the selected remedy meets these statutory requirements.

2.13.1 Protection of Human Health and the Environment

The selected remedy, Alternative 2, will protect human health and the environment, and achieve the RAOs for LHAAP-46, through MNA and LUC. Although this alternative does not provide for human intervention to remediate groundwater, the alternative is a passive subsurface remedial action conducted by natural processes and mechanisms. TCE and daughter products in the groundwater will be reduced to protective ARAR levels. The LUC would prevent human exposure to the contaminated groundwater by restricting access to the groundwater within the LUC boundaries. The monitoring activities associated with MNA will ensure that COCs and by-product (daughter) contaminants in groundwater do not discharge to nearby surface water bodies

at such levels that ARARs are exceeded. The LUC will be removed when it has been satisfactorily demonstrated through groundwater monitoring that the groundwater has achieved cleanup levels.

There are no short-term threats associated with the selected remedy that cannot be readily controlled. In addition, no adverse cross-media impacts are expected from the selected remedy.

2.13.2 Compliance with ARARs

The selected remedy of MNA and LUC complies with all ARARs. The ARARs are presented below and in **Table 2-10**.

Chemical-Specific ARARs

The chemical-specific ARAR is to reduce TCE and its daughter products in groundwater to the Federal SDWA MCLs. The MCLs for TCE, cis-1,2-DCE, and VC are 5, 70, and 2 µg/L, respectively. This alternative will return the contaminated shallow groundwater zone at LHAAP-46 to its potential beneficial use as drinking water, wherever practicable, which for the purposes of this ROD is considered to be attainment of the relevant and appropriate SDWA MCLs to the extent practicable, and consistent with 40 CFR 300.430(e)(2)(i)(B&C). If a return to potential beneficial uses is not practicable, this alternative would still meet the NCP expectation to prevent further migration of the plume, prevent exposure to the contaminated groundwater, and evaluate further risk reduction. Because modeling results indicate that maximum concentrations of COCs were below their respective MCLs where groundwater discharges into nearby surface water bodies, nearby surface water bodies will be protected from ARAR exceedances. In the event of remedy failure resulting in a release to surface water, 40 CFR 122, 125, 129, 130, and 131 and 30 TAC 307.1, 307.2, 307.3, 307.4, 307.5(a) and (b), 307.6, 307.7, 307.8 and 307.9 are considered potential future ARARs.

Location-Specific ARARs

LHAAP-46 has no location-specific ARARs. The USACE has not made a determination that jurisdictional wetlands exist at LHAAP-46 and neither are any identified on the USFWS database, therefore protection of wetlands is not considered a potential location-specific ARAR for this site.

Action-Specific ARARs

The selected remedy has several potential action-specific ARARs related to the following activities: waste generation, characterization, management, storage, and disposal activities; and well construction.

- **Wastes and disposal activities**: The processes of monitoring, intercepting, or treating contaminated groundwater may generate a variety of primary and secondary

waste surface water (e.g., soil, personal protective equipment, and dewatering and decontamination fluids). These waste surface waters are expected to be non-hazardous waste. All solid waste (defined as any solid, liquid, semisolid, or contained gaseous material intended for discard [40 CFR 261.2]) generated during remedial activities must be appropriately characterized to determine whether it contains RCRA hazardous waste (40 CFR 262.11; 30 TAC 335.62; 30 TAC 335.503[a][4]; 30 TAC 335.504). All wastes must be managed, stored, treated (if necessary), and disposed of in accordance with the ARARs for waste management listed in **Table 2-10** for the particular type of waste stream or contaminants in the waste.

- **Well construction**: The remedial action may involve the placement, use, or eventual plugging and abandonment of some type of groundwater monitoring, injection, and/or extraction wells, either for in situ treatment of the contaminated groundwater or for LTM of the groundwater. Available standards for well construction and plugging/abandonment would provide ARARs for such actions and include 30 TAC 331, Subchapters A, C, and H. Texas has promulgated technical requirements in Chapter 76 of Title 16 of the TAC applicable to construction, operation, and plugging/abandonment of water wells. In particular, 16 TAC 76.1000 (*Locations and Standards of Completion for Wells*), 16 TAC 76.1002 (*Standards for Wells Producing Undesirable Water or Constituents*) (LHAAP-46 contaminated groundwater could be considered "undesirable water" defined pursuant to Section 76.10[36] as "water that is injurious to human health and the environment or water that can cause pollution to land or other waters"), 16 TAC 76.1004 (*Standards for Capping and Plugging of Wells and Plugging Wells that Penetrate Undesirable Water or Constituent Zones*), and 16 TAC 76.1008 (*Pump Installation*) may provide ARARs for the placement, construction, and eventual plugging/abandonment of groundwater injection or extraction wells or the placement and long-term operation of groundwater monitoring wells for proposed groundwater remedial strategies.

- **Water Treatment**: Contaminated groundwater and wastewaters collected during well drilling or decontamination activities could be transported to the groundwater treatment plant at LHAAP-18/24 for processing, and would subsequently be discharged in compliance with the effluent limits for that plant. Such waters would be characterized, as required, before transport and managed accordingly in compliance with requirements for the type of waste contaminating the water. To assure compliance with the groundwater treatment plant's discharge limits, the incoming water must meet the waste acceptance criteria for the facility. On-site wastewater treatment units (as defined in 40 CFR 260.10) that are part of a wastewater treatment facility that is subject to regulation under Section 402 or Section 307(b) of the Clean Water Act (CWA) are not subject to RCRA Subtitle C hazardous waste management standards (40 CFR 270.1[c][2][v]; 40 CFR 264.1[g][6]; 30 TAC 335.42[d][1]). The USEPA has clarified that this exemption applies to all tanks, conveyance systems, and ancillary equipment, including piping and transfer trucks, associated with the wastewater treatment unit (53 Federal Register [FR] 34079, September 2, 1988).

2.13.3 Cost-Effectiveness

Alternative 2 is considered to be the best balance of tradeoffs because it provides the same level of protection to human health as Alternative 3 but at a lower cost. The selection of Alternative 2 over Alternative 3 saves 30% in total present worth cost. The capital present worth cost of Alternative 3 is 6 times higher than Alternative 2. The relatively high capital cost for Alternative 3 is due to the activities associated with the injection phase of in situ bioremediation. Alternatives 2 and 3 have similar outcomes in terms of short and long-term effectiveness and reduction in toxicity, mobility, and volume; the main difference between the two is that the MCLs are anticipated to be reached approximately 15 years later for Alternative 2.

Table 2-9 is the cost estimate summary table for the selected remedy. **Table 2-11** compares the cost and effectiveness of each alternative.

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

The selected remedy does not address the issue of permanent solution through disposal, treatment, or recovery of contaminants. However, the selected remedy provides the best balance of trade offs in terms of five balancing criteria and considering State and community acceptance. Alternative 2 would document effectiveness through the confirmation of MNA and the routine monitoring of the attenuation and migration of the contaminants in groundwater. Natural attenuation effectively controls plume migration and has stabilized the size of the area exhibiting COC and by-product (daughter) contaminant concentrations exceeding MCL values. Natural biodegradation is an irreversible treatment process that would reduce the mass and concentration of contaminants. Alternative 2 would provide almost immediate protection because the LUC would be implemented relatively quickly. Maintenance of these controls would be required until natural attenuation processes reduce COC and by-product (daughter) contaminant concentrations to below MCLs. Alternative 2 is easily implemented from a technical standpoint because no remedial activities would be performed, although routine maintenance of the LUC, evaluation of MNA, and sampling would be required. Alternative 2 has the lowest present worth and capital costs of the remedial alternatives.

2.13.5 Preference for Treatment as a Principal Element

The selected remedy does not satisfy the statutory preference for treatment as a principal element of the remedy. Although the selected remedy is not intended to address the statutory preference for treatment to the maximum extent practicable, the selected remedy offers, within a reasonable time frame and at a lower cost, a similar level of protection to human health and the environment than those remedy alternatives which satisfy the preference for treatment. Because no source materials constituting principal threats are present at the site, they will not be addressed within the scope of this action.

2.13.6 Five-Year Review Requirements

Section 121(c) of CERCLA and NCP §300.430(f)(5)(iii)(C) provide the statutory and legal basis for conducting five-year reviews. Because the final selected remedy will result in contaminants that remain on site above levels that allow unlimited use and unrestricted exposure, a review will be conducted every five years to ensure that the remedy continues to provide adequate protection of human health and the environment.

2.14 Significant Changes from the Proposed Plan

The Proposed Plan for LHAAP-46 was released for public comment in January 2010. The Proposed Plan identified Alternative 2, MNA and LUC, as the Preferred Alternative for groundwater remediation. The U.S. Army reviewed all written and verbal comments submitted during the public comment period. After careful consideration of the comments, it was determined that no significant changes to the remedy, as originally identified in the Proposed Plan, were necessary or appropriate.

Table 2-1
Summary of Chemicals of Potential Concern and Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Current
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Point	Chemical	Concentration Detected[1] (µg/L)		Frequency of Detection	Exposure Point Concentration (µg/L)	Statistical Measure
		Minimum	Maximum			
Incidental ingestion, inhalation of particulates, dermal contact	*Dioxin/Furan*					
	2,3,7,8-TCDD	1.98E-06	6.35E-06	---	6.35E-06	maximum
	Explosive					
	RDX	1.90E-01	3.20E-01	2/89	3.20E-01	maximum
	Metals					
	Aluminum	2.20E+02	8.00E+04	79/89	8.00E+04	maximum
	Antimony	8.00E+00	6.30E+01	4/91	6.30E+01	maximum
	Barium	2.00E+01	3.73E+03	68/91	3.73E+03	maximum
	Beryllium	5.00E-01	7.60E+01	18/70	7.60E+01	maximum
	Cadmium	3.00E-01	2.00E+01	15/91	2.00E+01	maximum
	Chromium	4.40E+00	4.70E+03	73/91	4.70E+03	maximum
	Manganese	4.90E+01	6.50E+03	90/91	6.50E+03	maximum
	Nickel	1.70E+01	1.19E+03	53/70	1.19E+03	maximum
	Silver	1.90E+00	1.20E+02	6/88	1.20E+02	maximum
	Strontium	4.60E+01	1.20E+04	87/91	1.20E+04	maximum
	Thallium	1.10E+00	2.00E+02	15/91	2.00E+02	maximum
	Vanadium	2.80E+00	1.40E+02	8/70	1.40E+02	maximum
	Non-Metallic Anion					
	Perchlorate	2.30E+01	3.00E+01	2/10	3.00E+01	maximum
	Pesticides					
	Aldrin	6.30E-03	6.30E-03	2/8	6.30E-03	maximum
	alpha-BHC	7.60E-03	7.60E-03	3/8	7.60E-03	maximum
	beta-BHC	5.40E-03	5.40E-03	3/8	5.40E-03	maximum
	delta-BHC	4.60E-03	4.60E-03	3/8	4.60E-03	maximum
	Semivolatile Organics					
	2,4-Dinitrotoluene	0.00E+00	0.00E+00	0/88	7.30E-02	maximum
	Bis(2-ethylhexyl)phthalate	4.70E-01	2.70E+01	28/87	2.70E+01	maximum
	Volatile Organics					
	Methylene chloride	8.80E-01	1.40E+00	2/91	1.40E+00	maximum
	Tetrachloroethene	1.10E+00	2.40E+00	4/91	2.40E+00	maximum
	Trichloroethene	7.10E-01	7.70E+01	14/91	---	
	Trichlorofluoromethane	2.10E+00	2.10E+00	4/91	2.10E+00	maximum
	Vinyl Chloride	6.80E-01	7.10E-01	2/91	7.10E-01	maximum

Table 2-1 (*continued*)
Summary of Chemicals of Potential Concern and Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Current
Medium: Soil
Exposure Medium: Soil (0 to 2 feet below ground surface)

Exposure Point	Chemical	Concentration Detected[1] (mg/kg)		Frequency of Detection	Exposure Point Concentration (mg/kg)	Statistical Measure
		Minimum	Maximum			
Incidental ingestion, inhalation of particulates, dermal contact	*Dioxin/Furan*					
	2,3,7,8-TCDD	2.86E-07	3.30E-05	---	4.23E-06	95% UCL
	Metals					
	Aluminum	7.30E+02	3.28E+04	107/151	8.07E+03	95% UCL
	Antimony	3.10E+00	6.30E+00	7/151	4.17E+00	95% UCL
	Barium	4.70E+00	2.06E+03	97/151	2.06E+03	Maximum
	Cadmium	2.31E+00	7.18E+00	4/151	7.18E+00	maximum
	Manganese	4.70E+00	3.74E+03	111/151	2.53E+02	95% UCL
	Mercury	4.40E-02	5.60E-01	8/142	5.60E-01	maximum
	Vanadium	8.00E+00	8.60E+01	83/83	2.89E+01	95% UCL
	Semivolatile Organics					
	Benzo(a)anthracene	7.50E+01	2.30E+00	5/149	2.30E+00	maximum
	Benzo(a)pyrene	7.70E+01	2.10E+00	9/149	2.10E+00	maximum
	Benzo(b)fluoranthene	7.50E+01	4.50E+00	11/149	4.50E+00	maximum
	Benzo(k)fluoranthene	7.10E+01	1.20E+00	6/149	3.78E-01	95% UCL
	Dibenzo(a,h)anthracene	1.10E+02	3.80E-01	2/149	3.80E-01	maximum
	Indeno(1,2,3-cd)pyrene	2.90E+02	1.60E+00	4/149	1.60E+00	maximum

Notes

[1] Minimum/maximum detected concentration above the reporting limit
---: No information available
95% UCL: 95% upper confidence level of the mean
µg/L: micrograms per liter
BHC: benzenehexachloride (hexachlorocyclehexane)
mg/kg: milligrams per kilogram
RDX: 1,3,5-Trinitroperhydro-1,3,5-triazine
TCDD: tetrachlorodibenzo-p-dioxin

References

Jacobs Engineering Group, Inc. (Jacobs), 2003, *Final Baseline Human Health and Screening Ecological Risk Assessment for the Group 4 Sites (Sites 04, 08, 35A, 35B, 35C, 46, 47, 48, 50, 60, 67, Goose Prairie Creek, Saunders Branch, Central Creek, and Caddo Lake), Longhorn Army Ammunition Plant, Karnack, Texas*, Final, Oak Ridge, TN, June.

Summary of Chemicals of Potential Concern and Medium-Specific Exposure Point Concentrations

The table presents the chemicals of potential concern (COPCs) and exposure point concentration (EPC) for each (i.e. the concentration used to estimate the exposure and risk from each COPC). The table includes the range of concentrations detected for each COPC, the frequency of detection (i.e. the number of times the chemical was detected in the samples collected at the site), the EPC, and the statistical measure upon which the EPC was based. The COPCs listed are the ones that were quantitatively evaluated for carcinogenic risk and non-carcinogenic hazard in the Baseline Human Health Risk Assessment (Jacobs, 2003).

Table 2-2
Carcinogenic Toxicity Data Summary

Pathway: Ingestion, Dermal Contact				
Chemical of Concern	Oral Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$	Dermal Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$	Weight of Evidence/ Carcinogen Guideline Description	Source/Date
Dioxin/Furan				
2,3,7,8-TCDD	1.50E+05	3.00E+05	Not Classified	USEPA-HEAST, 1997
Explosive				
RDX	1.10E-01	1.10E-01	C	USEPA-IRIS, 2001
Metals				
Aluminum	NTV	NTV	Not Classified	---
Antimony	NTV	NTV	Not Classified	---
Barium	NC	NC	D	USEPA-IRIS, 2001
Beryllium	NTV	NTV	B1	USEPA-IRIS, 2001
Cadmium	NTV	NTV	B1	TCEQ, 2001
Chromium	NC	NC	Not Classified	---
Manganese	NC	NC	D	USEPA-IRIS, 2001
Mercury	NC	NC	D	USEPA-IRIS, 2001
Nickel	NTV	NTV	A	USEPA-IRIS, 2001
Silver	NC	NC	D	USEPA-IRIS, 2001
Strontium	NTV	NTV	Not Classified	---
Thallium	NC	NC	Not Classified	---
Vanadium	NTV	NTV	Not Classified	---
Non-Metallic Anion				
Perchlorate	NTV	NTV	Not Classified	---
Pesticides				
Aldrin	1.70E+01	3.40E+01	B2	USEPA-IRIS, 2001
alpha-BHC	6.30E+00	6.49E+00	B2	USEPA-IRIS, 2001
beta-BHC	1.80E+00	1.98E+00	C	USEPA-IRIS, 2001
delta-BHC	1.80E+00	3.60E+00	B2	TCEQ, 2001
Semivolatile Organics				
2,4-Dinitrotoluene	6.80E-01	8.00E-01	B2	USEPA-IRIS, 2001
Benzo(a)anthracene	7.30E-01	8.20E-01	B2	USEPA, 1993
Benzo(a)pyrene	7.30E+00	8.20E+00	B2	USEPA-IRIS, 2001
Benzo(b)fluoranthene	7.30E-01	8.20E-01	B2	USEPA, 1993
Benzo(k)fluoranthene	7.30E-02	8.20E-02	B2	USEPA, 1993
Bis(2-ethylhexyl)phthalate	1.40E-02	7.37E-02	B2	USEPA-IRIS, 2001
Dibenzo(a,h)anthracene	7.30E+00	8.20E+00	B2	USEPA, 1993
Indeno(1,2,3-cd)pyrene	7.30E-01	8.20E-01	B2	USEPA, 1993
Volatile Organics				
Methylene chloride	7.50E-03	7.89E-03	B2	USEPA-IRIS, 2001
Tetrachloroethene	5.20E-02	5.20E-02	B2	USEPA-NCEA, 2001
Trichloroethene	1.10E-02	1.10E-02	B2	USEPA-NCEA, 2001
Trichlorofluoromethane	NTV	NTV	Not Classified	---
Vinyl Chloride	1.50E+00	1.50E+00	A	USEPA-IRIS, 2001

Table 2-2 (*continued*)
Carcinogenic Toxicity Data Summary

Pathway: Inhalation			
Chemical of Concern	Unit Risk Factor $(mg/m^3)^{-1}$	Weight of Evidence/ Carcinogen Guideline Description	Source/Date
Dioxin/Furan			
2,3,7,8-TCDD	3.30E+04	Not Classified	USEPA-HEAST, 1997
Explosive			
RDX	NTV	C	USEPA-IRIS, 2001
Metals			
Aluminum	NTV	Not Classified	---
Antimony	NTV	Not Classified	---
Barium	NC	D	USEPA-IRIS, 2001
Beryllium	2.40E+00	B1	USEPA-IRIS, 2001
Cadmium	1.80E+00	B1	USEPA-IRIS, 2001
Chromium	NC	Not Classified	---
Manganese	NC	D	USEPA-IRIS, 2001
Mercury	NC	D	USEPA-IRIS, 2001
Nickel	4.80E-01	A	USEPA-IRIS, 2001
Silver	NC	D	USEPA-IRIS, 2001
Strontium	NTV	Not Classified	---
Thallium	NC	Not Classified	---
Vanadium	NTV	Not Classified	---
Non-Metallic Anion			
Perchlorate	NTV	Not Classified	---
Pesticides			
Aldrin	4.90E-03	B2	USEPA-IRIS, 2001
alpha-BHC	1.80E-03	B2	USEPA-IRIS, 2001
beta-BHC	5.30E-04	C	USEPA-IRIS, 2001
delta-BHC	5.10E-04	B2	TCEQ, 2001
Semivolatile Organics			
2,4-Dinitrotoluene	NTV	B2	USEPA-IRIS, 2001
Benzo(a)anthracene	8.80E-05	B2	USEPA, 1993
Benzo(a)pyrene	8.80E-04	B2	USEPA-NCEA, 2001
Benzo(b)fluoranthene	8.80E-02	B2	USEPA, 1993
Benzo(k)fluoranthene	8.80E-06	B2	USEPA, 1993
Bis(2-ethylhexyl)phthalate	4.00E-03	B2	USEPA-NCEA, 2001
Dibenzo(a,h)anthracene	8.80E-04	B2	USEPA, 1993
Indeno(1,2,3-cd)pyrene	8.80E-05	B2	USEPA, 1993
Volatile Organics			
Methylene chloride	4.70E-04	B2	USEPA-IRIS, 2001
Tetrachloroethene	5.80E-07	B2	USEPA-NCEA, 2001
Trichloroethene	1.70E-03	B2	USEPA-NCEA, 2001
Trichlorofluoromethane	NTV	Not Classified	---
Vinyl Chloride	8.80E-03	A	USEPA-IRIS, 2001

Table 2-2 (*continued*)
Carcinogenic Toxicity Data Summary

Notes

--- : No information available
BHC: benzenehexachloride (hexachlorocyclehexane)
mg/kg-day: milligrams per kilogram per day
mg/m^3: milligrams per cubic meter
NC: Chemical not classified as a carcinogen
NTV: no toxicity value available
RDX: 1,3,5-Trinitroperhydro-1,3,5-triazine
TCDD: tetrachlorodibenzo-p-dioxin

Weight of Evidence/Carcinogen Guideline Description:

A - Human carcinogen
B1 - Probable human carcinogen – Indicates that limited human data are available
B2 - Probable human carcinogen – Indicates sufficient evidence in animals and inadequate or no evidence in humans
C - Possible human carcinogen
D - Not classifiable as a human carcinogen

References

Jacobs Engineering Group, Inc. (Jacobs), 2003, *Final Baseline Human Health and Screening Ecological Risk Assessment for the Group 4 Sites (Sites 04, 08, 35A, 35B, 35C, 46, 47, 48, 50, 60, 67, Goose Prairie Creek, Saunders Branch, Central Creek, and Caddo Lake), Longhorn Army Ammunition Plant, Karnack, Texas*, Final, Oak Ridge, TN, June.

Texas Commission on Environmental Quality (TCEQ), 2001. Update to 1998 Consistency Memorandum. Toxicity Factors Table, 15 March 2001.

U.S. Environmental Protection Agency (USEPA), 1993, *Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons*, Office of Research and Development, EPA/600/R-93/089, July 1993.

USEPA-HEAST, 1997. Human Health Effects Summary Tables (HEAST). FY-1995, Annual. Office of Emergency and Remedial Response, Washington, D.C. EPA/540/R-95-036.

USEPA-IRIS, 2001. Integrated Risk Information System (IRIS). United States Environmental Protection Agency Online Database for Toxicity Information on Hazardous Chemicals, 2001.

USEPA-NCEA, 2001. USEPA Region 3 Risk-Based Concentration Tables (5/8/2001). Referenced values from National Center for Environmental Assessment (NCEA).

Summary of Toxicity Assessment

The table provides carcinogenic risk information which is relevant to the contaminants of potential concern in soil and groundwater. The list of chemicals of concern presented here are the ones that were quantitatively evaluated for carcinogenic risk and non-carcinogenic hazard in the Baseline Human Health Risk Assessment (Jacobs, 2003).

Table 2-3
Non-Carcinogenic Toxicity Data Summary

Pathway: Ingestion, Dermal Contact						
Chemical of Concern	Chronic/ Subchronic	Oral RfD Value (mg/kg-day)	Dermal RfD (mg/kg-day)	Primary Target Organ	Combined Uncertainty/ Modifying Factors	Source/Date
Dioxin/Furan						
2,3,7,8-TCDD	Chronic	NTV	NTV	---	---	---
Explosive						
RDX	Chronic	3.00E-03	3.00E-03	Prostate	100/1	USEPA-IRIS, 2001
Metals						
Aluminum	Chronic	1.00E+00	1.00E-01	NA	NA	USEPA-NCEA, 2001
Antimony	Chronic	4.00E-04	6.00E-05	Longevity, blood glucose, and cholesterol	1000/1	USEPA-IRIS, 2001
Barium	Chronic	7.00E-02	4.90E-03	Kidney	3/1	USEPA-IRIS, 2001
Beryllium	Chronic	2.00E-03	1.40E-05	GIT	300/1	USEPA-IRIS, 2001
Cadmium	Chronic	5.00E-04	1.25E-05	Kidney	10/1	USEPA-IRIS, 2001
Chromium	Chronic	1.50E+00	1.95E-02	NA	100/10	USEPA-IRIS, 2001
Manganese	Chronic	4.70E-02	2.82E-03	CNS	1/1	USEPA-IRIS, 2001
Mercury	Chronic	3.00E-04	2.10E-05	Autoimmune effects	1000/1	USEPA-IRIS, 2001
Nickel	Chronic	2.00E-02	8.00E-04	Body weight	300/1	USEPA-IRIS, 2001
Silver	Chronic	5.00E-03	2.00E-04	Argyria	3/1	USEPA-IRIS, 2001
Strontium	Chronic	6.00E-01	1.20E-01	Bone	300/1	USEPA-IRIS, 2001
Thallium	Chronic	8.00E-05	8.00E-05	Blood	3000/1	USEPA-IRIS, 2001
Vanadium	Chronic	7.00E-03	1.82E-04	NA	NA	USEPA-HEAST, 1997
Non-Metallic Anion						
Perchlorate	Chronic	9.00E-04	9.00E-04	NA	NA	USEPA, 1998
Pesticides						
Aldrin	Chronic	3.00E-05	1.50E-05	Liver	1000/1	USEPA-IRIS, 2001
alpha-BHC	Chronic	8.00E-03	7.76E-03	NA	NA	ATSDR, 1997
beta-BHC	Chronic	NTV	NTV	---	---	---
delta-BHC	Chronic	3.00E-04	1.50E-04	NA	NA	TCEQ-Derived
Semivolatile Organics						
2,4-Dinitrotoluene	Chronic	2.00E-03	1.70E-03	CNS	100/1	USEPA-IRIS, 2001
Benzo(a)anthracene	Chronic	NTV	NTV	---	---	---
Benzo(a)pyrene	Chronic	NTV	NTV	---	---	---
Benzo(b)fluoranthene	Chronic	NTV	NTV	---	---	---
Benzo(k)fluoranthene	Chronic	NTV	NTV	---	---	---
Bis(2-ethylhexyl)phthalate	Chronic	2.00E-02	3.80E-03	Liver	1000/1	USEPA-IRIS, 2001
Dibenzo(a,h)anthracene	Chronic	NTV	NTV	---	---	---
Indeno(1,2,3-cd)pyrene	Chronic	NTV	NTV	---	---	---
Volatile Organics						
Methylene chloride	Chronic	6.00E-02	5.70E-02	Liver	100/1	USEPA-IRIS, 2001
Tetrachloroethene	Chronic	1.00E-02	1.00E-02	Liver	1000/1	USEPA-IRIS, 2001
Trichloroethene	Chronic	6.00E-03	6.00E-03	NA	NA	USEPA-NCEA, 2001
Trichlorofluoromethane	Chronic	3.00E-01	6.90E-02	Whole body (increased mortality)	1000/1	USEPA-IRIS, 2001
Vinyl Chloride	Chronic	3.00E-03	3.00E-03	Liver	30/1	USEPA-IRIS, 2001

Table 2-3 (*continued*)
Non-Carcinogenic Toxicity Data Summary

Pathway: Inhalation					
Chemical of Concern	Chronic/ Subchronic	Inhalation RfC (mg/m^3)	Primary Target Organ	Combined Uncertainty/ Modifying Factors	Source/Date
Dioxin/Furan					
2,3,7,8-TCDD	Chronic	NTV	---	---	---
Explosive					
RDX	Chronic	0.0005	NA	NA	TCEQ, 2001
Metals					
Aluminum	Chronic	0.0035	NA	NA	USEPA-NCEA, 2001
Antimony	Chronic	0.0005	Pulmonary toxicity, chronic interstitial inflammation	300/1	TCEQ, 2001
Barium	Chronic	0.00049	Fetus developmental effects	1000/1	USEPA-HEAST, 1997
Beryllium	Chronic	0.00002	Lungs	10/1	USEPA-IRIS, 2001
Cadmium	Chronic	0.0002	NA	NA	USEPA-NCEA, 2001
Chromium	Chronic	0.0001	NA	NA	TCEQ, 2001
Manganese	Chronic	0.00005	Impairment of neurobehavioral function	1000/1	USEPA-IRIS, 2001
Mercury	Chronic	0.0003	Hand tremor, memory loss	30/1	USEPA-IRIS, 2001
Nickel	Chronic	0.0002	Respiratory effects	NA	ATSDR, 1997
Silver	Chronic	0.00001	NA	NA	TCEQ, 2001
Strontium	Chronic	NTV	---	---	---
Thallium	Chronic	0.0001	NA	NA	TCEQ, 2001
Vanadium	Chronic	0.00005	NA	NA	TCEQ, 2001
Non-Metallic Anion					
Perchlorate	Chronic	NTV	---	---	---
Pesticides					
Aldrin	Chronic	NTV	---	---	---
alpha-BHC	Chronic	NTV	---	---	---
beta-BHC	Chronic	NTV	---	---	---
delta-BHC	Chronic	NTV	---	---	---
Semivolatile Organics					
2,4-Dinitrotoluene	Chronic	0.00015	NA	NA	TCEQ, 2001
Benzo(a)anthracene	Chronic	NTV	---	---	---
Benzo(a)pyrene	Chronic	NTV	---	---	---
Benzo(b)fluoranthene	Chronic	NTV	---	---	---
Benzo(k)fluoranthene	Chronic	NTV	---	---	---
Bis(2-ethylhexyl)phthalate	Chronic	NTV	---	---	---
Dibenzo(a,h)anthracene	Chronic	NTV	---	---	---
Indeno(1,2,3-cd)pyrene	Chronic	NTV	---	---	---
Volatile Organics					
Methylene chloride	Chronic	3	Liver	100/1	USEPA-HEAST, 1997
Tetrachloroethene	Chronic	0.49	NA	NA	USEPA-NCEA, 2001
Trichloroethene	Chronic	NTV	---	---	---
Trichlorofluoromethane	Chronic	0.7	Whole Body	1000/1	USEPA-HEAST, 1997
Vinyl Chloride	Chronic	0.1	Liver	30/1	USEPA-IRIS, 2001

Table 2-3 (*continued*)
Non-Carcinogenic Toxicity Data Summary

Notes

---: No information for a compound with no toxicity value (NTV)
BHC: benzenehexachloride (hexachlorocyclehexane)
CNS: Central nervous system
GIT: Gastrointestinal tract
IRIS: Integrated Risk Information System, USEPA
mg/kg-day: milligrams per kilogram per day
mg/m^3: milligrams per cubic meter
NA: Information not available
NTV: No toxicity value available
RDX: 1,3,5-Trinitroperhydro-1,3,5-triazine
RfC: Reference concentration
RfD: Reference dose

References

Agency for Toxic Substances and Disease Registry (ATSDR), 1997, Minimal Risk Levels (MRLs) for Hazardous Substances.

Jacobs Engineering Group, Inc. (Jacobs), 2003, *Final Baseline Human Health and Screening Ecological Risk Assessment for the Group 4 Sites (Sites 04, 08, 35A, 35B, 35C, 46, 47, 48, 50, 60, 67, Goose Prairie Creek, Saunders Branch, Central Creek, and Caddo Lake), Longhorn Army Ammunition Plant, Karnack, Texas*, Final, Oak Ridge, TN, June.

Texas Commission on Environmental Quality (TCEQ), 2001. Update to 1998 Consistency Memorandum. Toxicity Factors Table, 15 March, 2001.

U.S. Environmental Protection Agency (USEPA), 1998. *Perchlorate Environmental Contamination Toxicological Review and Risk Characterization based on Emergency Information*, Review Draft, Office of Research and Development. NCEA-1-0503, 31 December, 1998.

USEPA-HEAST, 1997. Health Effects Summary Table (HEAST). FY 1995, Annual Office of Emergency and Remedial Response. Washington, D.C. EPA/340/R-95-036.

USEPA-IRIS, 2001. Integrated Risk Information System. United States Environmental Protection Agency Online Database for Toxicity Information on Hazardous Chemicals, 2001.

USEPA-NCEA, 2001. USEPA Region 3 Risk-Based Concentration Tables (5/8/2001). Referenced values from National Center for Environmental Assessment (NCEA).

Summary of Toxicity Assessment

This table provides non-carcinogenic risk information relevant to the contaminants of concern in both soil and groundwater. The list of chemicals of potential concern presented here are the ones that were quantitatively evaluated for carcinogenic risk and non-carcinogenic hazard in the Baseline Human Health Risk Assessment (Jacobs, 2003). The uncertainty factor and modifying factor are used in the development of a references dose. The uncertainty factor adjusts results from dose-response studies in animals to make them applicable to humans. The modifying factor is used to account for uncertainties in the available toxicity data from which the reference dose is derived. In the risk assessment, the reference doses and concentrations were for the chronic case, to be conservative.

Table 2-4
Risk Characterization Summary – Carcinogens

Scenario Timeframe: Future
Receptor Population: Maintenance Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogen Risk			
				Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil (0 to 2 feet)	Soil and particulates	Incidental ingestion, inhalation of particulates, and dermal contact	*Dioxin/Furan*				
			2,3,7,8-TCDD	2.2E-07	7.4E-12	8.5E-08	3.1E-07
			Metals				
			Cadmium	NTV	6.8E-10	NTV	6.8E-10
			Semivolatile Organics				
			Benzo(a)anthracene	5.9E-07	1.1E-14	5.5E-07	1.1E-06
			Benzo(a)pyrene	5.4E-06	9.8E-14	5.0E-06	1.0E-05
			Benzo(b)fluoranthene	1.1E-06	2.1E-11	1.1E-06	2.2E-06
			Benzo(k)fluoranthene	9.7E-09	1.8E-13	9.0E-09	1.9E-08
			Dibenzo(a,h)anthracene	9.7E-07	1.8E-14	9.1E-07	1.9E-06
			Indeno(1,2,3-cd)pyrene	4.1E-07	7.4E-15	3.8E-07	7.9E-07
						Soil risk total =	1.7E-05
Groundwater	Groundwater	Ingestion or exposure through showering	*Dioxin/Furan*				
			2,3,7,8-TCDD	3.3E-06	NE	2.8E-05	3.1E-05
			Explosives				
			RDX	1.2E-07	NE	NE (Kp<=0.01)	1.2E-07
			Pesticides				
			Aldrin	3.7E-07	NE	NE (Kp<=0.01)	3.7E-07
			alpha-BHC	1.7E-07	NE	2.1E-08	1.9E-07
			beta-BHC	3.4E-08	NE	4.6E-09	3.9E-08
			delta-BHC	2.9E-08	NE	4.7E-09	3.4E-08
			Semivolatile Organics				
			2,4-Dinitrotoluene	1.7E-07	NE	NE (Kp<=0.01)	1.7E-07
			Bis(2-ethylhexyl)phthalate	1.3E-06	NE	8.6E-07	2.2E-06
			Volatile Organics				
			Methylene chloride	3.7E-08	4.0E-08	NE (Kp<=0.01)	7.7E-08
			Tetrachloroethene	4.4E-07	8.5E-11	1.7E-06	2.2E-06
			Vinyl Chloride	3.7E-06	3.8E-07	NE (Kp<=0.01)	4.1E-06
						Groundwater risk total =	4.0E-05
						Total risk (soil and groundwater) =	5.7E-05

Table 2-4 (*continued*)
Risk Characterization Summary – Carcinogens

Notes

BHC	benzenehexachloride (hexachlorocyclehexane)
Kp	Dermal permeability coefficient
NE	Not evaluated through this exposure pathway. Chemical is not identified as volatile.
NE(Kp<=0.01)	Based on USEPA Region 6 guidance, COPCs with a Kp<=0.01 were not evaluated for dermal contact while showering (USEPA, 1995)
NTV	No toxicity value available to quantitatively address this exposure
RDX	1,3,5-Trinitroperhydro-1,3,5-triazine
TCDD	Tetrachlorodibenzo-p-dioxin

References

U.S. Environmental Protection Agency (USEPA), *National Oil and Hazardous Substances Pollution Contingency Plan, Final Rule, 40 CFR Part 300*, March 8, 1990.

USEPA, *Supplemental Region VI Risk Assessment Guidance, May 5, 1995*.

Summary of Risk Characterization

The table provides risk estimates for the significant routes of exposure at LHAAP-46. These risk estimates are based on a reasonable maximum exposure and were developed by taking into account various conservative assumptions about the frequency and duration of a hypothetical future maintenance worker's exposure to soil and groundwater, as well as the toxicity of the chemicals of concern. The total risk from exposure to contaminated soil and groundwater at this site is estimated to be 5.7E-05. A risk below 10^{-4} is generally considered to be acceptable (USEPA, 1990). The soil and groundwater risks are acceptable.

Table 2-5
Risk Characterization Summary – Non-Carcinogens

Scenario Timeframe: Future
Receptor Population: Maintenance Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Non-Carcinogenic Hazard Quotient			
					Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil (0 to 2 feet)	Soil and particulates	Incidental ingestion, inhalation of particulates, dermal contact	*Metals*					
			Aluminum	N/A	7.9E-03	3.4E-04	5.1E-03	1.3E-02
			Antimony	Blood	1.0E-02	1.2E-06	4.3E-03	1.5E-02
			Barium	Kidney	2.9E-02	6.2E-04	2.6E-02	5.6E-02
			Cadmium	Kidney	7.0E-03	5.3E-06	1.8E-03	8.8E-03
			Manganese	CNS	5.3E-03	7.5E-04	5.6E-03	1.2E-02
			Mercury	Immune system	1.8E-03	2.8E-07	1.7E-03	3.5E-03
			Vanadium	N/A	4.0E-03	8.5E-05	9.9E-03	1.4E-02
							Soil Hazard Index Total =	1.2E-01
Groundwater	Groundwater	Ingestion or exposure through showering	*Explosives*					
			RDX	Prostate	1.0E-03	NE	NE (Kp<=0.01)	1.0E-03
			Metals					
			Aluminum	N/A	7.8E-01	NE	NE (Kp<=0.01)	7.8E-01
			Antimony	Blood	1.5E+00	NE	NE (Kp<=0.01)	1.5E+00
			Barium	Kidney	5.2E-01	NE	NE (Kp<=0.01)	5.2E-01
			Beryllium	Small intestine	3.7E-01	NE	NE (Kp<=0.01)	3.7E-01
			Cadmium	Kidney	3.9E-01	NE	NE (Kp<=0.01)	3.9E-01
			Chromium	N/A	3.1E-02	NE	NE (Kp<=0.01)	3.1E-02
			Manganese	CNS	1.4E+00	NE	NE (Kp<=0.01)	1.4E+00
			Nickel	Body weight	5.8E-01	NE	NE (Kp<=0.01)	5.8E-01
			Silver	Argyria	2.3E-01	NE	NE (Kp<=0.01)	2.3E-01
			Strontium	Bone	2.0E-01	NE	NE (Kp<=0.01)	2.0E-01
			Thallium	Blood	2.4E+01	NE	NE (Kp<=0.01)	2.4E+01
			Vanadium	N/A	2.0E-01	NE	NE (Kp<=0.01)	2.0E-01
			Non-Metallic Anion					
			Perchlorate	N/A	3.3E-01	NE	NE (Kp<=0.01)	3.3E-01
			Pesticides					
			Aldrin	Liver	2.1E-03	NE	NE (Kp<=0.01)	2.1E-03
			alpha-BHC	N/A	9.3E-06	NE	1.20E-06	1.0E-05
			delta-BHC	N/A	1.5E-04	NE	2.50E-05	1.7E-04
			Semivolatile Organics					
			2,4-Dinitrotoluene	CNS	3.6E-04	NE	NE (Kp<=0.01)	3.6E-04
			Bis(2-ethylhexyl)phthalate	Liver	1.3E-02	NE	8.60E-03	2.2E-02
			Volatile Organics					
			Methylene chloride	Liver	2.3E-04	8.0E-05	NE (Kp<=0.01)	3.1E-04
			Tetrachloroethene	Liver	2.3E-03	8.4E-04	9.4E-03	1.3E-02
			Trichlorofluoromethane	Whole body	6.8E-05	5.1E-04	4.4E-04	1.0E-03

Table 2-5 (*continued*)
Risk Characterization Summary – Non-Carcinogens

Scenario Timeframe: Future
Receptor Population: Maintenance Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Non-Carcinogenic Hazard Quotient			
					Ingestion	Inhalation	Dermal	Exposure Routes Total
			Vinyl Chloride	Liver	2.3E-03	1.2E-03	NE (Kp<=0.01)	3.5E-03
							Groundwater Hazard Index Total =	31
							Receptor Hazard Total (soil and groundwater) =	31
							Liver Hazard Total =	4.1E-02

Notes

BHC	benzenehexachloride (hexachlorocyclehexane)
CNS	Central nervous system
Kp	Dermal permeability coefficient
N/A:	Information was not available
NE	Not evaluated through this exposure pathway
NE (Kp<=0.01)	Based on USEPA Region 6 guidance, chemicals of potential concern with a Kp<=0.01 were not evaluated for dermal contact while showering (USEPA, 1995)
RDX	1,3,5-Trinitroperhydro-1,3,5-triazine

References

U.S. Environmental Protection Agency (USEPA), 1989, *Risk Assessment Guidance for Superfund, Vol. I: Human Health Evaluation Manual, (Part A)*, EPA/540/1-89/002, December.

USEPA, *Supplemental Region 6 Risk Assessment Guidance*, May 5, 1995.

Summary of Risk Characterization

The table provides hazard quotients (HQs) for each route of exposure and the hazard index (sum of hazard quotients) for all routes of exposure for LHAAP-46. The Risk Assessment Guidance for Superfund (USEPA, 1989) states that, generally, a hazard index (HI) greater than 1 indicates the potential for adverse non-carcinogenic effects. The estimated HI of 31 for groundwater indicates that the potential for adverse non-carcinogenic effects could occur from exposure to contaminants in that medium; the components having HQs greater than 1 are thallium, antimony, and manganese. The non-carcinogenic risk from exposure to trichloroethene in groundwater could not be evaluated due to the lack of non-carcinogenic toxicity criteria for trichloroethene. The estimated HI of 0.12 for soil is acceptable.

Table 2-6
Chemicals of Potential Concern in Groundwater

Chemical	Maximum Detected Concentration (µg/L)	Chemical Hazard Quotient	MCL (µg/L)	Retained as Chemical of Concern
Aluminum	80,000	0.78	--	No – Note 1
Antimony	63	1.5	6	No – Note 2
Arsenic	20	--	10	No – Note 2
Barium	1,400	0.20	2,000	No – Note 2
Beryllium	76	0.37	4	No – Note 2
Cadmium	20	0.39	5	No – Note 2
Chromium	4,700	0.03	100	No – Note 3
Lead	673	--	15	No – Note 2
Manganese	6,500	1.4	--	No – Note 4
Nickel	3,670	0.58	--	No – Note 3
Silver	120	0.23	--	No – Note 2
Strontium	12,000	0.20	--	No – Note 5
Thallium	200	24	2	No – Note 4
Vanadium	140	0.20	--	No – Notes 2 and 5
TCE	85.5	--	5	Yes
bis(2-ethylhexyl)phthalate	27	0.02	6	No – Note 6
Perchlorate	47.9	0.33	--	No – Note 2

Notes and Abbreviations:

1 – Elevated concentration in samples due to suspended particles from sampling techniques (low flow techniques not used)
2 – Recent samples do not have elevated concentration
3 – Elevated concentration due to suspended particles from well corrosion
4 – Chemical is naturally occurring
5 – Contribution to hazard index low
6 – Chemical detected in laboratory blank

-- *No chemical hazard quotient or no MCL available for the chemical*
MCL *Federal Safe Drinking Water maximum contaminant level*
TCE *trichloroethene*
µg/L *micrograms per liter*

Table 2-7
Chemicals of Concern in Groundwater and Cleanup Levels

Chemical	MCL (µg/L)	Note
Trichloroethene (TCE)	5	Retained as chemical of concern
cis-1,2-dichloroethene (DCE)	70	TCE daughter product
Vinyl chloride (VC)	2	DCE daughter product

Notes and Abbreviations:

MCL *Federal Safe Drinking Water maximum contaminant level*
µg/L *micrograms per liter*

Table 2-8
Comparative Analysis of Alternatives

Criteria	Alternative 1 No Action	Alternative 2 Monitored Natural Attenuation and Land Use Control	Alternative 3 In Situ Bioremediation, Monitored Natural Attenuation, and Land Use Control
Overall protection of human health and the environment	No active reduction in risk to a hypothetical future maintenance worker from contaminated groundwater (ingestion, contact when used as shower water, inhalation of volatiles when used as shower water).	Achieves RAOs. MNA would verify that groundwater was being attenuated to the MCLs. LUC would provide protection of human health until MCLs are achieved and the LUC becomes unnecessary.	Achieves RAOs. ISB and MNA would restore groundwater to the MCLs. LUC would provide protection of human health until MCLs are achieved and the LUC becomes unnecessary.
Compliance with ARARs	Possible that it would meet MCLs in an estimated 23 years by (unmonitored) natural attenuation, but this would be unverifiable without monitoring. No location-specific ARARs. Action-specific ARARs would not apply.	Would meet MCLs in an estimated 23 years to satisfy chemical-specific ARAR. No location-specific ARARs. Would meet action-specific ARARs for any wastes generated.	Would meet MCLs in an estimated 15 years to satisfy chemical-specific ARAR. No location-specific ARARs. Would meet action-specific ARARs for any wastes generated or wells constructed or abandoned.
Long-term effectiveness and permanence	Natural attenuation would occur, but its progress would be unverified by monitoring. No evaluation of natural attenuation's long-term effectiveness and permanence.	MNA would verify permanent reduction of contaminant levels in the groundwater over time. LUC would be effective and reliable so long as it is maintained until natural attenuation processes reduce groundwater contaminant levels to the MCLs.	Should be effective and permanent; however, some uncertainty exists regarding the ability of in-situ bioremediation to effectively reduce concentrations further and enhance natural attenuation; therefore further evaluation would be required. LUC would be effective and reliable so long as it is maintained until natural attenuation processes reduce groundwater contaminant levels to the MCLs.
Reduction of toxicity, mobility, or volume through treatment	No active reduction.	No active reduction.	Active treatment with ISB.
Short-term effectiveness	Continued risk to community through no action. No risk to workers. No impact to the environment.	Minimal impact to the community and the environment from short-term activities; installation of potable wells would be prohibited within the area protected by the LUC. Some potential short-term risks to workers associated with exposure to contaminated groundwater.	Minimal impact to the community and the environment from short-term activities; installation of potable wells would be prohibited within the area protected by the LUC. Some potential short-term risks to workers associated with exposure to contaminated groundwater and operation of drilling/construction equipment.

Table 2-8 (*continued*)
Comparative Analysis of Alternatives

Criteria	Alternative 1 No Action	Alternative 2 Monitored Natural Attenuation and Land Use Control	Alternative 3 In Situ Bioremediation, Monitored Natural Attenuation, and Land Use Control
Implementability	Readily implemented; no construction or operation. May require ROD amendment if future problems arise. No monitoring to verify that natural attenuation is in progress and that the plume is not migrating. No special materials or technology required.	Readily implemented. No construction. May require ROD amendment if a more active treatment is required (i.e., ISB). Regular monitoring to verify that MNA is effective and that the plume is not migrating. No special materials or technology required.	Involves common drilling work and possibly well construction. Treatability study may be necessary to verify that ISB is effective for the site conditions. Regular monitoring to verify that ISB is effective. Nutrients and microbes for ISB are commercially available.
Cost • Capital present worth • O&M present worth • Total present worth	 $0 $0 $0	 $60,500 $460,700 $521,200	 $379,000 $365,000 $744,000
State Acceptance	Not acceptable. Not protective of human health and the environment.	Acceptable	Acceptable
Community Acceptance	Not acceptable	Acceptable with reservations because of the proximity of the plume to drinking water wells outside LHAAP. Well proximity in relation to the plume was discussed in the March 9, 2010 public meeting.	Acceptable

Notes and Abbreviations:

ARAR applicable or relevant and appropriate requirement
ISB in situ bioremediation
LUC land use control
MCL maximum contaminant level
MNA monitored natural attenuation
O&M operation and maintenance
RAO remedial action objective

Table 2-9
Remediation Cost Table
Selected Remedy (Alternative 2)
Present Worth Analysis

Year	Fiscal Year	Capital Costs	Operation & Maintenance Costs			Present Value		
			MNA	Monitoring	Total	Discount Rate	Capital	O&M
						2.8%		
1	2010	$60,513	$55,833		$55,833	NPV	$60,514	$460,689
2	2011	0	$55,833		$55,833			
3	2012	0		$31,185	$31,185		Total Present Value	$521,203
4	2013	0		$26,811	$26,811			
5	2014	0		$69,336	$69,336			
6	2015	0		$16,674	$16,674			
7	2016	0		$16,674	$16,674			
8	2017	0		$16,674	$16,674			
9	2018	0		$16,674	$16,674			
10	2019	0		$59,199	$59,199			
11	2020	0			0			
12	2021	0			0			
13	2022	0			0			
14	2023	0			0			
15	2024	0		$59,199	$59,199			
16	2025	0			0			
17	2026	0			0			
18	2027	0			0			
19	2028	0			0			
20	2029	0		$59,199	$59,199			
21	2030	0			0			
22	2031	0			0			
23	2032	0			0			
24	2033	0			0			
25	2034	0		$59,199	$59,199			
26	2035	0			0			
27	2036	0			0			
28	2037	0			0			
29	2038	0			0			
30	2039	0		$59,199	$59,199			
		$60,513	$111,666	$490,018	$601,684			

Notes

MNA monitored natural attenuation
O&M operation & maintenance
VOC volatile organic compounds

Major assumptions are as described below. Quantities and assumptions are for cost estimating purposes only.

Capital costs include: 1) Allowance for legal fees, administration controls, and documentation; 2) Establishment of a database, licenses, and work plans.

Monitoring costs are based on the assumption that 8 wells are sampled in each sampling event. The frequency of sampling events is in accordance with the frequency described in the Record of Decision. In Years 1, 2, and 3, the samples are analyzed for VOCs and MNA parameters. Subsequent years are analyzed for VOCs only. Five-year reviews are conducted in Years 5, 10, 15, 20, 25, and 30.

The discount rate of 2.8% is based on the Office of Management and Budget Circular No. A-94, January 2008.

Table 2-10
Description of ARARs for Selected Remedy

Citation	Activity or Prerequisite/Status	Requirement
Groundwater		
Federal Safe Drinking Water Act Maximum Contaminant Levels (MCLs)	Applicable to drinking water at the tap—**relevant and appropriate** for water that could potentially be used for human consumption	Water designated as a current or potential source of drinking water must not exceed drinking water standard. The daughter products of TCE are cis-1,2-DCE and VC. The MCLs for TCE, cis-1,2-DCE, and VC are 5, 70, and 2 µg/L, respectively.
Waste Generation, Management, and Storage		
Characterization of Solid Waste 40 CFR 262.11 30 TAC 335.62 30 TAC 335.504 30 TAC 335.503(a)(4)	Generation of solid waste, as defined in 30 TAC 335.1—**applicable**.	Must determine whether the generated solid waste is RCRA hazardous waste by using prescribed testing methods or applying generator knowledge based on information regarding material or process used. If the waste is determined to be hazardous, it must be managed in accordance with 40 CFR 262–268. After making the hazardous waste determination as required, if the waste is determined to be nonhazardous, the generator shall then classify the waste as Class 1, Class 2, or Class 3 (as defined in Section 335.505 through Section 335.507) using one or more of the methods listed in Section 335.503(a)(4) and Section 335.508 and manage the waste in accordance with the requirements of Chapter 335 of the TAC for industrial solid waste.
Characterization of Hazardous Waste 40 CFR 264.13(a)(1); 40 CFR 268.7 30 TAC 335.504(3) 30 TAC 335.509 30 TAC 335.511	Generation of a RCRA hazardous waste for treatment, storage, or disposal—**applicable** if hazardous waste is generated (e.g., personal protective equipment [PPE]).	Must obtain a detailed chemical and physical analysis of a representative sample of the waste(s) that at a minimum contains all the information that must be known to treat, store, or dispose of the waste in accordance with 40 CFR 264 and 268. Must also determine whether the waste is restricted from land disposal under 40 CFR 268 et seq. by testing in accordance with prescribed methods or use of generator knowledge of waste.
Management of RCRA Hazardous Waters—Wastewater Treatment Unit Exclusion 40 CFR 264.1(g)(6) 40 CFR 270.1(c)(2) 30 TAC 335.41(d)(1)	Treatment/disposal of wastewater containing RCRA hazardous waste—**applicable** to management of contaminated groundwater if it is determined to contain RCRA characteristically hazardous waste.	On-site wastewater treatment units, as defined in 40 CFR 260.10, that are part of a wastewater treatment facility subject to regulation under Section 402 or Section 307(b) of the CWA are excluded from the requirements of RCRA Subtitle C (Note: USEPA has clarified that this exemption applies to all tank systems, conveyance systems, and ancillary equipment, including transfer trucks, associated with the wastewater treatment unit [53 FR 34079, September 2, 1988]).
Requirements for Temporary Storage of Hazardous Waste in Accumulation Areas 40 CFR 262.34(a) and (c)(1) 30 TAC 335.69(a) and (d)	On-site accumulation of 55 gallons or less of RCRA hazardous waste for 90 days or less at or near the point of generation—**applicable** if hazardous waste is generated (e.g., PPE) and stored in an accumulation area.	A generator may accumulate hazardous waste at the facility provided that • Waste is placed in containers that comply with 40 CFR 264.171 to 264.173 (Subpart I); and • Container is marked with the words "hazardous waste"; or • Container may be marked with other words that identify the contents.

Table 2-10 (*Continued*)
Description of ARARs for Selected Remedy

Citation	Activity or Prerequisite/Status	Requirement
Requirements for the Use and Management of Containers 40 CFR 264.171–264.173 30 TAC 335.69(e) 30 TAC 335.152(a)(7)	On-site storage/treatment of RCRA hazardous waste in containers for greater than 90 days—applicable if hazardous waste is generated (e.g., PPE) and is stored in containers.	Design and operating standards of 40 CFR 264.175(c) and 40 CFR 264.171, 264.172, and 264.173(a) and (b) must be met for the use and management of hazardous waste in containers.
Well Construction Standards—Monitoring or Injection Wells 16 TAC 76.1000	Construction of water wells—applicable to construction of new monitoring or injection wells, if needed.	Wells shall be completed in accordance with the technical requirements of Section 76.1000, as appropriate.
Well Construction Standards—Extraction Wells 16 TAC 76.1000(a) and (c) through (h) 16 TAC 76.1002(a) through (c) 16 TAC 76.1008(a) through (c)	Construction of water wells—applicable to construction of extraction (recovery) wells.	Wells shall be completed in accordance with the technical requirements of Section 76.1000, as appropriate. Water wells completed to produce undesirable water shall be cased to prevent the mixing of water or constituent zones. The annular space between the casing and the wall of the borehole shall be pressure grouted with cement or bentonite grout to the land surface. Bentonite grout may not be used if a water zone contains chloride water above 1500 ppm or if hydrocarbons are present. Wells producing undesirable water or constituents shall be completed in such a manner that will not allow undesirable fluids to flow onto the land surface. During installation of a water well pump, installer shall make a reasonable effort to maintain integrity of groundwater and to prevent contamination by elevating the pump column and fittings, or by other means suitable under the circumstances. Pump shall be constructed so that no unprotected openings into the interior of the pump or well casing exist.
Class V Injection Wells 30 TAC 331, Subchapters A,C and H	Installation, operation, and closure of injection wells fall in the category of Class V Injection Wells – relevant and appropriate.	Injection wells shall be constructed to the required specifications for isolation casing, surface completion, prevention of commingling, and confinement of undesirable groundwater to its zone of origin. Closure shall be accomplished by removing all of the removable casing and the entire well shall be pressure filled via a tremie pipe with cement from bottom to the land surface, or closure shall be performed by the alternative method for Class V Wells completed in zones of undesirable groundwater. Groundwater concentrations at time of well closure will determine the appropriate method of abandonment.

Table 2-10 (*Continued*)
Description of ARARs for Selected Remedy

Citation	Activity or Prerequisite/Status	Requirement
Treatment/Disposal		
Disposal of Wastewater (e.g., contaminated groundwater, dewatering fluids, decontamination liquids) 40 CFR 268.1(c)(4)(i) 30 TAC 335.431(c)	RCRA-restricted characteristically hazardous waste intended for disposal—applicable if extracted groundwater or rinsate from incinerator is determined to be RCRA characteristically hazardous .	Disposal is not prohibited if such wastes are managed in a treatment system subject to regulation under Section 402 of the CWA that subsequently discharges to waters of the United States.
Closure		
Standards for Plugging Wells that Penetrate Undesirable Water or Constituent Zones 16 TAC 76.1004(a) through (c)	Plugging and abandonment of wells—applicable to plugging and closure of monitoring and/or extraction wells.	If a well is abandoned, all removable casing shall be removed and the entire well pressure filled via a tremie pipe with cement from bottom up to the land surface. In lieu of this procedure, the well shall be pressure-filled via a tremie tube with bentonite grout of a minimum 9.1 lb/gal weight followed by a cement plug extending from land surface to a depth of not less than 2 feet. Undesirable water or constituents or the freshwater zone(s) shall be isolated with cement plugs.

Abbreviations

%	percent	LHAAP	Longhorn Army Ammunition Plant
µg/L	micrograms per liter	PPE	personal protective equipment
ARAR	applicable or relevant and appropriate requirement	ppm	part per million
CFR	Code of Federal Regulations	RCRA	Resource Conservation and Recovery Act of 1976
CWA	Clean Water Act of 1972	TAC	Texas Administrative Code
DCE	dichloroethene	TCE	trichloroethene
FR	Federal Register	USEPA	U.S. Environmental Protection Agency
FS	feasibility study	VC	vinyl chloride
lb/gal	pound per gallon		

Table 2-11
Cost and Effectiveness Data

	Alternative 1 No Action	Alternative 2 MNA and LUC	Alternative 3 ISB, MNA, and LUC
Present Worth Cost	$0	$521,200	$744,000
Incremental Cost	---	+$521,200	+$222,800
Long-Term Effectiveness and Permanence	Unmonitored and undocumented effectiveness and permanence	Effectiveness and permanence confirmed with monitoring	Effectiveness and permanence confirmed with monitoring
Reduction of Toxicity, Mobility, and Volume	Unmonitored and undocumented reduction	Reduction of COCs in groundwater to MCLs in 23 years	Reduction of COCs in groundwater to MCLs in 15 years
Short-Term Effectiveness	No short-term effectiveness, as the site will be left as-is	Immediate short-term effectiveness with LUC	Immediate short-term effectiveness with LUC
Cost-Effective	---	Yes	---

Notes

COC	chemical of concern
ISB	in situ bioremediation
LUC	land use control
MCL	maximum contaminant level
MNA	monitored natural attenuation

Cost Effectiveness Summary

The alternatives are shown from left to right in order of increasing cost. Incremental cost is the cost difference between the alternative in question and the alternative that is one step down in cost. The table focuses on the additional benefit gained from the incremental cost.

Alternative 2 is the most cost effective. It is anticipated to achieve an outcome similar to that of Alternative 3. Alternative 2 has a longer period of performance than Alternative 3, but has significant cost savings.

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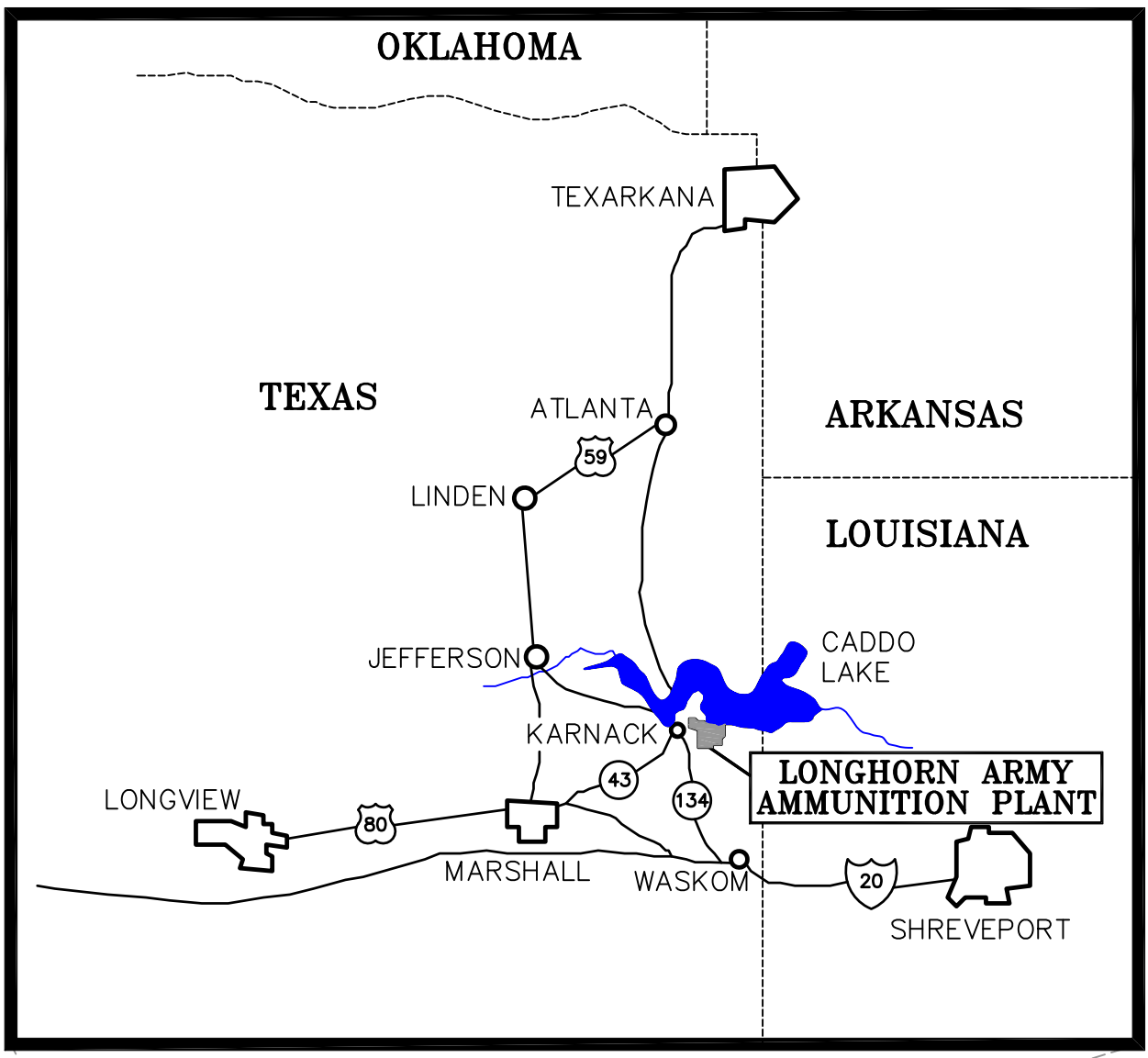
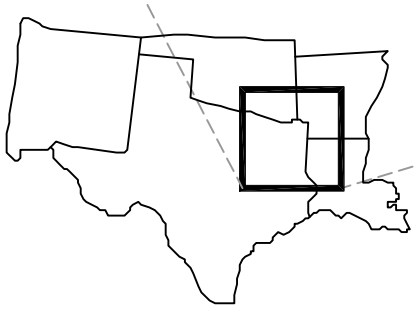




"DRAWING NOT TO SCALE"

IMAGE	X-REF	OFFICE	DRAWN BY		CHECKED BY		APPROVED BY		DRAWING NUMBER
---	---	Houston, Texas	L. JONES	12/17/03	G. JONES	10/07/09	P. SRIVASTAV	10/07/09	117591-A55

PLOT DATE: 10/07/09
FORMAT REVISION 3/25/99

Shaw

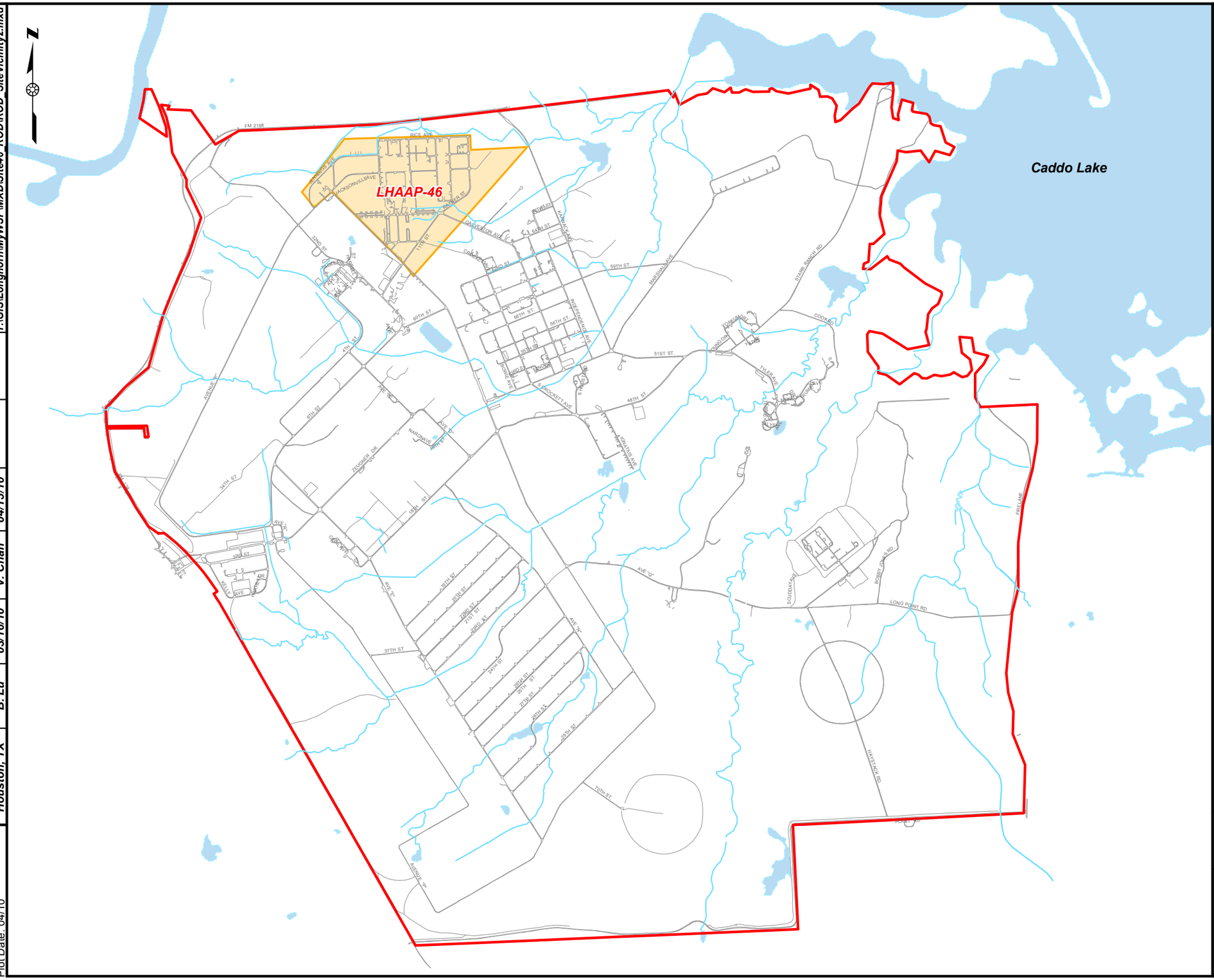
U.S. ARMY CORPS OF ENGINEERS
TULSA DISTRICT
TULSA, OKLAHOMA

FIGURE 2-1

LHAAP LOCATION MAP

LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

00098869



LEGEND

- Stream
- Road
- Site
- Lake
- LHAAP Boundary

OFFICE	DRAWN BY	CHECKED BY
Houston, TX	B. Lu 03/16/10	V. Chan 04/15/10

APPROVED BY

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Plot Date: 04/10

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TULSA DISTRICT
TULSA, OKLAHOMA

FIGURE 2-2

SITE VICINITY MAP
LHAAP-46, GROUP 4

LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

00098870

PLOT DATE: 04/27/10
FORMAT REVISION 5/13/02

IMAGE	X-REF	OFFICE	DRAWN BY		CHECKED BY		APPROVED BY		DRAWING NUMBER
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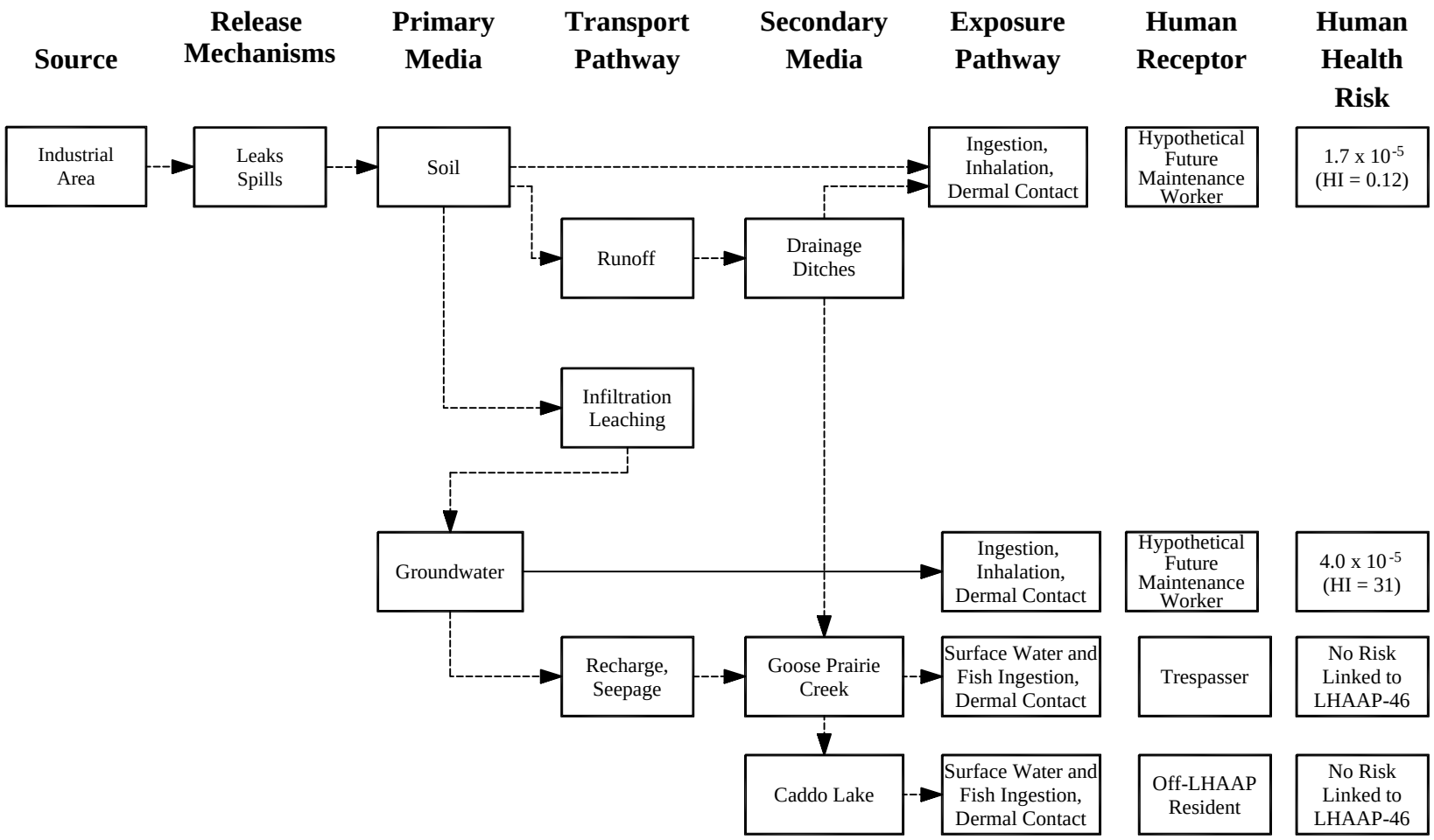

Pathway considered for remediation

Pathway *not* considered for remediation

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TULSA, OKLAHOMA

FIGURE 2-3
CONCEPTUAL SITE MODEL
LHAAP-46, GROUP 4
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

00098871

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APPROVED BY	
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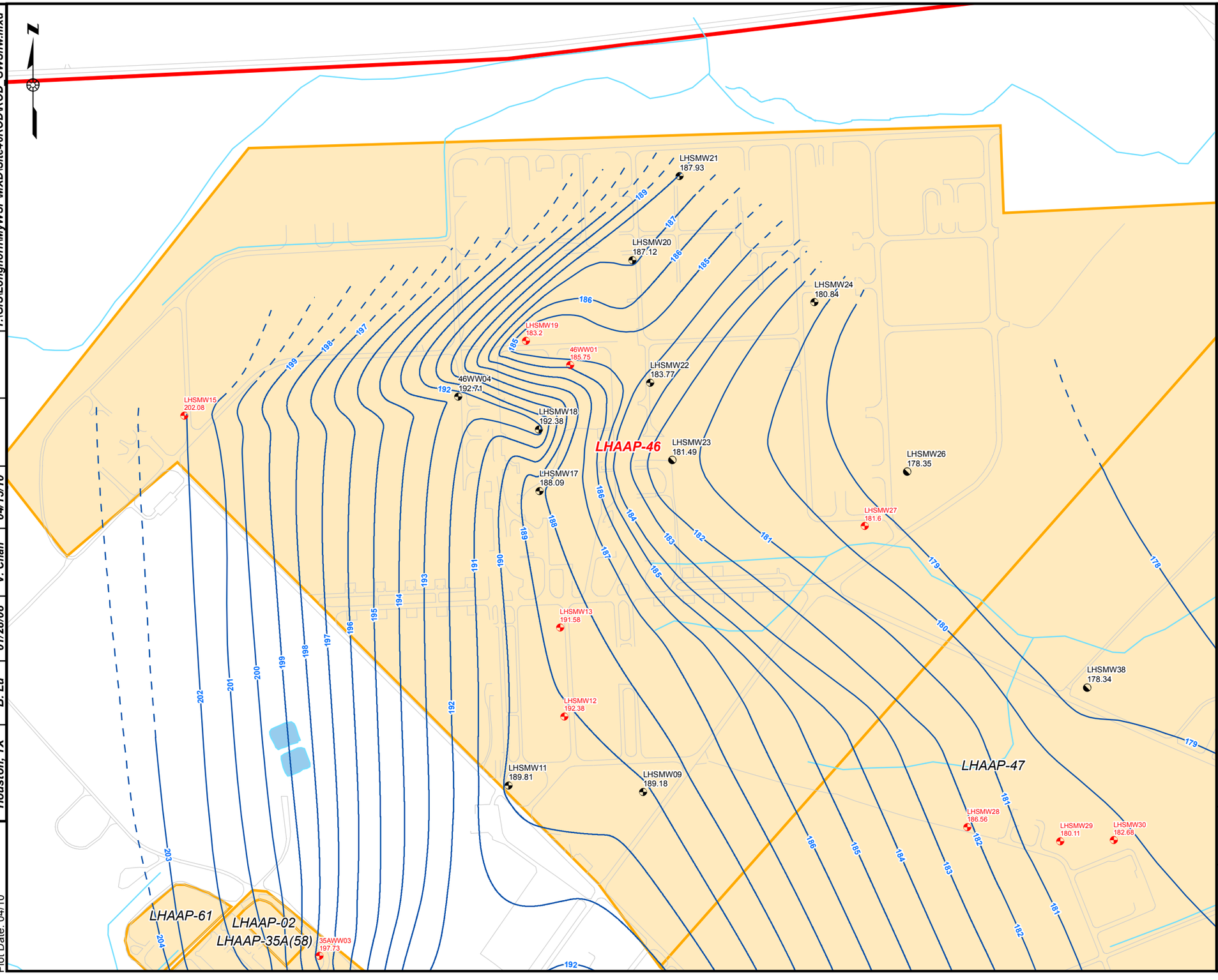
V. Chan	04/15/10
DRAWN BY	
B. Lu	01/28/08
OFFICE	
Houston, TX	



LEGEND

- Shallow Monitoring Well
- Shallow/Intermediate Monitoring Well
- Dry Shallow Monitoring Well (Elevation Represents Bottom of Well)
- Groundwater Elevation Contour
- Inferred Groundwater Elevation Contour
- Stream
- Road
- Approximate LHAAP Boundary
- Site

Notes:

1. Groundwater elevation measured on November 29 -- December 3, 2007.
2. Contours around LHSMW19 were based on the best assessment at the time of study.

0 200 400 800 Feet

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FIGURE 2-4

GROUNDWATER ELEVATION
CONTOUR MAP (SHALLOW ZONE)
LHAAP-46, GROUP 4

LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

Plot Date: 04/10

00098872

N

46WW05

LHSMW25
176.56

46WW02
180.11

46WW06

LHSMW23
181.49

LHAAP-46

LHSMW26
178.35

176

178

180

LHSMW38
178.34

LHSMW08
182.24

182

LHAAP-47

LHAAP-
61

LHAAP-02
LHAAP-35A(58)

LEGEND

- Shallow/Intermediate Monitoring Well
- Intermediate Monitoring well
- Groundwater Elevation Contour
- Inferred Groundwater Elevation Contour
- Stream
- Road
- Approximate LHAAP Boundary
- Site

Note:

Groundwater elevation measured on November 29 -- December 3, 2007.

0 200 400 800 Feet

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Houston, TX	B. Lu 01/28/08	V. Chan 03/16/10	

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Plot Date: 03/10

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TULSA, OKLAHOMA

FIGURE 2-5

GROUNDWATER ELEVATION
CONTOUR MAP (INTERMEDIATE ZONE)
LHAAP-46, GROUP 4

LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

00098873

FILE PATH	APPROVED BY	CHECKED BY
T:\GIS\LonghornMyWSP\MXD\Site46ROD\ROD_TCE_Shw.mxd		V. Chan 03/16/10

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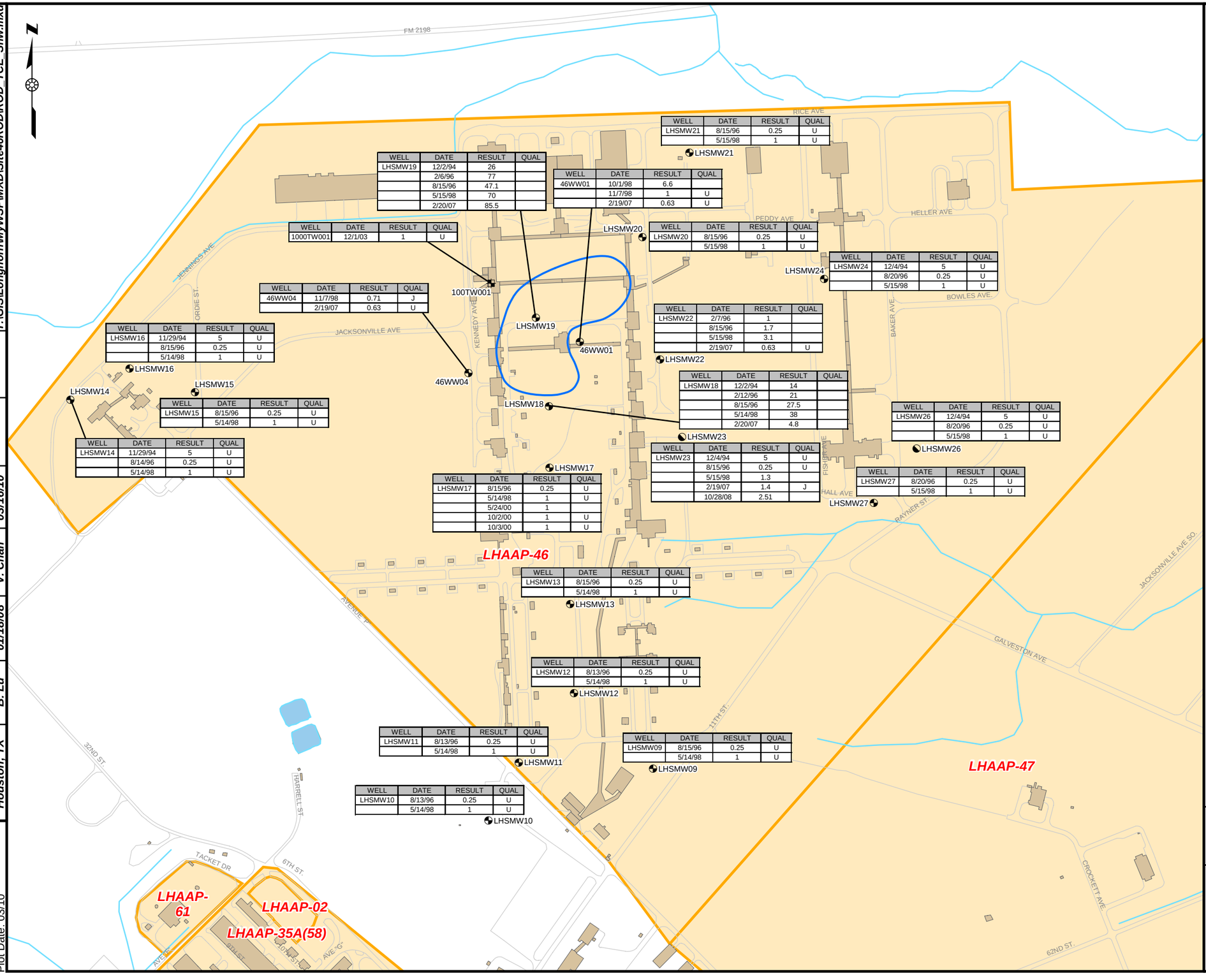
Houston, TX	B. Lu 01/18/08

Plot Date: 03/10



WELL	DATE	RESULT	QUAL
1000TW001	12/1/03	1	U

WELL	DATE	RESULT	QUAL
46WW01	10/1/98	6.6	
	11/7/98	1	U
	2/19/07	0.63	U

WELL	DATE	RESULT	QUAL
46WW04	11/7/98	0.71	J
	2/19/07	0.63	U

WELL	DATE	RESULT	QUAL
LHSMW09	8/15/96	0.25	U
	5/14/98	1	U

WELL	DATE	RESULT	QUAL
LHSMW10	8/13/96	0.25	U
	5/14/98	1	U

WELL	DATE	RESULT	QUAL
LHSMW11	8/13/96	0.25	U
	5/14/98	1	U

WELL	DATE	RESULT	QUAL
LHSMW12	8/13/96	0.25	U
	5/14/98	1	U

WELL	DATE	RESULT	QUAL
LHSMW13	8/15/96	0.25	U
	5/14/98	1	U

WELL	DATE	RESULT	QUAL
LHSMW14	11/29/94	5	U
	8/14/96	0.25	U
	5/14/98	1	U

WELL	DATE	RESULT	QUAL
LHSMW15	8/15/96	0.25	U
	5/14/98	1	U

WELL	DATE	RESULT	QUAL
LHSMW16	11/29/94	5	U
	8/15/96	0.25	U
	5/14/98	1	U

WELL	DATE	RESULT	QUAL
LHSMW17	8/15/96	0.25	U
	5/14/98	1	U
	5/24/00	1	
	10/2/00	1	U
	10/3/00	1	U

WELL	DATE	RESULT	QUAL
LHSMW18	12/2/94	14	
	2/12/96	21	
	8/15/96	27.5	
	5/14/98	38	
	2/20/07	4.8	

WELL	DATE	RESULT	QUAL
LHSMW19	12/2/94	26	
	2/6/96	77	
	8/15/96	47.1	
	5/15/98	70	
	2/20/07	85.5	

WELL	DATE	RESULT	QUAL
LHSMW20	8/15/96	0.25	U
	5/15/98	1	U

WELL	DATE	RESULT	QUAL
LHSMW21	8/15/96	0.25	U
	5/15/98	1	U

WELL	DATE	RESULT	QUAL
LHSMW22	2/7/96	1	
	8/15/96	1.7	
	5/15/98	3.1	
	2/19/07	0.63	U

WELL	DATE	RESULT	QUAL
LHSMW23	12/4/94	5	U
	8/15/96	0.25	U
	5/15/98	1.3	
	2/19/07	1.4	J
	10/28/08	2.51	

WELL	DATE	RESULT	QUAL
LHSMW24	12/4/94	5	U
	8/20/96	0.25	U
	5/15/98	1	U

WELL	DATE	RESULT	QUAL
LHSMW26	12/4/94	5	U
	8/20/96	0.25	U
	5/15/98	1	U

WELL	DATE	RESULT	QUAL
LHSMW27	8/20/96	0.25	U
	5/15/98	1	U

LEGEND

- Shallow Monitoring Well
- Shallow/Intermediate Monitoring Well
- Temporary Monitoring Well
- 2007 TCE Plume (5 µg/L)
- Stream
- Road
- Former Building or Concrete Slab
- Site

Note:

1. Sampling results reported in micrograms per liter (µg/L).

0 200 400 800 Feet

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FIGURE 2-6

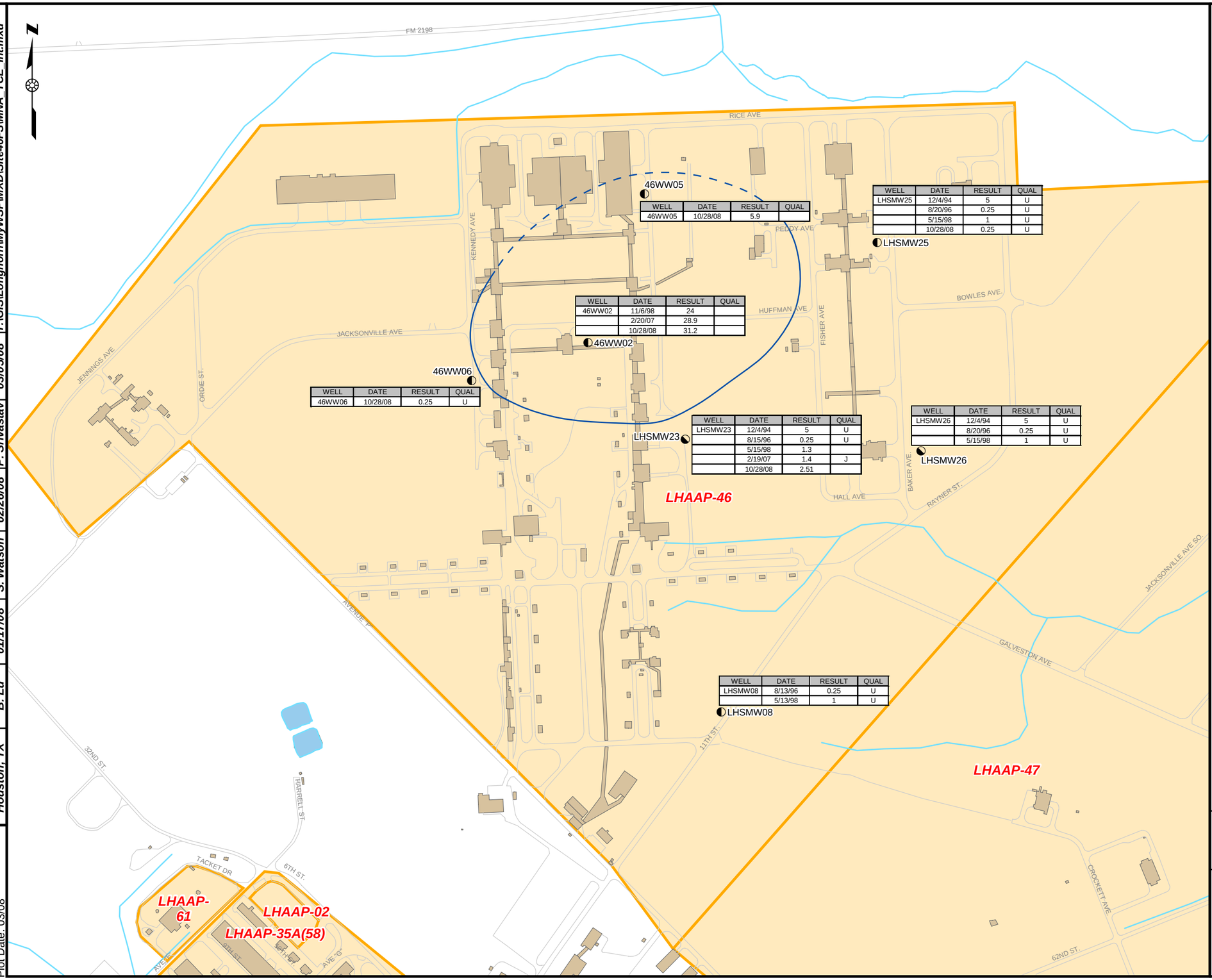
TCE IN SHALLOW ZONE
LHAAP-46, GROUP 4

LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

00098874

FILE PATH	T:\GIS\Longhorn\MyWSP\MXD\Site46FS\MNA_TCE_Int.mxd
APPROVED BY	P. Srivastav 03/05/08
CHECKED BY	S. Watson 02/26/08
DRAWN BY	B. Lu 01/17/08
OFFICE	Houston, TX

Plot Date: 03/08



LEGEND

- Shallow/Intermediate Monitoring Well
- Intermediate Monitoring Well

TCE Plumes (5 µg/L)

- 2008
- 2008 (Inferred)
- Stream
- Road
- Former Building or Concrete Slab
- Site

Note:

1. Sampling results reported in micrograms per liter (µg/L).

0 200 400 800 Feet

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FIGURE 2-7

TCE IN INTERMEDIATE ZONE
LHAAP-46, GROUP 4

LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

3.0 Responsiveness Summary

The Responsiveness Summary serves three purposes. First, it provides the U .S. Army, USEPA, and TCEQ with information about community concerns with the preferred alternative at LHAAP-46 as presented in the Proposed Plan. Second, it shows how the public's comments were considered in the decision-making process for selection of the remedy. Third, it provides a formal mechanism for the U.S. Army to respond to public comments.

The U.S. Army, USEPA, and TCEQ provide information regarding LHAAP-46 through public meetings, the Administrative Record file for the facility, and announcements published in the Shreveport Times and Marshall News Messenger newspapers. **Section 2.3** discusses community participation on LHAAP-46, including the dates for the public comment period, the date, location, and time of the public meetings, and the location of the Administrative Record. The following documents related to community involvement were added to the Administrative Record:

- Transcript of the public meeting on March 9, 2010
- Presentation slides from the March 9, 2010 public meeting
- Questions and comments from the public during the public comment period, and the response to comments from the U.S. Army dated June 4, 2010.

3.1 Stakeholder Issues and Lead Agency Responses

This section summarizes and responds to significant issues raised by stakeholders, including the public and community groups, received in written or verbal form. These concerns were addressed by the U.S. Army in the public meetings as much as possible as well as in the U.S. Army's response to comments available in the Administrative Record. The questions and comments from the public shown below may have been summarized.

Question/comment: What is the rationale behind the choice of Alternative 2 (MNA) over Alternative 3 (in situ bioremediation)? How do you know the plume is stable?

Response: The success of meeting the RAOs with Alternative 2 is ensured in several ways: 1) findings from past site investigations, 2) the monitoring program that is to be implemented, and 3) the inclusion of the contingency remedy to address uncertainties. The basis for presenting MNA as a suitable remedy for LHAAP-46 is the Preliminary Evaluation of Natural Attenuation, which is Appendix A of the FS (Shaw, 2009). The evaluation evaluated evidence of ongoing natural attenuation in accordance with USEPA guidelines (USEPA, 1998). It concluded that natural attenuation was at work and could be anticipated to degrade COC concentrations to the

cleanup levels. The evaluation of MNA will continue as the monitoring program provides new data. For 2 years, sampling will occur quarterly. Provided that MNA is satisfactory as described in **Section 2.12.2**, sampling will occur semiannually for the next 3 years. In subsequent years, sampling will occur annually until the next CERCLA five-year review for LHAAP sites. Then, sampling will occur every 5 years, on the same schedule as the other LHAAP CERCLA five-year reviews. To address the uncertainty of natural attenuation, a contingency remedy is included in the remedy. The contingency remedy would implement in situ bioremediation at the site if MNA performance is not satisfactory. The decision on whether MNA has been successful will be made after 2 years of MNA, when results will be available for the 8 quarterly sampling events and a performance evaluation is conducted. The specific criteria of the performance evaluation will be developed in the RD, but are generally discussed in **Section 2.12.2**.

A participant in the public meeting asked why Alternative 3 (in situ bioremediation) was not selected as the preferred alternative. The selection was made in accordance with statutory determinations that steer the decision making process. The FS (Shaw, 2009), Proposed Plan (U.S. Army, 2010), and ROD walk step-by-step through the process. Alternatives 2 and 3 are both expected to attain RAOs, and both would ultimately return groundwater to it potential beneficial use. Since the alternatives have similar long-term effectiveness, the alternative with the lower cost was selected.

The estimated time to achieve cleanup levels is within 23 years based on TCE; the derivation of the estimate is described in the FS, Appendix A (Shaw, 2009). In the course of the remedy, the additional monitoring results will allow more accurate time estimates. Currently, no daughter products have been detected above their associated MCLs. As the TCE continues to degrade, daughter products may begin to exceed their MCLs. Degradation rates will also be calculated for daughter products when enough data is available.

Question/comment: The potential migration of the TCE plume towards the public drinking water wells outside LHAAP is a key concern to the public.

Response: The U.S. Army has evaluated the VOC plume at LHAAP-46 and its potential to migrate offsite to three public drinking water wells (Caddo Lake Water Supply Corporation Wells 1, 2, and 3). The wells are located in close proximity to the LHAAP perimeter, along the northwest corner. The wells are isolated from the plumes by distance, depth, and groundwater flow direction. The closest of the three wells is approximately a half mile away from the plume. These wells draw from the drinking water aquifer, which is separate from the TCE plumes in the shallow and intermediate groundwater zones. The wells are upgradient of the plumes, meaning groundwater from the plume does not flow towards these wells. Furthermore, the plume is stable and has not shown evidence of migrating. LTM will provide assurance that any plume migration will be discovered so that mitigation measures can be evaluated.

Participants in the public meeting inquired about evidence that the plume is stable in the lateral and vertical directions. Sampling results and investigations support that the plume is stable. Regarding the lateral direction, the *Preliminary Evaluation of Natural Attenuation*, Appendix A of the FS (Shaw, 2009) reports that the plume was degrading at a greater rate than it could migrate, and that MNA was acting as an adequate containment mechanism. The apparent plume edge in the shallow zone has been decreasing in time as demonstrated by data from 1996 to 2007 show. Regarding the vertical direction, there is a cluster of wells completed in the shallow, intermediate, and deep groundwater zones. The wells are located within the areal extent of the intermediate groundwater plume. The deep zone is not contaminated as demonstrated by results from well 46WW03. It should be noted that the Caddo Lake Water Supply Corporation Wells draw water from a drinking water aquifer, not to be confused with the deep zone groundwater. The drinking water aquifer is at a depth of 250 to 430 feet bgs, while the deep zone groundwater at LHAAP-46 begins at approximately 33 ft bgs.

Another participant questioned the sampling frequency and procedures. The sampling frequency is in accordance with USEPA recommendations for this site. Sampling and analytical processes follow set procedures to ensure consistency and to provide quality data.

Question/comment: All analyses of thallium in filtered groundwater samples at LHAAP-46 exceeded the MCL. The Army has stated that the thallium is probably naturally occurring. Thus, it is not considered to be a COC. However, this conclusion does not appear to be supported by the data. First, there is no reliable background data for thallium. Second, the filtered/unfiltered ratios are approximately 1, indicating that that the thallium is dissolved in the groundwater and not associated with suspended sediment. Finally, "… the consistent thallium/iron ratios…" that the U.S. Army cites as evidence of a natural source do not appear to exist. The thallium/iron ratios vary by more than a factor of ten. That is not consistent. The Army should perform reliable analyses of background thallium concentrations and re-evaluate its conclusion regarding the source of thallium. If the U.S. Army cannot clearly show that the thallium found at LHAAP-46 is naturally occurring, thallium should be considered a COC.

Response: The U.S. Army has reviewed the commenter's concerns over the geochemical evaluation for thallium; however the conclusion reached continues to be that thallium is naturally occurring at LHAAP-46. The reviewer's three concerns (regarding background data, filtered/unfiltered ratios, and thallium/iron [Tl/Fe] ratios) are discussed below.

The reporting limits for the background data set were high (mostly at 20 µg/L compared to an MCL of 2 µg/L), but it is believed that other lines of evidence adequately indicate that thallium is naturally occurring, specifically, the Tl/Fe ratios (discussed below) and the soil investigation results that do not indicate a release of thallium-based compounds at LHAAP-46.

In regards to the filtered/unfiltered ratios, the U.S. Army recognizes that some portion of the thallium detected in the samples may be in solution and not associated with suspended particulates. The LHAAP-46 geochemical evaluation report clearly states that some portion of the thallium detected in the site samples may be in solution, as evidenced by the filtered/unfiltered ratios that range from 0.897 to 1.72 (median of 1.11). However, that is not a proof of thallium contamination, as the element can naturally occur in solution. It should also be noted that the filtration process may not remove all suspended materials, especially fine particulates that can pass through a 0.45-micron filter.

Regarding the Tl/Fe ratios, it is important to note that naturally occurring elements in groundwater commonly exhibit a wide range in trace/major element ratios. At LHAAP-46, the Tl/Fe ratios of the September 2007 samples range from a minimum of 7.75E-04 to a maximum of 1.26E-02, which is common for this trace element. Higher thallium concentrations would also be expected if contamination were present; however, the September 2007 site concentrations only range from 1.94 J µg/L to 8.54 J µg/L. These Tl/Fe ratios and thallium concentrations are comparable with background groundwater data sets at other facilities. For example, at Redstone Arsenal, Alabama, the background Tl/Fe ratios range from 8.34E-05 to 9.98E-02, and the unfiltered background thallium concentrations range from 3.4 J to 9.2 µg/L. At a military facility in New Mexico, the background Tl/Fe ratios range from 9.12E-06 to 1.04E-02, and the unfiltered background thallium concentrations range from 0.0513 J µg/L to 13 µg/L.

The geochemical evaluation in the FS (Shaw, 2009) acknowledged that four 1996 groundwater samples contained anomalously high thallium, collected from wells LHSMW24 and LHSMW27 in February and from LHSMW08 and LHSMW21 in August. These detections may or may not reflect contamination. Of note is the fact that one of these anomalously high concentrations (200 µg/L) is observed in a field duplicate sample (LHSMW08-960813-FD); the corresponding regular sample (LHSMW08-960813) is nondetect for thallium, with a reporting limit of 90 µg/L. The lack of reproducibility suggests that the field duplicate's thallium detection is questionable. Another important observation is that the elevated 1996 thallium concentrations are not reproducible in subsequent sampling rounds. The 1998 samples from wells LHSMW08 and LHSMW27 are nondetect for thallium, at a reporting limit of 1 µg/L. The 1998 thallium detections for the LHSMW21 and LHSMW24 samples, 1.5 µg/L and 4.5 µg/L, are two orders of magnitude lower than their 1996 detections. Well LHSWM24 was resampled in September 2007 and its thallium concentration remains low (5.29 J µg/L in the regular sample and 5.22 J µg/L in its field duplicate). The significant decrease in recent thallium concentrations argues against the presence of thallium contamination in site groundwater.

Given the lack of corroborative soil results, the inability to reproduce the high concentrations of the earlier samples, and the recent thallium concentrations that are similar to those of background groundwater data sets at other facilities, the U.S. Army considers thallium in the recent

LHAAP-46 groundwater samples to be naturally occurring. Thus, thallium is not considered a COC. However, to respond to the public concern and to confirm this decision, additional groundwater sampling for thallium will be integrated into the RD phase for LHAAP-46.

Question/comment: There are large areas at LHAAP-46 without any monitor wells e.g., the western area between LHSMW15 and 46WW04, the eastern area east of LHSMW24, and the southern area south of LHSMW27. Given the long history of LHAAP, it is not possible to know where all spills or disposal of hazardous materials occurred, whether authorized or unauthorized. No area should be presumed to be uncontaminated. The Army should install monitor wells in all areas of LHAAP-46.

Response: The site was evaluated during several investigations focusing on areas where operations occurred. It is unlikely that spills occurred in areas far away from the main production areas. Groundwater wells are positioned to evaluate groundwater both in suspect areas where there were operations and downgradient of those areas. An Environmental Baseline Study by Plexus collected groundwater samples across Longhorn using temporary wells in suspect areas not previously evaluated. The results did not indicate the presence of contaminated areas other than those reported in the RI (Jacobs, 2002a).

3.2 Technical and Legal Issues

This section is used to expand on technical and legal issues. However, there are no issues of that nature beyond the technical issues already discussed in **Section 3.1**.

4.0 References

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USEPA, 1999, *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites*, OSWER Directive 9200.4.-17P, April.

USEPA, 2004, *Performance Monitoring of MNA Remedies for VOCs in Ground Water*, EPA/600/R-04/027, April.

Glossary of Terms

Administrative Record File – The body of reports, official correspondence, and other documents that establish the official record of the analysis, clean up, and final closure of a site.

ARARs – Applicable or relevant and appropriate requirements. Refers to the federal and state requirements that a selected remedy will attain.

Attenuation - The process by which a compound is reduced in concentration over time, through absorption, adsorption, degradation, dilution, and/or transformation.

Background Levels – Naturally-occurring concentrations of inorganic elements (metals) that are present in the environment and have not been altered by human activity.

Baseline Ecological Risk Assessment (BERA) – A study conducted as part of a RI to determine the risk posed to environmental receptors by site-related chemicals.

Baseline Human Health Risk Assessment (BHRRA) – A study conducted as part of a RI to determine the risk posed to human health by site-related chemicals.

Characterization – The compilation of all available data about the waste unit to determine the rate and extent of contaminant migration resulting from the waste site, and the concentration of any contaminants that may be present.

Chemicals of Concern (COC) – Those chemicals that significantly contribute to a pathway in an exposure model of a hypothetical receptor (e.g., a child that resides on a site). They exceed either the calculated numerical limit for cumulative site carcinogenic risk (1 in 10,000 exposed individuals) or the calculated numerical limit of 1 for non-carcinogenic effects, a value proposed by the USEPA.

Chemicals of Potential Concern (COPCs) – Those chemicals that are identified as a potential threat to human health or the environment and are evaluated further in the baseline risk assessment. COCs are a subset of the COPCs that are identified in the Remedial Investigation/Feasibility Study as needing to be addressed by the response action proposed in the Record of Decision.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) – CERCLA was enacted by Congress in 1980 and was amended by the Superfund Amendments and Reauthorization Act in 1986. CERCLA provides federal authority to respond directly to releases or threatened releases of hazardous substances that may endanger public health or the

environment. CERCLA established prohibitions and requirements concerning closed and abandoned hazardous waste sites and established the Superfund Trust Fund.

Contaminant Plume – A column of contamination with measurable horizontal and vertical dimensions that is suspended and moves with groundwater.

Exposure – Contact of an organism with a chemical or physical agent. Exposure is quantified as the amount of the agent available at the exchange boundaries of the organism (e.g., skin, lungs, gut) and available for absorption.

Federal Facility Agreement (FFA) – A legal binding agreement among USEPA, TCEQ, and U.S. Army that sets the standards and schedules for the comprehensive remediation of Longhorn Army Ammunition Plant.

Groundwater – Underground water that fills pores in soil or openings in rocks to the point of saturation.

National Priorities List (NPL) – The USEPA's list of the most serious uncontrolled or abandoned hazardous waste sites identified for possible long-term remedial action under Superfund. USEPA is required to update the NPL at least once a year. A site must be on the NPL to receive money from the Trust Fund for remedial action.

Organic Compounds – Carbon compounds such as solvents, oils, and pesticides. Most are not readily dissolved in water.

Perchlorate – Ammonium perchlorate is a strong oxidizing compound that was used in various industries (solid rocket and jet propellant, medical field, and other processes).

Record of Decision (ROD) – A legal document presenting the remedial action selected for a site or operable unit. It is based on information and technical analyses generated during the RI/FS and consideration of public comments on the statement of basis/proposed plan and community concerns.

Remedial Investigation (RI) – A study designed to gather data needed to determine the nature and extent of contamination at a Superfund site.

Resource Conservation and Recovery Act (RCRA) – Gives USEPA the authority to control the generation, transportation, treatment, storage, and disposal of hazardous waste. RCRA focuses only on active and future facilities and does not address abandoned or historical sites.

Responsiveness Summary – A summary of oral and/or written comments received during the proposed plan comment period and responses to these comments. The responsiveness summary is a key part of a ROD and highlights community concerns.

Proposed Plan – A plan for a site cleanup that proposes a recommended or preferred remedial alternative. The Proposed Plan is available to the public for review and comment. The preferred alternative may change based on public and other stakeholder input.

Superfund Amendments and Reauthorization Act (SARA) – Amended CERCLA in 1986. SARA resulted in more emphasis on permanent remedies for cleaning up hazardous waste sites, increased the focus on human health problems posed by hazardous waste sites, and encouraged greater citizen participation in making decisions on how sites should be cleaned up.

Superfund – The common name used for CERCLA; also referred to as the Trust Fund. The Superfund Program was established to help fund cleanup of hazardous waste sites. It also allows legal action to force those responsible for sites to clean them up.

Trichloroethene (TCE) – TCE is a colorless or blue liquid with an odor similar to ether. It is man made and does not occur naturally in the environment. TCE was once commonly used to remove oils and grease from metal parts and is used in the dry cleaning industry.

Appendix A
Public Meeting Newspaper and Media Notices

PUBLIC NOTICE
THE UNITED STATES ARMY INVITES PUBLIC COMMENT ON THE PROPOSED PLANS FOR ENVIRONMENTAL SITES LHAAP-46, -49, -50, -35A(58), AND THE PISTOL RANGE, LONGHORN ARMY AMMUNITION PLANT, TEXAS

The U.S. Army is the lead agency for environmental response actions at Longhorn Army Ammunition Plant (LHAAP). In partnership with Texas Commission on Environmental Quality and the U.S. Environmental Protection Agency Region 6, the U.S. Army has developed Proposed Plans for the following NPL sites: LHAAP-46, LHAAP-49, LHAAP-50, LHAAP-35A(58), and the Pistol Range. Although the Proposed Plans identify preferred remedies for each of the sites, the U.S. Army welcomes the public's review and comments. The public comment period begins January 25, 2010, and concludes February 23, 2010. **On Tuesday, January 26, 2010, from 6:00 to 8:00 p.m., the U.S. Army is inviting all interested parties to attend an open house forum to view the Proposed Plans and ask questions. The open house forum will be held at the Karnack Community Center, Highway 134 and Spur 449, Karnack, Texas.** Copies of the Proposed Plans and supporting documentation are available for public review at the Marshall Public Library, 300 S. Alamo, Marshall, Texas, 75670. Summaries of each of the sites, including discussion of various alternatives that were evaluated, are provided below.

LHAAP-46, the former Plant 2 production area, is located in the north-central portion of LHAAP and covers an area of approximately 190 acres. Plant 2 was used to produce pyrotechnic devices from February 1952 to 1956 and was reactivated to produce pyrotechnic and illumination devices from 1964 until approximately 1997. Three alternatives were evaluated for addressing the contaminated groundwater at the site: 1) no action; 2) monitored natural attenuation (MNA) and land use controls (LUCs); and 3) in situ bioremediation, short-term LUCs, and long-term monitoring (LTM). Based on available information, the preferred remedy is MNA and LUCs. The preferred remedy would utilize groundwater use restriction LUCs to protect human health by preventing human exposure to contaminated groundwater and MNA to return the contaminated water to its potential beneficial use as drinking water, wherever practicable.

LHAAP-49, a former Acid Storage Area, is located in the west-central portion of LHAAP and covers an area of approximately 30 acres. The site was used from 1942 to 1945 for formulation and storage of acids and acid mixtures in support of trinitrotoluene production. Based on available information, the preferred remedy at this time is no action. The recommendation is based on the existing data and determination of no unacceptable risk to human health or to ecological receptors at LHAAP-49.

LHAAP-50, a former sump water tank, is located in the north-central portion of LHAAP and covers an area of approximately 1 acre. Historically, LHAAP-50 contained a 47,000-gallon capacity aboveground storage tank which received wastewater from various industrial waste sumps from 1955 to 1988. Three alternatives were evaluated for addressing the contaminated groundwater and soil at the site: 1) no action; 2) soil - excavation, groundwater - MNA and LUCs; and 3) soil - excavation, groundwater - in situ bioremediation, MNA, and LUCs. Based on available information, the preferred remedy at this time is the second alternative: excavation and off-site disposal of perchlorate-contaminated soils, and MNA and LUCs for groundwater. The preferred remedy would ensure protection of human health by eliminating the soil-to-groundwater and soil-to-surface water pathways, implementing groundwater use restriction LUCs to prevent exposure to contaminated groundwater, and implementing MNA until groundwater cleanup levels are achieved.

LHAAP-35A(58), known as the Shops Area, is located in the north-central portion of LHAAP and covers approximately 11 acres. The Shops Area was established in 1942 as part of the installation's initial construction. Plant-operated laundry, automotive, woodworking, metalworking, painting, refrigeration, and electrical shops served the needs of the overall facility and became inactive in 1996 and 1997. Four alternatives were evaluated for addressing the contaminated groundwater at the site: 1) no action; 2) MNA with LUCs; 3) in situ bioremediation with short-term LUCs and LTM; and 4) in situ bioremediation followed by MNA and LUCs for the eastern plume, and MNA and LUCs for the western plume. Based on available information, the preferred remedy at this time is the fourth alternative: in situ bioremediation followed by MNA and LUCs for the eastern plume, and MNA and LUCs for the western plume. The preferred remedy would ensure protection of human health by 1) implementing groundwater use restriction LUCs which prevent human exposure to contaminated groundwater and 2) returning the contaminated water to its potential beneficial use as a drinking water, wherever practicable, through MNA and in situ bioremediation.

The former **Pistol Range** is located in the southeastern portion of LHAAP and covers an area of approximately 0.4 acres. The area was used by base security personnel as early as the 1950s and intermittently through 2004 as a small arms firing range. The target area was a natural, wooded slope at the eastern side of the site. Soil with contamination above industrial cleanup levels was excavated and disposed off site during a 2009 removal action. Based on available information, the preferred remedy at this time is no action. The recommendation is based on existing data and determination of no unacceptable risk to human health or to ecological receptors.

For further information or to submit written comments, contact: Dr. Rose M. Zeiler, Longhorn Army Ammunition Plant, P.O. Box 220, Ratcliff, Arkansas, 72951; phone number 479-635-0110 or e-mail rose.zeiler@us.army.mil.

PUBLIC NOTICE
THE UNITED STATES ARMY INVITES PUBLIC COMMENT ON THE PROPOSED PLANS FOR ENVIRONMENTAL SITES LHAAP-46, -49, -50, -35A(58), AND THE PISTOL RANGE, LONGHORN ARMY AMMUNITION PLANT, TEXAS
PUBLIC MEETING AT KARNACK COMMUNITY CENTER MARCH 9, 2010

The U.S. Army is the lead agency for environmental response actions at Longhorn Army Ammunition Plant (LHAAP). In partnership with Texas Commission on Environmental Quality and the U.S. Environmental Protection Agency Region 6, the U.S. Army has developed Proposed Plans for the following NPL sites: LHAAP-46, LHAAP-49, LHAAP-50, LHAAP-35A(58), and the Pistol Range. Although the Proposed Plans identify preferred remedies for each of the sites, the U.S. Army welcomes the public's review and comments. The public comment period began January 25, 2010, and has been extended to March 25, 2010. **On Tuesday, March 9, 2010, from 7:00 to 9:00 p.m., the U.S. Army is inviting all interested parties to attend a public presentation of the proposed remedies for these sites and to ask questions and provide comments on the Proposed Plans. Questions, comments, and responses on the Proposed Plans will be recorded by a court reporter. This public meeting will be held at the Karnack Community Center, Highway 134 and Spur 449, Karnack, Texas.** Copies of the Proposed Plans and supporting documentation are available for public review at the Marshall Public Library, 300 S. Alamo, Marshall, Texas, 75670. Summaries of each of the sites, including discussion of various alternatives that were evaluated, are provided below.

LHAAP-46, the former Plant 2 production area, is located in the north-central portion of LHAAP and covers an area of approximately 190 acres. Plant 2 was used to produce pyrotechnic devices from February 1952 to 1956 and was reactivated to produce pyrotechnic and illumination devices from 1964 until approximately 1997. Three alternatives were evaluated for addressing the contaminated groundwater at the site: 1) no action; 2) monitored natural attenuation (MNA) and land use controls (LUCs); and 3) in situ bioremediation, short-term LUCs, and long-term monitoring (LTM). Based on available information, the preferred remedy is MNA and LUCs. The preferred remedy would utilize groundwater use restriction LUCs to protect human health by preventing human exposure to contaminated groundwater and MNA to return the contaminated water to its potential beneficial use as drinking water, wherever practicable.

LHAAP-49, a former Acid Storage Area, is located in the west-central portion of LHAAP and covers an area of approximately 30 acres. The site was used from 1942 to 1945 for formulation and storage of acids and acid mixtures in support of trinitrotoluene production. Based on available information, the preferred remedy at this time is no action. The recommendation is based on the existing data and determination of no unacceptable risk to human health or to ecological receptors at LHAAP-49.

LHAAP-50, a former sump water tank, is located in the north-central portion of LHAAP and covers an area of approximately 1 acre. Historically, LHAAP-50 contained a 47,000-gallon capacity aboveground storage tank which received wastewater from various industrial waste sumps from 1955 to 1988. Three alternatives were evaluated for addressing the contaminated groundwater and soil at the site: 1) no action; 2) soil - excavation, groundwater - MNA and LUCs; and 3) soil - excavation, groundwater - in situ bioremediation, MNA, and LUCs. Based on available information, the preferred remedy at this time is the second alternative: excavation and off-site disposal of perchlorate-contaminated soils, and MNA and LUCs for groundwater. The preferred remedy would ensure protection of human health by eliminating the soil-to-groundwater and soil-to-surface water pathways, implementing groundwater use restriction LUCs to prevent exposure to contaminated groundwater, and implementing MNA until groundwater cleanup levels are achieved.

LHAAP-35A(58), known as the Shops Area, is located in the north-central portion of LHAAP and covers approximately 11 acres. The Shops Area was established in 1942 as part of the installation's initial construction. Plant-operated laundry, automotive, woodworking, metalworking, painting, refrigeration, and electrical shops served the needs of the overall facility and became inactive in 1996 and 1997. Four alternatives were evaluated for addressing the contaminated groundwater at the site: 1) no action; 2) MNA with LUCs; 3) in situ bioremediation with short-term LUCs and LTM; and 4) in situ bioremediation followed by MNA and LUCs for the eastern plume, and MNA and LUCs for the western plume. Based on available information, the preferred remedy at this time is the fourth alternative: in situ bioremediation followed by MNA and LUCs for the eastern plume, and MNA and LUCs for the western plume. The preferred remedy would ensure protection of human health by 1) implementing groundwater use restriction LUCs which prevent human exposure to contaminated groundwater and 2) returning the contaminated water to its potential beneficial use as a drinking water, wherever practicable, through MNA and in situ bioremediation.

The former **Pistol Range** is located in the southeastern portion of LHAAP and covers an area of approximately 0.4 acres. The area was used by base security personnel as early as the 1950s and intermittently through 2004 as a small arms firing range. The target area was a natural, wooded slope at the eastern side of the site. Soil with contamination above industrial cleanup levels was excavated and disposed off site during a 2009 removal action. Based on available information, the preferred remedy at this time is no action. The recommendation is based on existing data and determination of no unacceptable risk to human health or to ecological receptors.

For further information or to submit written comments, contact: Dr. Rose M. Zeiler, Longhorn Army Ammunition Plant, P.O. Box 220, Ratcliff, Arkansas, 72951; phone number 479-635-0110 or e-mail rose.zeiler@us.army.mil.

MEDIA RELEASE

The United States Army has prepared Proposed Plans for five environmental sites at the Longhorn Army Ammunition Plant: LHAAP-46, -49, -50, -35A(58) and the former Pistol Range. The Proposed Plans are documents that describe the sites and their proposed remedies. The Proposed Plans were developed to facilitate public involvement in the remedy selection process.

Copies of the Proposed Plans and supporting documentation are available for public review at the Marshall Public Library, 300 S. Alamo, Marshall, Texas 75670 beginning January 25, 2010. The public comment period has been extended to March 25, 2010.

An informal open forum was held on January 26, 2010. A second public meeting, with a formal question and answer session, will be held on March 9, 2010, from 7:00 to 9:00 p.m. at the Karnack Community Center, Highway 134 and Spur 449, Karnack, Texas 75661.

All written public comments on the Proposed Plans must be postmarked on or before March 25, 2010. Written comments may be provided to Dr. Rose M. Zeiler, Longhorn Army Ammunition Plant, P. O. Box 220, Ratcliff, Arkansas, 72951 or e-mailed to rose.zeiler@us.army.mil. E-mailed comments must be submitted by close of business on March 25, 2010.

Shaw® Shaw Environmental, Inc.

Date: ***October 25, 2010***

Project No.:117591

TRANSMITTAL LETTER:

To: Mr. Aaron Williams

***Address*:** US Army Corps of Engineers - Tulsa
CESWT-PP-M
1645 South 101st East Ave
Tulsa, Oklahoma 74128

Re: *Final* Record of Decision, LHAAP-50, Former Sump Water Tank, Group 4, Longhorn Army Ammunition Plant
Contract No. W912QR-04-D-0027/DS02

For: Review ____ As Requested ____ Approval ____ Corrections ____ Submittal ____ Other X ____

Item No:	*No. of Copies*	*Date:*	*Document Title*
1	2	September 2010	**Final Record of Decision, LHAAP-50, Former Sump Water Tank, Group 4, Longhorn Army Ammunition Plant, Karnack, Texas**

Aaron,
Enclosed are two copies of the above-named document. Copies have been distributed as indicated at the end of this message. Please call with any questions or comments.

Sincerely:

Praveen Srivastav
Project Manager

CC: **Distribution List:**
Mr. J. Lambert – USACE, Tulsa (sent to A. Williams for distribution)
Mr. A. Maly – USAEC (electronic only)
Ms. Rose Zeiler – BRAC-LHAAP
Mr. S. Tzhone – EPA Region 6 (2)
Ms. F. Duke– TCEQ, Austin (2)
Mr. D. Vodak– TCEQ, Tyler
Mr. P. Bruckwicki– U.S. Fish and Wildlife Service

00098890

DEPARTMENT OF THE ARMY
LONGHORN ARMY AMMUNITION PLANT
POST OFFICE BOX 220
RATCLIFF, AR 72951

October 25, 2010

DAIM-ODB-LO

Mr. Stephen Tzhone
US Environmental Protection Agency
Superfund Division (6SF-AT)
1445 Ross Avenue
Dallas, TX 75202-2733

Re: Final Record of Decision, LHAAP-50, Former Sump Water Tank, Group 4, Longhorn Army Ammunition Plant, Karnack, Texas, September 2010

Dear Mr. Tzhone,

The above-referenced document is being transmitted to you for your records. The document has been prepared by Shaw Environmental, Inc. (Shaw) on behalf of the Army as part of Shaw's performance based contract for the facility.

The point of contact for this action is the undersigned. I ask that Praveen Srivastav, Shaw's Project Manager, be copied on any communications related to the project. I may be contacted at 479-635-0110, or by email at rose.zeiler@us.army.mil.

Sincerely,

Rose M. Zeiler, Ph.D.
Longhorn AAP Site Manager

Copies furnished:
F. Duke, TCEQ, Austin, TX
D. Vodak, TCEQ, Tyler, TX
P. Bruckwicki, Caddo Lake NWR, TX
J. Lambert, USACE, Tulsa District, OK
A. Williams, USACE, Tulsa District, OK
A. Maley, USAEC, TX
P. Srivastav, Shaw – Houston, TX (for project files)

DEPARTMENT OF THE ARMY
LONGHORN ARMY AMMUNITION PLANT
POST OFFICE BOX 220
RATCLIFF, AR 72951

October 25, 2010

DAIM-ODB-LO

Ms. Fay Duke (MC-136)
SSDAT/Superfund Section
Remediation Division
Texas Commission on Environmental Quality
12100 Park 35 Circle, Bldg D
Austin, TX 78753

Re: Final Record of Decision, LHAAP-50, Former Sump Water Tank, Group 4,
Longhorn Army Ammunition Plant, Karnack, Texas, September 2010
SUP 126

Dear Ms. Duke,

The above-referenced document is being transmitted to you for your records. The document has been prepared by Shaw Environmental, Inc. (Shaw) on behalf of the Army as part of Shaw's performance based contract for the facility.

The point of contact for this action is the undersigned. I ask that Praveen Srivastav, Shaw's Project Manager be copied on any communications related to the project. I may be contacted at 479-635-0110, or by email at rose.zeiler@us.army.mil.

Sincerely,

Rose M. Zeiler, Ph.D.
Longhorn AAP Site Manager

Copies furnished:
S. Tzhone, USEPA Region 6, Dallas, TX
D. Vodak, TCEQ, Tyler, TX
P. Bruckwicki, Caddo Lake NWR, TX
J. Lambert, USACE, Tulsa District, OK
A. Williams, USACE, Tulsa District, OK
A. Maly, USAEC, TX
P. Srivastav, Shaw, Houston, TX (for project files)