

**FINAL
RECORD OF DECISION
LHAAP-35B (37), CHEMICAL LABORATORY AND
LHAAP-67, ABOVEGROUND STORAGE TANK FARM
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS**



**Prepared for
U.S. Army Corps of Engineers
Tulsa District
1645 South 101st Avenue
Tulsa, Oklahoma**

**Prepared by
Shaw Environmental, Inc.
3010 Briarpark, Suite 400
Houston, Texas 77042**

**TERC No. DACA56-94-D-0020, Task Order No. 0109
Shaw Project No. 845714**

June 2010

Table of Contents

List of Tables	iii
List of Figures	iii
List of Appendices	iii
Glossary of Terms	iii
Acronyms and Abbreviations	iv
1.0 The Declaration.....	1-1
1.1 Site Name and Location	1-1
1.2 Statement of Basis and Purpose	1-1
1.3 Assessment of the Site.....	1-2
1.4 Description of the Selected Remedy	1-2
1.5 Statutory Determinations	1-3
1.6 ROD Data Certification Checklist.....	1-4
1.7 Authorizing Signatures	1-5
2.0 Decision Summary.....	2-1
2.1 Site Name, Location, and Description	2-1
2.2 Site History and Enforcement Activities.....	2-2
2.2.1 History of Site Activities	2-2
2.2.2 History of Investigative Activities	2-3
2.2.3 History of CERCLA Enforcement Activities	2-5
2.3 Community Participation.....	2-5
2.4 Scope and Role of Response Action	2-6
2.5 Site Characteristics.....	2-7
2.5.1 Conceptual Site Model	2-8
2.5.2 Nature and Extent of Contamination.....	2-12
2.5.2.1 LHAAP-35B (37)	2-12
2.5.2.2 LHAAP-67	2-14
2.6 Current and Potential Future Land and Resource Uses	2-16
2.6.1 Current and Future Land Uses	2-16
2.6.2 Current and Future Surface Water Uses	2-17
2.6.3 Current and Future Groundwater Uses	2-17
2.7 Summary of Site Risks	2-18
2.7.1 Human Health Risk Assessment Summary.....	2-18
2.7.1.1 Identification of Chemicals of Concern.....	2-19
2.7.1.2 Exposure Assessment	2-20
2.7.1.3 Toxicity Assessment	2-22
2.7.1.4 Risk Characterization.....	2-22
2.7.1.5 Uncertainty.....	2-27
2.7.1.6 Notification and Recordation Requirements.....	2-27
2.7.2 Ecological Risk Assessment Summary	2-27
2.8 Remedial Action Objectives.....	2-28
2.9 Description of Alternatives.....	2-28
2.9.1 Common Elements.....	2-28

Table of Contents (continued) _____

2.9.2	Description of Remedy Components	2-29
2.10	Summary of Comparative Analysis of Alternatives	2-32
2.11	Principal Threat Wastes	2-37
2.12	The Selected Remedy	2-37
2.12.1	Summary of Rationale for the Selected Remedy	2-37
2.12.2	Description of the Selected Remedy	2-38
2.12.3	Summary of the Estimated Remedy Costs	2-40
2.13	Statutory Determinations	2-40
2.14	Significant Changes from the Proposed Plan	2-43
3.0	References	3-1
4.0	Responsiveness Summary	4-1

List of Tables

Table 2-1	Summary of Soil Analytical Data LHAAP-35B (37)	2-44
Table 2-2	Summary of Groundwater Analytical Data LHAAP-35B (37).....	2-46
Table 2-3	Summary of Soil Analytical Data LHAAP-67	2-48
Table 2-4	Summary of Groundwater Analytical Data LHAAP-67	2-49
Table 2-5	Occurrence, Distribution, and Selection of Chemicals of Concern LHAAP-35B (37) Groundwater	2-50
Table 2-6	Occurrence, Distribution, and Selection of Chemicals of Concern LHAAP-67 Groundwater	2-51
Table 2-7	Cancer Toxicity Data Summary - LHAAP-35B (37) and LHAAP-67	2-52
Table 2-8	Non-Cancer Toxicity Data Summary – LHAAP-35B (37) and LHAAP-67	2-54
Table 2-9	Risk Characterization Summary – LHAAP-35B (37) Carcinogens in Surface Soil and Groundwater	2-56
Table 2-10	Risk Characterization Summary – LHAAP-35B (37) Non-Carcinogens in Surface Soil and Groundwater	2-57
Table 2-11	Risk Characterization summary – LHAAP-67 Carcinogens in Surface Soil and Groundwater	2-58
Table 2-12	Risk Characterization Summary – LHAAP-67 Non-Carcinogens in Surface Soil and Groundwater	2-59
Table 2-13	Comparative Analysis of Alternatives.....	2-60
Table 2-14	Remediation Cost Table – LHAAP-35B (37) Alternative 2	2-63
Table 2-15	Remediation Cost Table - LHAAP-67 Alternative 2.....	2-64

List of Figures

Figure 2-1	Location of Longhorn Army Ammunition Plant
Figure 2-2	Site Location Map, LHAAP-35B(37) and LHAAP-67
Figure 2-3	Sampling Locations LHAAP-35B(37)
Figure 2-4	Site Map with Sampling Locations, Record of Decision, LHAAP-67, Group 4
Figure 2-5	Groundwater Elevation Map, Shallow Zone, Record of Decision, LHAAP-35B(37), Group 4
Figure 2-6	Groundwater Elevation Map, Shallow Zone, Record of Decision, LHAAP-67, Group 4
Figure 2-7	Conceptual Site Model, Record of Decision, LHAAP-35B(37), Group 4
Figure 2-8	Conceptual Site Model, Record of Decision, LHAAP-67, Group 4

List of Appendices

Appendix A Public Announcements

Glossary of Terms

Located at the end of this ROD

Acronyms and Abbreviations

ABS	absorption fraction of chemicals through skin
AF	adherence factor (dermal exposure)/adjustment factor (inhalation exposure)
ARAR	applicable or relevant and appropriate requirement
AT	averaging time
BERA	baseline ecological risk assessment
Bgs	below ground surface
BRAC	Base Realignment and Closure
CDI	chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm ²	square centimeters
cm/sec	centimeters per second
COC	chemicals of concern
DCA	Dichloroethane
DCE	Dichloroethene
CSM	conceptual site model
ECOP	environmental condition of property
ED	exposure duration
EF	exposure frequency
EPC	exposure point concentration
ERA	ecological risk assessment
FFA	Federal Facility Agreement
FI	Fraction absorbed by the ingestion pathway
FS	feasibility study
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
IRIS	Integrated Risk Information System
Jacobs	Jacobs Engineering Group, Inc
kg	kilogram
Kp	permeability factor
LHAAP	Longhorn Army Ammunition Plant
LUC	land use control
MCL	maximum contaminant level
m ³ /kg	cubic meters per kilogram
mg/cm ²	milligrams per square centimeters
mg/day	milligrams per day
mg/kg-day	milligrams per kilogram per day
mg/L	milligrams per liter
MNA	monitored natural attenuation

Acronyms and Abbreviations (continued)

MSC	medium specific concentration
Msl	mean sea level
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
NCEA	USEPA National Center for Environmental Assessment
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priorities List
O&M	operation and maintenance
PCB	polychlorinated biphenyl
PCE	Tetrachloroethene
PEF	particulate emission factor
p,p-DDE	Dichlorodiphenyltrichloroethane
p,p-DDT	Dichlorodiphenyldichloroethylene
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RD	remedial design
RFA	RCRA Facility Assessment
RfD	reference dose
RI	remedial investigation
RME	reasonable maximum exposure
ROD	record of decision
SA	surface area
SARA	Superfund Amendments and Reauthorization Act
SF	slope factor
Shaw	Shaw Environmental, Inc.
SVOC	semivolatile organic compounds
2,3,7,8-TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TCA	Trichloroethane
TCE	Trichloroethene
TCEQ	Texas Commission on Environmental Quality
TNT	Trinitrotoluene
TPH	total petroleum hydrocarbon
USAEHA	U.S. Army Environmental Hygiene Agency
USATHAMA	U.S. Army Toxic and Hazardous Material
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
VF	volatilization factor
VOC	volatile organic compound

1.0 *The Declaration*

1.1 *Site Name and Location*

LHAAP-35B (37), Chemical Laboratory and LHAAP-67, Aboveground Storage Tank Farm

Longhorn Army Ammunition Plant
Karnack, Texas

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

1.2 *Statement of Basis and Purpose*

This decision document covers two sites, LHAAP-35B (37) and LHAAP-67, because of the similarity in specific site problems and because the set of actions (remedies) to be performed over time are similar and concurrent. This decision document presents the selected remedies for LHAAP-35B (37), Chemical Laboratory, and LHAAP-67, Aboveground Storage Tank Farm at the former Longhorn Army Ammunition Plant (LHAAP) in Karnack, Texas. The remedy was chosen in accordance with 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).

The remedy selection was based on the Administrative Record for these sites, including the remedial investigation (RI) and baseline risk assessment reports (Jacobs Engineering Group, Inc. [Jacobs] 2002a, 2002b, 2003), feasibility study (FS) (Shaw Environmental, Inc. [Shaw], 2005a, 2005b), the monitored natural attenuation (MNA) modeling report (Shaw, 2007a), the natural attenuation evaluation report (Shaw, 2007b), the installation-wide baseline ecological risk assessment (BERA) report (Shaw, 2007c), the Proposed Plan (U.S. Army, 2008a), and other related documents contained in the Administrative Record files for LHAAP-35B (37) and LHAAP-67.

This document is issued by the U.S. Army who is 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 remedies.

1.3 *Assessment of the Site*

Implementing the response actions 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 into the environment.

1.4 *Description of the Selected Remedy*

The selected remedy for both LHAAP-35B (37) and LHAAP-67 includes utilizing land use controls (LUCs) and MNA. The remedy meets the remedial action objectives (RAOs) developed for these sites to protect human health and the environment by preventing human exposure to chlorinated solvents-contaminated groundwater [1,1-dichloroethene (DCE), trichloroethene (TCE), and tetrachloroethene (PCE) at LHAAP-35B (37) and 1,1,1-trichloroethane (TCA), 1,1,2-TCA, 1,2-dichloroethane (DCA), TCE, and 1,1-DCE at LHAAP-67], ensuring containment of the chlorinated solvents-contaminated groundwater for the protection of surface water, and returning the groundwater to its potential beneficial use as drinking water wherever practicable.

Due to the potential for chlorinated solvents-contaminated groundwater to migrate, MNA will be implemented to assure that the plumes will not migrate to nearby surface water bodies at levels that may present an unacceptable risk to human health and the environment. The monitoring and reporting associated with this remedy will continue until MCLs are achieved. Monitoring will be used to demonstrate that MNA is effective. Due to the unacceptable risk posed by chlorinated solvents in groundwater during the MNA remedy, LUCs are needed in the impacted areas to ensure the protection of human health by preventing human exposure to the contaminated groundwater. The selected LUCs will prevent human exposure to chlorinated solvents-contaminated groundwater through the restriction of groundwater use. The LUCs will remain in place until MCLs are achieved.

Based on groundwater modeling, groundwater MCLs are expected to be met at LHAAP-35B(37) through natural attenuation in 28 to 38 years for PCE, 39 to 43 years for TCE, and 16 to 21 years for 1,1-DCE. Considering the lithologic variability, particularly the lateral and vertical change from sand to clay, the times to MCL may range to an order of magnitude greater. For LHAAP-67, MCLs would be met through natural attenuation in 17 to 66 years for TCE, 20 to 34 years for 1,1-DCE, and 21 to 43 years for 1,2-DCA. Although the times to MCL attainment for 1,1,1-TCA and 1,1,2-TCA were originally calculated to be 22 and 20 years respectively, these two volatile organic compounds (VOCs) are no longer detected above MCLs at LHAAP-67 (Shaw, 2007e, U.S. Army, 2008b). The need to continue the LUCs to restrict groundwater use and MNA will be reviewed every five years.

The specific LUCs and implementation details will be included in the land use component of the remedial design (RD) and the LUCs are identified in Section 2.9.1. The MNA plan will also be

presented in the RD. Within 90 days of ROD signature, the Army will prepare and submit the RD to USEPA and TCEQ consistent with the schedule of Section XVI of the Federal Facility Agreement (FFA). The Army will be responsible for implementation, maintenance, periodic inspection, and enforcement of LUCs in accordance with the RD. Although the Army may transfer these responsibilities to another party through property transfer agreement or other means, the Army will remain 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 LUCs and any related transfer or lease provisions; and (5) confirming 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 a 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 a 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 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 C.F.R. §300.435 and 40 C.F.R. §300.430(f)(4)(iii)(B).

1.5 Statutory Determinations

The selected remedy does not satisfy the statutory preference for treatment as a principle 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 principle threats will be addressed within the scope of this action. In addition, the remedy offers long-term effectiveness through the implementation of LUCs, 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-35B (37) and LHAAP-67, 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-35B (37) and LHAAP-67 groundwater.

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure, a statutory review

will be conducted within five years after initiation of remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

1.6 ROD Data Certification Checklist

The following information is included in the Decision Summary section of this ROD.

- 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 sites as a result of the Selected Remedy (**Section 2.6**).
- Chemicals of concern (COCs) and their respective medium specific exposure point concentrations (EPCs) (**Section 2.7**).
- Baseline risk represented by the COCs (**Section 2.7**).
- Cleanup levels established for COCs and the basis for these levels (**Section 2.7**).
- Discussion of how source materials constituting principle threats are addressed (**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 2.12.3**).

Additional information can be found in the Administrative Record file for these sites.

2.0 *Decision Summary*

2.1 *Site Name, Location, and Description*

LHAAP-35B (37), Chemical Laboratory and LHAAP-67, Aboveground Storage Tank Farm.

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

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

The former LHAAP is an inactive, government-owned, formerly contractor-operated and maintained Department of Defense facility located in central east Texas in the northeast corner of Harrison County. As shown on **Figure 2-1**, LHAAP is approximately 14 miles northeast of Marshall, Texas, and approximately 40 miles west of Shreveport, Louisiana. The former U.S. Army installation occupied over 8,400 acres between State Highway 43 at Karnack, Texas, and the southwestern shore of Caddo Lake and is accessed by 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.

LHAAP-35B (37), the Chemical Laboratory, encompasses approximately 12.2 acres and is located in the north-central portion of LHAAP near the southwestern corner of LHAAP-47 and south of the intersection of Avenue P and 59th Street (**Figure 2-2**). The surface features at LHAAP-35B (37) include a mixture of asphalt-paved roads and parking area, several administration buildings, the former Chemical Laboratory (Building 29-A), and a mixture of wooded and grassy vegetation-covered areas. The topography in this area is relatively flat with the surface drainage flowing into Goose Prairie Creek. The creek runs perpendicular to the western border of the site and then turns south through the east-central portion of the site and eventually drains into Caddo Lake.

LHAAP-67, a former aboveground storage tank farm, covers an area of approximately 1.9 acres and is located in the central portion of LHAAP on the southeast corner of 48th Street and Ignatius Avenue (**Figure 2-2**). The site is relatively flat. The nearest significant surface water body to LHAAP-67 is Central Creek located approximately 870 feet southeast of the site.

These sites are surrounded by an area (nearly 7,000 acres) that was transferred by the U.S. Department of the Army to the U.S. Fish and Wildlife Service (USFWS) for management as the Caddo Lake National Wildlife Refuge. The U.S. Army is acting in partnership with USEPA Region 6 and TCEQ. As the lead agency for environmental response actions at LHAAP, the U.S. Army is charged with planning and implementing remedial actions at LHAAP-35B (37) and LHAAP-67.

2.2 Site History and Enforcement Activities

2.2.1 History of Site Activities

LHAAP was established in December 1941 with the primary mission of manufacturing trinitrotoluene (TNT). Production of TNT began at Plant 1 in October 1942 and continued through World War II until August 1945, when the facility was placed on standby status until February 1952. In 1952 the facility was reactivated and production of pyrotechnic ammunition, such as photoflash bombs, simulators, hand signals, and tracers for 40 millimeter ammunition continued at Plant 2, northeast of Plant 1, through 1956.

In December 1954, a third facility, Plant 3, began production of solid-fuel rocket motors for tactical missiles. Rocket motor production at Plant 3 continued to be the primary operation at LHAAP until 1965 when Plant 2 was reactivated for the production of pyrotechnic and illuminating ammunition. In the years following the Vietnam conflict, LHAAP continued to produce flares and other basic pyrotechnic or illuminating items for the U.S. Department of Defense inventory. From September 1988 to May 1991, LHAAP was also used for the static firing and elimination of Pershing I and II rocket motors in compliance with the Intermediate-Range Nuclear Force Treaty in effect between the United States and the former Union of Soviet Socialist Republics.

LHAAP-35B (37): The Chemical Laboratory was built during the construction of Plant 3 (1953-1955) and was originally used to support the production activities at LHAAP. These support activities included research and testing of materials used in the production processes and quality assurance testing. Also, one waste rack sump was located at the site. In 1998, the site was used as a staging area in support of investigation activities.

LHAAP-67: When operational LHAAP-67 consisted of seven aboveground storage tanks of unknown size. The tanks were surrounded with earthen dikes designed to contain potential

spills. Site personnel indicated that the tanks were used for solvent storage. The tanks have been removed and the only structure remaining at the site is a railroad bed.

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 define 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.

In addition to the installation wide investigations, site-specific investigations were conducted for LHAAP-35B (37) and LHAAP-67 and included the following:

LHAAP-35B (37)

- Between 1993 and 1998 several investigations were conducted in a phased approach to identify the presence and extent of contamination in soil and groundwater at LHAAP-35B (37). Four monitoring wells were installed; three wells were completed in the shallow groundwater zone, and one well was installed in the intermediate groundwater zone. Soil samples were collected from the waste rack sump location, well borings, and two additional borings. Groundwater samples were collected from the four wells and analyzed for VOCs, semivolatile organic compounds (SVOCs), metals, and explosive compounds. Later samples were analyzed for pesticides, polychlorinated biphenyls (PCB), herbicides, total petroleum hydrocarbon (TPH), perchlorate and cyanide. Soil samples were analyzed for VOCs, SVOCs, explosive compounds, metals, pesticides, PCBs, and dioxin/furans. **Figure 2-3** shows the monitoring and sampling locations. Investigation results indicated that there was no significant contamination in the surrounding soils. Multiple constituents were detected in the groundwater; primarily DCE, TCE, and PCE.

- One additional monitoring well was installed in the intermediate groundwater zone in 2004 as part of a groundwater data gaps investigation. The concentrations of the primary contaminants detected in groundwater during this investigation were lower than historical concentrations (Shaw, 2007d). In December 2006, three new monitoring wells were installed at the site. The purpose of the newly installed wells was to define the downgradient extent of contamination, determine whether the contamination was in the upper or lower shallow groundwater zone, and evaluate natural attenuation in groundwater. COCs were not detected in the lower shallow groundwater zone suggesting that PCE and TCE are only present in the upper shallow groundwater zone. 1,1-DCE was either not detected or was below the MCL in all monitoring wells (Shaw, 2007a).
- In 2005, an FS was conducted for LHAAP-35B (37) to present an analysis of remedial approaches and provide a basis for remedy selection consistent with the intended future use of the site as a wildlife refuge (Shaw, 2005b).
- Baseline Risk Assessment – From 1998 to 2007, a baseline human health risk assessment (HHRA) and a BERA were conducted (Jacobs, 2003; Shaw, 2007c). The HHRA indicated that the future maintenance worker exposure to on-site soil generated an acceptable cancer risk and non-cancer hazard. However, the groundwater posed an unacceptable cancer risk and non-cancer hazard to a future maintenance worker from hypothetical groundwater consumption. The BERA concluded that no unacceptable risk was present for the ecological receptors.

LHAAP-67

- Between 1998 and 2000 RI activities were conducted to identify the presence and extent of contamination in soil and groundwater at LHAAP-67. Seven monitoring wells were installed in the shallow groundwater zone. Soil samples were collected from three borings. Groundwater samples were collected from the wells and analyzed for VOCs, SVOCs, metals, explosive compounds and perchlorate. Soil samples were analyzed for VOCs, SVOCs, explosive compounds, and metals. **Figure 2-4** shows the monitoring and sampling locations. Investigation results indicated that there were metals and methylene chloride in the surrounding soils. Multiple constituents were detected in the groundwater; primarily 1,1,1-TCA, 1,1,2-TCA, 1,2-DCA, TCE, and 1,1- DCE.
- In 2004, as part of the groundwater data gaps investigation, additional groundwater sampling was conducted at the site. Groundwater analytical results indicate that chlorinated compounds detected above the MCLs were present in only one shallow monitoring well and at concentrations that were lower than those reported during the RI (Shaw, 2007d). In December 2006, additional groundwater sampling was conducted at the site. Analytical results indicated that only one well (67WW01) exhibited concentrations of TCE, 1,1-DCE, and 1,2-DCA exceeding their respective MCLs. Currently, 1,1,1-TCA and 1,1,2-TCA are not exceeding the MCLs (Shaw, 2007a).

- In 2005, an FS was conducted for LHAAP-67 to present an analysis of remedial approaches and provide a basis for remedy selection consistent with the intended future use of the site as a wildlife refuge (Shaw, 2005a).
- Baseline Risk Assessment – From 1998 to 2007, a baseline HHRA and a BERA were conducted (Jacobs, 2003; Shaw, 2007c). The HHRA indicated that the future maintenance worker exposure to on-site soil generated an acceptable cancer risk and non-cancer hazard. However, the groundwater posed an unacceptable cancer risk and non-cancer hazard to a future maintenance worker from hypothetical groundwater consumption. The BERA concluded that no unacceptable risk was present for the ecological receptors.

2.2.3 History of CERCLA Enforcement Activities

Due to the release of hazardous substances, pollutants, and contaminants from O&M activities at the facility, LHAAP was placed on the NPL on August 9, 1990. Activities to remediate contamination associated with the listing of LHAAP as a NPL site began in 1990. After the 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. Although not specifically listed as NPL sites, LHAAP-35B (37) and LHAAP-67 are considered NPL caliber by USEPA, TCEQ and Army and are addressed as such.

In order to evaluate a remedy for the sites, final FS reports were issued for LHAAP 35B (37) and LHAAP-67 (Shaw 2005a and 2005b). A Proposed Plan (U.S. Army, 2008a) facilitating public involvement in the selection of the remedy for LHAAP 35B (37) and LHAAP-67 was issued in June, 2008.

2.3 Community Participation

The U.S. Army, USEPA, TCEQ and the Restoration Advisory Board (RAB) have provided public outreach to the surrounding community concerning LHAAP 35B(37) and LHAAP-67 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 CERCLA Sections 113 (k)(2)(b), 117(a), and 121(f)(1)(g).

The Final Proposed Plan (U.S. Army, 2008a) for the selection of the remedy for LHAAP 35B(37) and LHAAP-67 was released to the Administrative Record, that is publically available in the Marshall Public Library, in June 2008 for public review and comment. A notice of availability of the Proposed Plan and other related documents in the Administrative Record file was published in *The Shreveport Times* and the *Marshall News Messenger* on June 16, 2008. A 30-day public comment period for the Proposed Plan began on June 17, 2008. The public

meeting was held on June 23, 2008. No comments were received during the public comment period. The Proposed Plan was re-opened for comment in March 2010 to address an administrative concern. A notice of availability of the Proposed Plan and other related documents in the Administrative Record file was published in the *Marshall News Messenger* and *The Shreveport Times* on February 21, 2010 and February 22, 2010, respectively. The public comment period was held from March 8 to April 8, 2010. The public meeting was held on March 9, 2010. A member of the RAB requested a public comment period extension of 30 days. Because the Proposed Plan was already open to public comment for a total of 60 days including the original 2008 public comment period, an additional 14 days were granted and the public comment period was extended to April 22, 2010. Written comments are addressed in the Responsiveness Summary, which is included in this ROD as **Section 4.0**.

Copies of the Administrative Record documents were made available to the public at several information repository locations, including LHAAP, USEPA Region 6 Library, TCEQ, and Marshall Public Library. Currently, the public repository of the Administrative Record may be found at the following location:

Public Library

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-35B (37) and LHAAP-67 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 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 Army intends to return the contaminated shallow groundwater zone at LHAAP-35B(37) and LHAAP-67 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 C.F.R. § 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 toward and discharge into Goose Prairie Creek adjacent to LHAAP-35B (37) and Central Creek near LHAAP-67, 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 LUCs may be terminated.

The selected remedy will ensure protection of human health and the environment. The selected remedy will include LUCs that restrict groundwater use. Groundwater monitoring will be implemented to demonstrate that the plumes are not migrating and to verify that contaminant levels are being reduced. LUCs may be terminated when contaminant levels are reduced to MCLs.

2.5 Site Characteristics

This section of the ROD presents an overview of the characterization of LHAAP-35B (37) and LHAAP-67 with respect to known or suspected sources of contamination, types of contamination, and affected media. Known or potential routes of contaminant migration are also discussed.

LHAAP-35B (37)

LHAAP-35B (37), a Chemical Laboratory, approximately 12.2 acres in size, is located in the north-central portion of LHAAP (**Figure 2-2**) near the southwestern corner of LHAAP-47 (**Figure 2-3**). The nearest significant surface water body is Goose Prairie Creek. The creek runs perpendicular to the western border of the site and then turns south through the east-central portion of the site and eventually drains into Caddo Lake. Caddo Lake is a source of drinking water for several communities in Louisiana.

Topsoil at LHAAP-35B(37) ranges in thickness from 0 to 4 feet and consists of the Quaternary silty clay underlain by alternating layers of clayey sand, silty sand, and poorly sorted sand of the Wilcox Group. The sand layers are laterally discontinuous and separated by silty clay.

Groundwater at the site was encountered at 12 to 33 feet below ground surface (bgs) in the upper shallow zone, to 47 feet in the lower shallow zone, and at about 70 feet in the intermediate zone. December 2007 shallow and intermediate groundwater data indicated that flow at the site was to

the south-southeast (Figure 2-5), although the shallow groundwater flow direction may vary locally during high water table conditions due to the influence of Goose Prairie Creek.

For the shallow groundwater zone, hydraulic conductivity values in the sand units ranged from a minimum value of 4.3×10^{-4} centimeters per second (cm/sec) in the northwest portion of the site to a maximum value of 7.7×10^{-4} cm/sec east of the site. The average groundwater flow rate is 1.74 feet/day for LHAAP-35B(37), based on the average hydraulic conductivity, hydraulic gradient, and effective porosity (Shaw, 2007e).

LHAAP-67

LHAAP-67, a former Aboveground Storage Tank Farm, approximately 1.9 acres in size, is located in the central portion of LHAAP on the southeast corner of 48th Street and Ignatius Avenue (**Figure 2-2**). The nearest significant surface water body to LHAAP-67 is Central Creek located approximately 870 feet southeast of the site (**Figure 2-4**). Runoff from LHAAP-67 could potentially discharge to surface water in Central Creek which flows into Caddo Lake. The lake is a source of drinking water supply for several neighboring communities in Louisiana.

Across the site, below the surficial fill, lies a silty clay of the Wilcox Group ranging in thickness from about 2 to 15 feet. The clay grades into a fine-grained silty sand thickening toward the east-southeast.

Groundwater at the site, encountered at depths of 17 to 20 feet bgs, has an easterly and southeasterly flow (**Figure 2-6**). For the shallow groundwater zone, hydraulic conductivity values of the sand units ranged from a minimum value of 1.2×10^{-5} cm/sec to a maximum value of 1.0×10^{-2} cm/sec. The average groundwater flow rate is 14.7 feet/day for LHAAP-67, based on the average hydraulic conductivity, hydraulic gradient and effective porosity (Shaw, 2007e).

2.5.1 Conceptual Site Model

LHAAP-35B (37)

The overall conceptual site model (CSM) for LHAAP-35B (37) is illustrated in **Figure 2-7**. The model presents those pathways that have been demonstrated to be complete, as evidenced by the presence of contamination and an expected receptor or hypothetical receptor. The U.S. Army has also considered the NCP's expectation to return usable groundwaters to their potential beneficial uses wherever practicable and the State of Texas designation of all groundwater as potential drinking water, unless otherwise classified, and consistent with 30 TAC 335.563(h)(1). Although the groundwater is not currently being used, nor is it expected to be used in the future, the groundwater pathway is being considered for remediation because it has the potential to

present an unacceptable risk to the maintenance worker. Those pathways that are likely incomplete or have negligible impact are not being considered for remediation.

Except for a single detection of acetone at 21 micrograms per kilogram ($\mu\text{g}/\text{kg}$), there were no detections of VOCs in the soil samples taken from LHAAP-35B (37). Although low concentrations of SVOCs, metals, dioxins, furans, and pesticides were detected, the carcinogenic risk and non-carcinogenic hazard for soil was acceptable for a future maintenance worker.

Groundwater contamination was detected in monitoring wells LHSMW58, 35BWW04, and 35BWW05, and in monitoring well LHSMW59 and its replacement well 35BWW08, located several hundred feet and potentially upgradient from LHSMW58. The contamination in monitoring wells LHSMW59 and 35BWW08 may be due to an unidentified historic source in the vicinity of these wells. Alternatively, potential variations in local groundwater flow direction may have caused contamination from a historic source located within the vicinity of monitoring well LHSMW58 to migrate to monitoring wells LHSMW59 and 35BWW08. Eleven different VOCs were detected in monitoring well LHSMW58 and six different VOCs were detected in monitoring well LHSMW59 during the sampling events. The groundwater COCs include 1,1-DCE, TCE, and PCE and they are contained entirely within the upper shallow groundwater sands. The maximum 1,1-DCE, TCE, and PCE concentrations detected in groundwater at LHAAP-35B(37) are 58 micrograms per liter ($\mu\text{g}/\text{L}$), 330 $\mu\text{g}/\text{L}$, and 34 $\mu\text{g}/\text{L}$, respectively, which exceed the MCLs of 7 $\mu\text{g}/\text{L}$, 5 $\mu\text{g}/\text{L}$, and 5 $\mu\text{g}/\text{L}$, respectively. There is no groundwater contamination of the intermediate zone, and although there is likely limited interconnectivity between the shallow and intermediate zones because of the laterally and vertically discontinuous nature of the channel sands, flow is predominantly horizontal through these units.

Although not indicated by the data, there is a concern that the COCs present in shallow groundwater beneath LHAAP-35B (37) could potentially discharge to surface water in Goose Prairie Creek which flows to Caddo Lake, a drinking water source. The LHAAP-35B(37) potentiometric map generated from the December 2007 water level measurements indicates that the groundwater flow at LHAAP-35B (37) has a predominantly south-southeasterly flow direction, although the overall trend in groundwater flow direction at Longhorn is east-northeast toward Caddo Lake. Surveyed elevation of the Goose Prairie Creek bed is 186.86 feet above mean sea level (msl), and the water level elevation in the shallow groundwater zone is 186.31 feet msl (measured in September 2004). These data indicate that the shallow zone water table is below the creek and does not discharge to the Goose Prairie Creek during certain parts of the year. Additional creek and groundwater elevation data is provided in Table 2, Appendix M of the Shaw Final Modeling Report Derivation of Soil and Groundwater Concentrations Protective of Surface Water and Sediment LHAAP Revision I, February 2007. However, due to uncertainties regarding the seasonal variations in the water table elevation it is assumed that the shallow groundwater may discharge into the creek when the water table is higher. Because the

intermediate zone is deeper than the shallow zone, it is improbable that the groundwater from the intermediate zone would discharge to Goose Prairie Creek.

Modeling calculations were completed to assess the potential for the COCs present in shallow groundwater at LHAAP-35B (37) to migrate toward and discharge to Goose Prairie Creek. The modeling assumes an instantaneous source (i.e., contaminant plume) with no contaminant leaching from vadose zone soil to groundwater. Based on the results of the instantaneous source model, PCE and 1,1-DCE will not appear at detectable levels where groundwater discharges into Goose Prairie Creek. The maximum concentration of TCE (3.63 µg/L) appears at the point of entry of the groundwater into Goose Prairie Creek after approximately 39 to 43 years (Shaw, 2007e), and is below the MCL for TCE of 5 µg/L. TCE would be diluted further after entry into the surface water, most likely to undetectable levels. Note that the TCE concentration used for the modeling was the historical maximum of 330 µg/L detected at monitoring well LHSMW59. It is, therefore, concluded that contaminants present in the shallow groundwater at LHAAP-35B (37) will not adversely impact Goose Prairie Creek surface water during intermittent periods of discharge to the creek.

LHAAP-67

The overall conceptual model for LHAAP-67 is illustrated in **Figure 2-8**. The model presents those pathways that have been demonstrated to be complete, as evidenced by the presence of contamination, and an expected receptor or hypothetical receptor. The U.S. Army has also considered the NCP's expectation to return usable groundwaters to their potential beneficial uses wherever practicable and the State of Texas designation of all groundwater as potential drinking water, unless otherwise classified, and consistent with 30 TAC 335.563(h)(1). Although the groundwater is not currently being used, nor is it expected to be used in the future, the groundwater pathway is being considered for remediation because it has the potential to present an unacceptable risk to the maintenance worker. Those pathways that are likely incomplete or have negligible impact are not being considered for remediation. It is assumed that in the past, releases from the tanks contaminated the soil and then leached from the soil into the groundwater. Previous soil investigation indicated the presence of methylene chloride at a relatively low concentration of 5.9 µg/kg in the 0- to 5-foot-depth interval. Based on the soil sampling investigation, residual contamination is likely not present in the soils at significant levels. This is believed to be due to the volatilization and vertically downward migration of the contaminants that might have been present in the vadose zone. A relatively small area of contamination is observed in the shallow groundwater, with the extent of contamination defined, both laterally and vertically. The groundwater contamination poses an unacceptable carcinogenic risk and non-carcinogenic hazard to a future maintenance worker under an industrial scenario. There is no groundwater contamination of the intermediate zone, and although there is likely limited interconnectivity between the shallow and intermediate zones

because of the laterally and vertically discontinuous nature of the channel sands, flow is predominantly horizontal through these units.

Although not indicated by the data, there is a concern that the COCs (1,1-DCE, 1,2-DCA, 1,1,1-TCA, 1,1,2-TCA, and TCE) present in groundwater beneath LHAAP-67 could potentially discharge to surface water in Central Creek located to the southeast of the site, which flows to Caddo Lake, a drinking water source. The shallow groundwater potentiometric surface indicates that the groundwater from LHAAP-67 has an easterly and southeasterly flow and may discharge into Central Creek. Surveyed elevation of the Central Creek bed is 168.54 feet above mean sea level (msl), and the water level elevation in the shallow groundwater zone is 168.05 feet msl (measured in September 2004). These data indicate that the shallow zone water table is below the creek and does not discharge to the Central Creek during certain parts of the year. Additional creek and groundwater elevation data is provided in Table 3, Appendix M of the Shaw Final Modeling Report Derivation of Soil and Groundwater Concentrations Protective of Surface Water and Sediment LHAAP Revision I, February 2007. However, due to uncertainties regarding the seasonal variations in the water table elevation it is assumed that the shallow groundwater may discharge into the creek when the water table is higher. Because the intermediate zone is deeper than the shallow zone, it is improbable that the groundwater from the intermediate zone would discharge to Central Creek.

Modeling calculations were completed to assess the potential for groundwater COCs at LHAAP-67 to migrate toward and discharge to nearby Central Creek (Shaw, 2007e). Two different scenarios were modeled using a total simulation period of 100 years, which was long enough to capture the maximum contaminant concentrations where groundwater discharges into Central Creek. The first scenario assumes an instantaneous source in which there is no contaminant leaching from vadose zone soil to groundwater. The second scenario, which is more conservative and less likely, assumes a continuous source of contaminant leaching from the vadose zone soil to groundwater over time. This scenario was considered in order to account for a case where a VOC source may be present in the soil in an area or depth that was not sampled during the RI. Based on the results of the instantaneous source model, the maximum COC concentrations were below their respective MCLs where groundwater discharges into Central Creek. Furthermore, based on the results of the continuous source model, multiple groundwater COCs could eventually exceed their respective MCLs where groundwater discharges into Central Creek in less than 16, but up to 29 years. Therefore, additional modeling was completed with calculated dilution within Central Creek. The resultant concentrations of the COCs in Central Creek after dilution were less than 3 percent of their respective MCLs. It is, therefore, concluded that contaminants present in the groundwater at LHAAP-67 will not adversely impact the surface water.

2.5.2 Nature and Extent of Contamination

2.5.2.1 LHAAP-35B (37)

From April 1993 to October 1998, RI activities were conducted in three phases at LHAAP-35B (37). The RIs were conducted to define the nature and extent of contamination at LHAAP-35B (37) by Jacobs (Jacobs, 2002a). During the three phases of investigation, soil and groundwater samples were collected and analyzed for VOCs, SVOCs, explosive compounds, metals, pesticides, PCBs, and dioxins/furans. In addition, groundwater samples from Phase III were analyzed for herbicides, TPH, and cyanide. The sampling locations are shown on **Figure 2-3**. **Tables 2-1** and **2-2** present summaries of the analytical data. Analytical results indicated that environmental contamination exists at LHAAP-35B (37).

Soil. During RI activities, 10 soil samples were collected from six locations including a waste rack sump location. The soil analytical results indicated that metals, VOCs, SVOCs, pesticides, and dioxins/furans were detected in soils samples. Metals including aluminum, arsenic, barium, beryllium, cadmium, calcium, total chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, strontium, vanadium, and zinc were detected at low concentrations in soil. Acetone was the only VOC detected at a low concentration in one of the ten soil samples. Ten SVOCs were detected infrequently and at low concentrations in the surface soil samples including benzo(a)anthracene, benzo(b)pyrene, benzo(b)fluoranthene, benzo(g,h,i)pyrene, chrysene, fluoranthene, indeno(1,2,3-c,d)pyrene, phenanthrene, pyrene, and bis(2-ethylhexyl)phthalate. Three pesticides including aldrin, p,p-DDT (dichlorodiphenyldichloroethylene), and p,p-DDE (dichlorodiphenyltrichloroethane) and dioxins/furans were also detected. Despite the number of contaminants found, none of the contaminants were determined to pose unacceptable risk to the industrial maintenance worker (Jacobs, 2003).

Groundwater. Between 1993 and 1998, ten groundwater samples were collected from four monitoring wells to characterize the shallow and intermediate groundwater at LHAAP-35B (37). Metals, VOCs, SVOCs, explosives, and furans were detected in groundwater at the site. Twenty metals, including aluminum, antimony, barium, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, sodium, strontium, thallium, vanadium, and zinc were detected in multiple monitoring wells. Of the 13 VOCs detected in groundwater, four VOCs were only detected once in monitoring well LHSMW58 including 1,1-DCE, benzene, chloroform, and total 1,2-DCA. 1,2,4-trichlorobenzene, acetone, and carbon disulfide were each also only detected once in monitoring wells LHSMW59, 35BWW02 and 35BWW03, respectively. Other VOCs detected at the site included 1,1,1-TCA, 1,1-DCE, chlorobenzene, PCE, TCE, trichlorofluoromethane, and cis-1,2-DCE. The primary VOC contaminants detected in groundwater at the site; 1,1-DCE, TCE, and PCE were detected at maximum concentrations of 58, 330, and 34 parts per billion, respectively.

Only two SVOCs, di-n-octylphthalate and bis(2-ethylhexyl)phthalate and two explosive compounds 1,3-dinitrobenzene and tetryl were detected at low concentrations in monitoring wells LHSMW58 and LHSMW59. Two furans, total hexachlorinated dibenzofurans and 1,2,3,4,7,8-hexachlorodibenzofuran, were each detected once in monitoring well LHSMW59. Anions including chloride, nitrate, nitrite, and sulfate exhibited a degree of variability across the site.

Sampling for perchlorate was first performed at 35BWW02 in 1998. Two samples for perchlorate analysis were collected from LHSMW58 in 2000.

In 2004, as part of the groundwater data gaps investigation, an additional monitoring well, 35BWW03, was installed in the intermediate groundwater zone, and additional groundwater sampling was conducted at the site (Shaw, 2007d). Groundwater samples were collected from four monitoring wells (35BWW01, 35BWW03, LHSMW58, and LHSMW59) (35BWW02 was dry), and analyzed for VOCs. A total of five VOCs were detected in monitoring wells 35BWW03, LHSMW58, and LHSMW59. Carbon disulfide was detected in monitoring well 35BWW03 at a concentration of 8 µg/L, and chlorobenzene was detected in monitoring well LHSMW58 at 2J µg/L. 1,1-DCE, PCE, and TCE were also detected in monitoring well LHSMW58 at concentrations of 4J µg/L, 20 µg/L, and 33 µg/L, respectively. PCE and TCE were detected in monitoring well LHSMW59 at concentrations of 3J µg/L and 180 µg/L, respectively. The concentrations of the primary contaminants detected during this investigation were lower than historical concentrations.

In August 2006, groundwater samples were collected from the existing four monitoring wells (35BWW01, 35BWW03, LHSMW58 and LHSMW59); one well (35BWW02) was dry. The water samples were analyzed for the primary VOCs contaminants, TCE, PCE and 1,1-DCE. TCE, PCE and 1,1-DCE were detected in the shallow groundwater zone in monitoring wells LHSMW58 and LHSMW59 at maximum concentrations of 135, 21.8 and 2.11 µg/L, respectively. These concentrations were lower than the Jacobs data. PCE at 21.8 µg/L was higher than the 2004 data.

In December 2006, three new monitoring wells were installed at the site. The purpose of these wells was to define the downgradient extent of contamination, determine whether the contamination was in the upper or lower shallow groundwater zone, and evaluate natural attenuation in groundwater (Shaw, 2007b). VOCs were not detected in the lower shallow groundwater zone suggesting that PCE and TCE are only present in the upper shallow groundwater zone. TCE, PCE and 1,1-DCE were detected in monitoring wells LHSMW58, LHSMW59, and 35BWW04 at maximum concentrations of 166, 30.1 and 3.34 µg/L, respectively. Results of the groundwater monitoring indicated that LHAAP-35B (37)

contaminants are confined in the shallow groundwater zone and have not migrated into the intermediate zone.

In September 2007, two monitoring wells, 35BWW07 and 35BWW08, were installed at the site. The purpose of monitoring well 35BWW07 was to define the downgradient extent of contamination. The purpose of monitoring well 35BWW08 was as a replacement well for monitoring well LHSMW59. Monitoring well LHSMW59 was plugged and abandoned. Monitoring well LHSMW59 had been completed in both the upper and lower shallow groundwater zones at LHAAP-35B (37). Both of the new monitoring wells were completed in the upper shallow groundwater zone. The two monitoring wells were sampled for VOCs. Four VOCs (Acetone, cis-1,2-DCE, PCE, and TCE) were detected in monitoring well 35BWW08 at concentrations of 6.04, 0.407, 0.981, and 150 µg/L, respectively. VOCs were not detected in monitoring well 35BWW07. Results of the groundwater sampling indicate that the elevated VOC concentrations are located in the upper shallow groundwater zone at LHAAP-35B (37).

In addition, natural attenuation has effectively controlled plume migration and appears to have stabilized the VOC plume. The groundwater data collected at LHAAP-35B (37) indicated a decrease in PCE and TCE concentrations from their historical high values over the 12 year monitoring period. The MNA evaluation demonstrated that natural attenuation mechanisms, including reductive biodegradation, dilution, dispersion, sorption, and volatilization, may all be contributing to the observed reduction in COC concentrations at LHAAP-35B (37). Biodegradation pathways such as cometabolic or oxidative dechlorination may also have contributed to the reduction of COCs at the site (Shaw, 2007a). **Table 2-2** presents the maximum concentrations of all constituents detected in groundwater at LHAAP-35B (37) during the RI and subsequent investigations.

Groundwater was determined by the baseline risk assessment to pose an unacceptable risk or hazard to a hypothetical future maintenance worker at LHAAP-35B (37) under an industrial scenario (Jacobs, 2003). The primary COCs for LHAAP-35B (37) groundwater are TCE, PCE, and 1,1-DCE due to their significant contribution to the total risk. Additionally, hazardous substances present in LHAAP-35B (37) groundwater could also potentially discharge to surface water in Goose Prairie Creek, which flows to Caddo Lake, a drinking water supply.

2.5.2.2 LHAAP-67

Soil

During RI activities, nine soil samples were collected from three soil borings that were completed immediately adjacent to the existing monitoring well locations. The soil borings were sampled for VOC, SVOCs, metals, and explosive compounds. Soil analytical results indicated that metals and one VOC were detected in soil samples. Metals including aluminum, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium,

manganese, nickel, potassium, selenium, silver, sodium, strontium, vanadium, and zinc were detected at low concentrations in soil. Methylene chloride was the only VOC detected at a maximum concentration of 5.9 µg/kg in the soil samples. No SVOCs or explosive compounds were detected in the soil. **Table 2-3** presents maximum concentrations of the constituents detected in soil at LHAAP-67. None of the detected compounds were determined to pose unacceptable risk to the industrial maintenance worker (Jacobs, 2003).

Groundwater

Between 1998 and 2000, groundwater samples were collected from seven monitoring wells to characterize the shallow and intermediate groundwater at LHAAP-67. Metals, VOCs, and anions were detected in groundwater at the site. Nineteen metals, including aluminum, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, selenium, sodium, strontium, thallium, and zinc were detected in multiple monitoring wells. Of the metals detected, only thallium and barium, having maximum concentrations of 0.0021 and 3.3 milligrams per liter (mg/L), exceeded their respective MCLs of 0.002 and 2 mg/L, respectively. Out of the twelve VOCs detected in groundwater, five VOCs 1,1,1-TCA, 1,1,2-TCA, 1,2-DCA, TCE, and 1,1-DCE were detected at maximum concentrations of 1,800, 33, 27, 6.3, and 380 µg/L, respectively, levels that exceeded their respective MCLs. No SVOCs were detected in the groundwater samples.

In 2004, as part of the groundwater data gaps investigation, additional groundwater sampling was conducted at the site. Groundwater samples were collected from the seven existing monitoring wells and analyzed for VOCs. Groundwater analytical results indicate that only three VOCs were detected above the MCLs. TCE, 1,1-DCE, and 1,2-DCA at concentrations of 6, 280, and 13 µg/L, respectively, were present in only one shallow monitoring well 67WW01 and at concentrations that were lower than those reported during the RI.

In August 2006, groundwater samples were collected from the existing six monitoring wells (67WW01, 67WW02, 67WW03, 67WW05, 67WW06, and 67WW07). The water samples were analyzed for the primary VOCs contaminants. Contaminants were only detected in monitoring well 67WW01 except for 1,2-DCA that was detected at a concentration of 3.02J µg/L in monitoring well 67WW06. TCE, 1,1-DCE, 1,2-DCA, and 1,1,2-TCA were detected in well 67WW01 at concentrations of 5.38, 153, 5.57, and 0.035J µg/L, respectively. These concentrations were lower than the levels detected during the previous RI activities.

In December 2006, additional groundwater sampling was conducted at the site including monitoring and evaluation of the natural attenuation process. Analytical results indicated that only one well (67WW01) exhibited concentrations of TCE (5.99 µg/L), 1,1-DCE (179 µg/L), 1,2-DCA (6.1 µg/L) and vinyl chloride (2.34 µg/L) exceeding their respective MCLs. During

both the 2004 and 2006 sampling events, 1,1,1-TCA and 1,1,2-TCA were detected below their respective MCLs.

At LHAAP-67, the evaluation of historical VOC trends provided strong evidence that natural attenuation processes have contributed to a significant reduction in COC concentrations and prevented plume migration. This data also suggested that natural attenuation mechanisms other than reductive biodegradation such as dilution, dispersion, sorption, and volatilization are likely the primary contributors to the reduction in COC concentrations at LHAAP-67. Other biodegradation pathways such as cometabolic or oxidative dechlorination may also have contributed to the reduction of COCs (Shaw, 2007a). **Table 2-4** presents the maximum concentrations of all constituents detected in groundwater at LHAAP-67 during the RI and subsequent investigations.

Groundwater was determined by the baseline risk assessment to pose an unacceptable risk or hazard to a hypothetical future maintenance worker at LHAAP-67 under an industrial scenario (Jacobs, 2003). The primary COCs for LHAAP-67 groundwater are TCE, 1,1-DCE, and 1,2-DCA, 1,1,1-TCA and 1,1,2-TCA due to their significant contribution to the total risk. Additionally, hazardous substances present in LHAAP-67 groundwater could also potentially discharge to surface water in Central Creek, which flows to Caddo Lake, a drinking water source.

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. Large production activities continued until the facility was determined to be in excess of the Army's needs in 1997. The plant area has been relatively dormant since that time. Selected areas of the plant were used for waste management (e.g., treatment or disposal). 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. Approved access for hunters is very limited.

The anticipated future use is as a part of a wildlife refuge, which is consistent with an industrial use scenario for risk assessment purposes (U.S. Army, 2004). The U.S. Army has already transferred nearly 7,000 acres, including LHAAP-67, to the USFWS for management as The

Caddo Lake National Wildlife Refuge. LHAAP-35B (37) and LHAAP-67 sites are surrounded by an area that has already been transferred to the USFWS.

2.6.2 Current and Future Surface Water Uses

Streams on LHAAP currently support wildlife and aquatic life. While humans may have limited access to some streams during annual hunts, there is no routine human use of streams on LHAAP. The streams do not carry adequate numbers and size of fish to support either sport or subsistence fishing. The streams discharge 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 the streams and lake are the same as the current uses.

2.6.3 Current and Future Groundwater Uses

Groundwater in the deep aquifer (250-430 feet bgs) near LHAAP is currently used as a drinking water source. 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. Because of the large distance between these wells and LHAAP, their location upgradient of LHAAP, and the completion of the wells in a zone stratigraphically lower than the depth of groundwater contamination at LHAAP, water removal from these wells is not expected to affect groundwater flow at the site, nor be impacted by LHAAP's contaminated groundwater. In addition, there are several livestock and domestic wells located in the vicinity of LHAAP with depths averaging approximately 250 feet.

There are three deep water supply wells located on LHAAP (**Figure 2-2**) and all three supply water to the buildings currently in use at the installation. All three wells supply water to the tap, but none are used for drinking water, even though uncontaminated. These wells are located upgradient of LHAAP-35B (37) and LHAAP-67. One well is located at the Fire Station/Security Office approximately 0.35 miles and 1.0 mile northwest of LHAAP-35B (37) and LHAAP-67, respectively. The second well is located approximately one-half mile southwest of the Fire Station/Security Office, 0.6 miles west of LHAAP-35B (37) and 1.14 miles west-northwest of LHAAP-67. The third well is located north of the administration building, near the entrance to LHAAP approximately 1.42 miles southwest of LHAAP-35B (37) and 1.97 miles west-

southwest of LHAAP-67. Two additional wells previously supplied water to the installation, but these have been plugged and abandoned. None of the water supply wells are associated with or in imminent danger from the localized contaminated groundwater at LHAAP-35B (37) and LHAAP-67.

Although the anticipated future use of the facility as a wildlife refuge may not include the use of the groundwater at LHAAP-35B(37) and LHAAP-67 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

This section summarizes the results of the baseline human health and ecological risk assessments conducted for LHAAP-35B (37) and LHAAP-67 (Jacobs, 2003; Shaw, 2007c). Certain changes to the ecological portion of the assessment were made since 2002 and are discussed below. Risk assessments were conducted during the RI for LHAAP-35B (37) and LHAAP-67 in accordance with USEPA risk assessment guidance (USEPA, 1989). The assessments provide a basis for taking action, if any, and identifying the chemicals and exposure pathways that should be addressed by a remedial action. The data used for the HHRA was collected prior to 2003. The occurrence of COCs and the toxicity data used in the HHRA are shown in **Tables 2-5** through **2-8**. The results of the HHRA for LHAAP-35B (37) and LHAAP-67 are summarized in **Tables 2-9** through **2-12**.

Figures 2-7 and **2-8** present the CSM for exposure pathways associated with LHAAP-35B (37) and LHAAP-67. The CSM illustrate the contaminant source medium, release mechanisms, exposure pathways, migration routes, and potential receptors at the site.

The risk assessments consist of an HHRA (Jacobs, 2003) and an ecological risk assessment (ERA) (Shaw, 2007c). The overall goal of both the HHRA and the ERA is to furnish information to risk managers and stakeholders to assist in the evaluation of options for closure, biomonitoring, and/or remediation of a site to mitigate the risks.

2.7.1 Human Health Risk Assessment Summary

An HHRA is based on a conservative estimate of the potential cancer risk or noncancer hazard from potential exposure. The following three factors were considered in the evaluation:

- Nature and extent of contamination at LHAAP-35B (37) and LHAAP-67
- Exposure pathways through which human receptors are or may be exposed to those contaminants at the site

- Potential toxic effects of those contaminants

Risk from exposure to soil and groundwater are presented in the summary of risks for these sites. Potential risks to human health were determined according to USEPA guidance to ensure that conservative estimates of potential health effects are obtained. The risk estimates reflect the anticipated uses of the land.

A conservative estimate of risk was developed incorporating the potential exposure pathways, which included direct skin contact with contaminated soil, incidental ingestion of soil, inhalation of contaminated chemical vapors and soil particles, ingestion of groundwater, dermal contact with both soil and groundwater, and inhalation of vapors during non-ingestion groundwater use. Plausible human receptors that may be exposed to soil and/or groundwater at the sites included maintenance workers under future land use conditions consistent with the anticipated use as a national wildlife refuge (industrial scenario), and on-site trespassers under current site conditions. It was assumed that trespassers would not have contact with groundwater.

The HHRA was performed to determine potential health impacts of human exposure to chemicals detected in soil between 0 to 2 feet bgs (for the maintenance worker) and 0 to 6 inches bgs (for the trespasser). Health impacts from groundwater were also evaluated for hypothetical use of the groundwater underlying LHAAP-35B (37) and LHAAP-67 as a potable water source (Jacobs, 2003).

2.7.1.1 Identification of Chemicals of Concern

LHAAP-35B (37)

The HHRA for LHAAP-35B (37) was based on ten soil samples that were collected from five locations (**Table 2-1**). Thirty-three groundwater samples were collected from eight wells (**Table 2-2**) (Jacobs, 2003). The frequency of detections shown in **Table 2-1** and **Table 2-2** varies as a result of the different lists of analytes specified by the various groundwater sampling efforts described in the Jacobs (2003) risk assessment, and subsequent sampling events.

The soil analytical results indicated that metals, VOCs, SVOCs, pesticides, and dioxins/furans were detected in soil samples. Of these detected chemicals, the risk assessment identified no COCs in soil from both 0 to 0.5 feet bgs and 0 to 2 feet bgs (Jacobs, 2003).

Metals, VOCs, SVOC, explosives, and dioxin/furans were detected in groundwater (**Table 2-2**). The risk assessment identified antimony, thallium, 1,1-DCE, PCA, and TCE as COCs in groundwater. The ranges of detected concentrations, frequency of detection, and EPC of each COC in groundwater are shown in **Table 2-5**.

LHAAP-67

The assessment for LHAAP-67 was based on 11 soil samples that were collected from three soil borings (**Table 2-3**). The frequency of detections shown in **Table 2-3** varies as a result of the different lists of analytes specified by the various sampling efforts described in the Jacobs (2003) risk assessment.

The soil analytical results indicated that metals, VOCs, SVOCs, pesticides, and dioxins/furans were detected in soil samples. Of these detected chemicals, the risk assessment identified no chemicals as COCs in soil from both 0 to 0.5 feet bgs and 0 to 2 feet bgs (Jacobs, 2003).

Metals and VOCs were detected as COCs in groundwater. The risk assessment identified barium, manganese, strontium, thallium, 1,1,1-TCA, 1,1,2-TCA, 1,1-DCE, 1,2-DCA, and TCE as COCs. The ranges of detected concentrations, frequency of detection, and EPC of each COC in groundwater are shown in **Table 2-6**.

2.7.1.2 Exposure Assessment

The exposure assessment evaluated potential exposure of current trespassers and future maintenance workers at each site. Each assessment involved assumptions of a high reasonable maximum exposure (RME). The RME assumptions were designed to provide high estimates of exposure and lead to a conservatively high estimate of related risk. The exposure pathways evaluated in the risk assessment are shown for LHAAP-35B (37) and LHAAP-67 in **Figures 2-7** and **2-8**, respectively. The HHRA by Jacobs (2003) evaluated the current trespasser and future maintenance workers at each site.

Current Trespasser Scenario

Exposure of the trespasser at either site was evaluated only for chemicals contained in soil within 0 to 0.5 feet bgs. The exposures evaluated incidental soil ingestion, dermal contact with soil, inhalation of particulates generated from soil, and the inhalation of volatile emissions from soil. Access to the groundwater is only at the active areas of the plant, which does not include either LHAAP-35B (37) or LHAAP-67. The trespasser to either site was assumed to be a 70 kilogram (kg) adult with an averaging time (AT) of 70 years for cancer risk. The trespasser was assumed to visit either site at an exposure frequency (EF) of 50 days/year. The trespasser was assumed to visit either site for exposure duration (ED) of 12 years. The AT for non-cancer hazard equals the ED value.

The assumed soil ingestion rate was 100 milligrams per day (mg/day) for both sites and the fraction absorbed by the ingestion pathway (FI) was 1.0, that is to indicate that it was assumed that ingested chemicals were completely absorbed into the body.

For the dermal exposure assessment, the exposed skin surface area (SA) value of 3,500 square centimeters (cm²) was assumed. The value of the adherence factor of soil to skin (AF) for the absorption was 0.1 milligrams per square centimeter (mg/cm²). The values of the absorption

fraction of chemicals through the skin (ABS) are chemical specific and the same values were used for both sites. The details of the ABS calculations are provided in the risk assessment document (Jacobs, 2003).

For the dust inhalation exposure assessment, the particulate emission factor (PEF) was assumed to equal 4.63×10^9 cubic meters per kilogram (m^3/kg) at both sites. Chemical specific volatilization factors (VFs) were calculated for each volatile chemical. Details of these calculations are provided in the risk assessment document (Jacobs, 2003).

Groundwater ingestion was considered to be an incomplete exposure pathway in the risk assessment for the trespasser scenario at both sites (**Figures 2-7 and 2-8**).

Future On-Site Maintenance Worker Scenario

Exposure of the maintenance worker at either site was evaluated for chemicals contained in soil within 0 to 2 feet bgs and groundwater. The exposures evaluated incidental soil ingestion, dermal contact with soil, inhalation of particulates generated from soil, and the inhalation of volatile emissions from soil.

The maintenance worker was assumed to be a 70 kg adult with an AT of 70 years for cancer risk. The assumed EF for the maintenance worker was 250 days/year, and the assumed ED was 25 years. The AT for noncancer hazard equals the ED value.

The assumed soil ingestion rate was 100 mg/day and the FI was 1.0. For the dermal exposure assessment, the SA value was 3,200 cm^2 and the AF value was 0.2 mg/cm^2 . The values of the ABS are chemical specific and the same values were used for both sites. The details of the ABS calculations are provided in the risk assessment document (Jacobs, 2003).

For the dust inhalation exposure assessment, the PEF was assumed to equal 4.63×10^9 m^3/kg at both sites. Chemical specific VFs were calculated for each volatile chemical. Details of these calculations are provided in the risk assessment document (Jacobs, 2003).

Exposures to groundwater were evaluated for the maintenance worker scenario. The maintenance worker was assumed to ingest groundwater at a rate of 1 liter per day. Dermal exposures and inhalation of volatiles from groundwater were assumed to occur during showering.

For the dermal exposure assessment, the SA value was 23,000 cm^2 and the exposure time was 0.20 hours/day. The EF and ED values assumed for ingestion exposures were used in the dermal exposure evaluation. The calculations of permeability factor (K_p) that describe absorption of chemicals in water through skin are chemical specific and are described in the risk assessment document (Jacobs, 2003).

For the inhalation exposure to vapors from groundwater, an AF of 0.5 was made to the EF to account for the reduced time that the maintenance worker spends indoors. The volatilization factor (K) of 0.5 liter per cubic meter was used in the vapor inhalation assessment.

2.7.1.3 Toxicity Assessment

The toxicity factors used to evaluate cancer and non-cancer risk from exposure to COCs are shown in **Tables 2-7** and **2-8**, respectively. The cancer slope factors, or inhalation unit risk factors, and noncancer reference doses (RfDs), or inhalation reference concentrations, were selected from the USEPA Integrated Risk Information System (IRIS). If no value was available in the IRIS, then values from the USEPA National Center for Environmental Assessment (NCEA) or the TCEQ were used.

2.7.1.4 Risk Characterization

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

$$\text{Risk} = \text{chronic daily intake (CDI)} \times \text{SF}$$

Where: Risk = the probability of an individual's developing cancer

CDI = chronic daily intake averaged over 70 years (milligrams per kilogram per day [mg/kg-day])

SF = slope factor, expressed as (mg/kg-day)⁻¹

These risks are probabilities that usually are expressed in scientific notation (e.g., 1×10^{-6}). An excess lifetime cancer risk of 1×10^{-6} indicates that an exposed individual has a 1 in 1,000,000 chance of developing cancer as a result of the exposure. This is referred to as the "excess lifetime cancer risk" because it would be in addition to the risks of cancer individuals face from other causes. The chance of an individual's 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 10^{-6} to 10^{-4} .

The potential for noncancer effects is evaluated by comparing an exposure level over a specified time with an 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 noncarcinogenic effects from that chemical are unlikely. The hazard index (HI) is generated by adding the HQs for all COCs that affect the same target organ or act through the same mechanism of action within a medium or across all media to which the individual may reasonably be exposed. An HI < 1 indicates that,

based on the sum of all HQs from different contaminants and exposure routes, toxic noncarcinogenic effects from all contaminants are unlikely. An HI>1 indicates that site-related exposures may present a hazard to human health.

The HQ is calculated as follows:

$$\text{Noncancer HQ} = \text{CDI/RfD}$$

Where: CDI = chronic daily intake

RfD = reference dose

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

LHAAP-35B (37)

Current Trespasser Scenario

All cancer risks associated with potential exposure of the trespasser to COCs in soil by all exposure pathways is 4×10^{-7} when rounded to 1 significant figure as specified in USEPA (1989) guidance, which is below the 1×10^{-6} to 1×10^{-4} acceptable range (USEPA, 1990). The calculated noncancer HI for potential exposure to COCs by all exposure pathways is 0.02 rounded to 1 significant figure as specified in USEPA (1989) guidance, which is below the acceptable value of 1 (USEPA, 1990).

Future On-Site Maintenance Worker Scenario

Cancer risks associated with potential exposure of the future maintenance worker to COCs in surface soil (0 to 0.5 feet bgs) and groundwater are summarized in **Table 2-9**. The calculated cancer risk for potential exposure to COCs in soil at LHAAP-35B (37) is 5×10^{-6} when rounded to 1 significant figure, which is within the 1×10^{-6} to 1×10^{-4} acceptable range (USEPA, 1990).

The calculated cancer risk for potential exposure to COCs in groundwater is 6×10^{-4} , which is above the 1×10^{-6} to 1×10^{-4} acceptable ranges (USEPA, 1990). The risk is predominantly associated with exposure to 1,1-DCE (4.6×10^{-4}) by the ingestion pathway, which is above the acceptable range. Additional risk was estimated for PCE, TCE, and 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), with a cumulative risk above 1×10^{-4} , although estimates for the individual chemicals are within the acceptable range. Significant risk was associated with inhalation exposures to 1,1-DCE and TCE.

The calculated noncancer HQ and HI values associated with exposures to surface soil and groundwater are summarized in **Table 2-10**. The HI value for all COCs in soil is 0.1, rounded to 1 significant figure, and is below the acceptable value of 1 (USEPA, 1990).

The HI that was calculated for potential exposure to COCs in groundwater is 20, which is above the acceptable value of 1 (USEPA, 1990). The HI is predominantly associated with exposure to thallium and antimony by the groundwater ingestion route. Additional HI above the acceptable value of 1 is associated with TCE by the combined exposures of groundwater ingestion and dermal contact while showering.

Summary of LHAAP-35B (37) Site Risks and Hazards

No unacceptable cancer risk or noncancer hazard was identified for exposures of the trespasser or the future maintenance worker to chemicals in surface soil or subsurface soil at this site. All unacceptable risks or hazards were associated with potential exposures of the future maintenance worker to chemicals detected in groundwater.

Cancer risks above acceptable USEPA criteria are predominantly associated with exposure of the future maintenance worker to 1,1-DCE, PCE, TCE, and 2,3,7,8-TCDD by the direct groundwater ingestion and dermal contact pathways, but significant risk was associated with inhalation exposures to 1,1-DCE and TCE while showering.

Noncancer hazards above acceptable USEPA criteria are predominantly associated with exposure to thallium and antimony by the groundwater ingestion route and to TCE by the combined exposures of groundwater ingestion and dermal contact while showering.

Chemicals were identified as COCs in groundwater based on a comparison of the acceptable cancer risk range of 1×10^{-6} to 1×10^{-4} or an HI limit of 1, as described in USEPA (1990) guidance. No COCs were identified by this method for the current trespasser scenario. For the future maintenance worker scenario, thallium, antimony, 1,1-DCE, PCE, TCE, and 2,3,7,8-TCDD were identified as COCs in groundwater at LHAAP-35B (37) (**Table 2-9** and **Table 2-10**).

Although it was reported that thallium and antimony contributed to the groundwater noncarcinogenic hazard, only 2 of 10 samples detected thallium and antimony in the 1996 sampling event and the detections were J-qualified (i.e., the reported values were estimated values since they were below the reporting limit). The conclusions of the 2002 RI (Jacobs, 2002a) were that thallium and antimony had not been detected in the follow-on 1998 sampling event and that the groundwater at Site 35B(37) was not considered to be contaminated with metals (Jacobs, 2002a).

LHAAP-67

Current Trespasser Scenario

All cancer risks associated with potential exposure of the trespasser to COCs in soil by all exposure pathways is 2×10^{-8} , when rounded to 1 significant figure as specified in USEPA (1989) guidance, which is well below the 1×10^{-6} to 1×10^{-4} acceptable range (USEPA, 1990).

The calculated noncancer HI for potential exposure to COCs by all exposure pathways is 0 rounded to 1 significant figure as specified in USEPA (1989) guidance, which is below the acceptable value of 1 (USEPA, 1990).

Future On-Site Maintenance Worker Scenario

Cancer risks associated with potential exposure of the future maintenance worker to chemicals of potential concern in surface soil (0 to 0.5 feet bgs) and groundwater are summarized in **Table 2-11**. The calculated cancer risk for potential exposure to COCs in soil at LHAAP-67 is 3×10^{-7} rounded to 1 significant figure, which is below the 1×10^{-6} to 1×10^{-4} acceptable range (USEPA, 1990).

The calculated cancer risk for potential exposure to COCs in groundwater is 3×10^{-3} , which is above the 1×10^{-6} to 1×10^{-4} acceptable range (USEPA, 1990). The risk is predominantly associated with exposure to 1,1-DCE inhalation and dermal contact pathways while showering, and ingestion (**Table 2-11**). Cancer risks from exposures to all other compounds in groundwater are within the acceptable risk range.

The calculated noncancer HQ and HI values associated with exposures to surface soil and groundwater are summarized in **Table 2-12**. The calculated noncancer HI for potential exposure to COCs in groundwater is 4, which is above the acceptable HI value of 1. The HI is predominantly associated with exposure to 1,1-DCE, 1,2-DCA, 1,1,1-TCA, and 1,1,2-TCA by inhalation and dermal contact pathways while showering. The noncancer HI associated with barium, manganese, strontium, and thallium exposure by groundwater ingestion is also above the USEPA acceptable level.

Summary of LHAAP-67 Site Risks and Hazards

No unacceptable cancer risk or noncancer hazard was identified for exposures of the trespasser or the future maintenance worker to chemicals in surface soil or subsurface soil at this site. All unacceptable risks or hazards were associated with potential exposures of the future maintenance worker to chemicals detected in groundwater.

Cancer risks at LHAAP-67 that are above acceptable USEPA criteria are predominantly associated with exposure of the future maintenance worker to 1,1-DCE by the groundwater ingestion and dermal contact pathways, and ingestion.

Noncancer hazards above acceptable USEPA criteria are predominantly associated with exposure to 1,1-DCE, 1,2-DCA, 1,1,1-TCA, 1,1,2-TCA by inhalation and dermal contact pathways while showering, and with barium, manganese, strontium, and thallium exposure by groundwater ingestion.

Chemicals were identified as COCs in groundwater based on a comparison the acceptable cancer risk range of 1×10^{-6} to 1×10^{-4} or an HI limit of 1, as described in USEPA (1990) guidance. No COCs were identified by this method for the current trespasser scenario. For the future maintenance worker scenario, 1,1,1-TCA, 1,1,2-TCA, 1,2-DCA, 1,1-DCE, barium, manganese, strontium, and thallium were identified as COCs in groundwater at LHAAP-67 (**Table 2-11** and **Table 2-12**).

Although the Jacobs (2003) risk assessment reported that barium, manganese, strontium, and thallium contributed to the groundwater noncancer HI, barium and thallium have MCL values that govern requirements for further remedial actions. As described in Section VI.1 of the TCEQ Consistency Memorandum (TCEQ, 1998 as updated through 2006), the MCL specified in the Safe Drinking Water Act represents the cleanup level (GW-Ind MSC) for chemicals having an MCL, and those chemicals are not included in the cumulative risk estimate for groundwater. The metals without MCLs, manganese and strontium represent HQ values of $7.2E-01$ and $1.2E-01$, respectively. Because these values, and their sum, are below the acceptable HI value of 1, manganese and strontium do not represent unacceptable noncancer hazards for groundwater use as drinking water.

Barium was detected in five of nine groundwater samples with the maximum concentration of 3.3 mg/L (Appendix C of Jacobs, 2002b) that exceeds the MCL (2 mg/L). All other detections were below the MCL. Thallium was detected in three of nine groundwater samples (Appendix C of Jacobs, 2002b). Two detections, 0.0012 mg/L and 0.0015 mg/L, were below the MCL (0.002 mg/L). One concentration of 0.0021 mg/L was approximately equal to the MCL.

The concentration of barium was detected in only one of multiple groundwater sampling events that occurred between 1998 and 2000. The concentration of thallium equals the MCL within the precision of duplicated measurements (± 0.0005 mg/L), and occurs in only one of nine groundwater samples.

2.7.1.5 Uncertainty

Uncertainties in the risk estimates are associated with the use of J-qualified (estimated) values in the assessment. This uncertainty could result in either high or low risk estimates. The use of the maximum soil and groundwater concentrations in all assessments is expected to result in highly conservative risk estimates in accordance with USEPA policy to ensure that the resulting estimates are protective of human health.

2.7.1.6 Notification and Recordation Requirements

A notification will be filed in the county record to comply with the non-residential soil requirements for Texas Administrative Code (TAC) Risk Reduction Rule (RRR) Std 2 closure. The notification will include a survey of the area evaluated for risk and will indicate that future land use is considered suitable for non-residential use only because it has not been evaluated for unrestricted use. This notification will accompany transfer documents. Certification of the non-residential use of the two sites will be transmitted to USEPA and TCEQ every five years by the Army, and after transfer, by the Army or the transferee. For as long as five year reviews are required at the sites, the certification may be included in that document.

2.7.2 Ecological Risk Assessment Summary

An installation-wide BERA has been completed for LHAAP (Shaw 2007c). A BERA is 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, populations, communities, 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. The individual sites at LHAAP were grouped into one of these sub-areas, which were delineated based on commonalities of historical use, habitat type, and spatial proximity to each other. Therefore, any conclusions regarding the potential for chemicals detected at individual sites to adversely affect the environment must be made in the context of the overall conclusions of the sub-area in which the site falls. Sites LHAAP-35B (37) and LHAAP-67 lie within the Industrial Sub-Area. The BERA concluded that no unacceptable risk was present in the Industrial Sub-

Area (Shaw, 2007c) and therefore, no further action is needed at these two sites for the protection of ecological receptors.

2.8 Remedial Action Objectives

Army recognizes USEPA's policy to return all groundwater to beneficial uses, based upon the non-binding programmatic expectation in the NCP. The RAOs for LHAAP-35B (37) and LHAAP-67, which address contamination associated with the media at the sites and take into account the future uses of LHAAP streams, land, and groundwater include:

- 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
- Return of groundwater to its potential beneficial uses as drinking water, wherever practicable

2.9 Description of Alternatives

Under a hypothetical industrial use scenario, groundwater was found to present an unacceptable risk or hazard at LHAAP-35B (37) and LHAAP-67. Thus the purpose of the remedial alternatives is to present the decision maker with technical and economic options for mitigation of risk from the groundwater at LHAAP-35B (37) and LHAAP-67. The alternatives were developed to achieve the RAOs and the statutory requirements under CERCLA; however, each alternative is unique in its strategy and approach and presents a reasonable spectrum of final conditions. The four alternatives considered for LHAAP-35B (37) and LHAAP-67 are discussed in the following sections.

2.9.1 Common Elements

Because contamination would be left in place at LHAAP-35B (37) and LHAAP-67 for Alternative 2 Monitored Natural Attenuation (MNA), and because contamination would be present for the duration of remedial activities in Alternatives 3, In Situ Bioremediation, and 4, Groundwater Extraction, On Site Treatment, Surface Water Discharge, LUCs would be common to these alternatives. The LUCs would support the RAOs. The Army intends to provide details of the LUCs implementation actions in a RD document for the two sites.

The LUCs to prevent human exposure to residual groundwater contamination presenting an unacceptable risk to human health:

- Ensure no withdrawal or use of groundwater beneath the sites for anything other than environmental monitoring and testing

The U.S. Army would be responsible for implementation, maintenance, inspection, reporting, and enforcement of the LUCs. The Army intends to provide details of the LUCs implementation and maintenance actions in an RD for LHAAP-35B (37) and LHAAP-67. The groundwater restriction LUCs shall be maintained until the concentrations of contaminants in groundwater have been reduced to levels below their respective MCLs. In addition, the Texas Department of Licensing and Regulation responsible for notifying well drillers of groundwater restrictions would be notified and a notification and/or recordation with the Harrison County Courthouse would include a map showing the areas of groundwater restriction at the site.

In order to transfer this property (LHAAP-35B (37) and LHAAP-67), an Environmental Condition of Property (ECOP) document will be prepared and attached to the letter of transfer. The property will be transferred subject to the land use and restriction covenants that are identified in the ECOP. These restrictions would prohibit or restrict property uses that may result in exposure to the contaminated groundwater (e.g., drilling restrictions, residential/agricultural land use restrictions, drinking water well restrictions).

Alternatives 2, 3, and 4 also include inspection and long-term groundwater monitoring activities. Monitoring would be continued as required to demonstrate effectiveness of the remedies, compliance with MCLs, to-be-considered requirements, RAOs, and to support CERCLA Five-Year Reviews.

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.

2.9.2 Description of Remedy Components

Alternative 1 – No Action. As required by the NCP, the no action alternative provides a comparative baseline against which the action alternatives can be evaluated. Under this alternative, the groundwater would be left “as is” without implementing any additional containment, removal, treatment, or other mitigating actions. No other actions, such as LUCs, would be implemented to prevent potential human exposure to contaminated groundwater or to demonstrate that nearby surface water bodies are protected from groundwater impacts.

LHAAP-35B (37):

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

LHAAP-67:

Estimated Capital Cost: \$0

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

Alternative 2 – Land Use Controls and Monitored Natural Attenuation. Alternative 2 is the preferred alternative. The objectives of this alternative are to prevent contaminated groundwater from migrating into nearby surface water, to return groundwater to its potential beneficial use as drinking water, wherever practicable, and to ensure no use of the groundwater as a drinking water source. MNA is a passive remedial action that relies on natural biological, chemical, and physical processes that act to reduce the mass and concentration of groundwater COCs under favorable conditions.

This alternative returns the contaminated shallow groundwater zone at LHAAP-35B(37) and LHAAP-67 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 C.F.R. § 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. This alternative also includes LUCs to prevent human exposure to residual groundwater contamination presenting an unacceptable risk to human health. The groundwater restriction LUCs shall be maintained until the concentration of contaminants in groundwater have been reduced to levels below their respective MCLs and any residual contamination has been sufficiently reduced to allow unrestricted use of the groundwater at LHAAP-35B (37) and LHAAP-67. Based on groundwater modeling, groundwater MCLs are expected to be met through natural attenuation in 28 to 38 years for PCE, 39 to 43 years for TCE, and 16 to 21 years for 1,1-DCE at LHAAP-35B (37) (Shaw, 2007e and U.S. Army, 2008b). Considering the lithologic variability, particularly the lateral and vertical change from sand to clay, the times to MCL may range to an order of magnitude greater. For LHAAP-67, MCLs would be met through natural attenuation in 17 to 66 years for TCE, 20 to 34 years for 1,1-DCE, and 21 to 43 years for 1,2-DCA. Although the times to MCL for 1,1,1-TCA and 1,1,2-TCA were originally modeled to be 22 and 20 years respectively, these two VOCs are no longer detected above MCLs at LHAAP-67 (Shaw, 2007b; U.S. Army, 2008b).

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.

LHAAP-35B (37):

Estimated Capital Cost: \$79,000

Estimated O&M Cost: \$393,000
Estimated Duration: 30 years
Estimated Present Worth Cost: \$282,000

LHAAP-67:

Estimated Capital Cost: \$47,000
Estimated O&M Cost: \$607,000
Estimated Duration: 30 years
Estimated Present Worth Cost: \$316,000

Alternative 3 – In Situ Bioremediation, Land Use Controls (Short Term). The objectives of this alternative are to prevent contaminated groundwater from migrating into nearby surface water, to return groundwater to its potential beneficial use as drinking water, wherever practicable, and to ensure no use of the groundwater as a drinking water source.

This alternative returns the contaminated shallow groundwater zone at LHAAP-35B(37) and LHAAP-67 to its potential beneficial use as drinking water, 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 C.F.R. § 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. To achieve these objectives, this alternative utilizes in situ bioremediation to reduce groundwater contaminant concentrations to the MCLs, and maintains LUCs only until such time that the MCLs are met for groundwater contaminants through remediation. Based on estimates from the Feasibility Study, groundwater MCLs are expected to be met through in situ bioremediation in 6 years. Considering the lithologic variability, particularly the lateral and vertical change from sand to clay, the times to MCL may range to an order of magnitude greater.

LHAAP-35B (37):

Estimated Capital Cost: \$2,535,000
Estimated O&M Cost: \$317,000
Estimated Duration: 6 years
Estimated Present Worth Cost: \$2,664,000

LHAAP-67:

Estimated Capital Cost: \$1,691,000
Estimated O&M Cost: \$367,000
Estimated Duration: 6 years
Estimated Present Worth Cost: \$1,793,000

Alternative 4 – Groundwater Extraction, On-Site Treatment, Surface Water Discharge, and Land Use Controls (Short Term). The objectives of this alternative are to prevent contaminated groundwater from migrating into nearby surface water, to return groundwater to its

potential beneficial use as drinking water, wherever practicable, and to ensure no use of the groundwater as a drinking water source.

This alternative returns the contaminated shallow groundwater zone at LHAAP-35B(37) and LHAAP-67 to its potential beneficial use as drinking water, wherever practicable, 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 C.F.R. § 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. To achieve these objectives, this alternative uses groundwater extraction to remove contaminants from groundwater for treatment and maintains LUCs only until such time that the MCLs are achieved for groundwater contaminants. The extracted groundwater would be piped to the existing groundwater treatment plant. Based on estimates from the Feasibility Study, groundwater MCLs are expected to be met through groundwater extraction and on-site treatment at some point beyond 30 years. Further study would be required to more accurately quantify this timeframe. Considering the lithologic variability, particularly the lateral and vertical change from sand to clay, the times to MCL may range to an order of magnitude greater.

LHAAP-35B (37):

Estimated Capital Cost: \$1,271,000
Estimated O&M Cost: \$1,764,000
Estimated Duration: 30 years
Estimated Present Worth Cost: \$2,095,000

LHAAP-67:

Estimated Capital Cost: \$1,211,000
Estimated O&M Cost: \$1,904,000
Estimated Duration: 30 years
Estimated Present Worth Cost: \$1,957,000

2.10 Summary of Comparative Analysis of Alternatives

Nine criteria identified in the NCP 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. The “Detailed Analysis of Alternatives” can be found in the FSs for the two sites (Shaw, 2005a; 2005b). **Table 2-13** summarizes the comparative analysis of the alternatives presented in this ROD.

1. Overall Protection of Human Health and the Environment

The four alternatives provide varying levels of human health protection. Alternative 1, no action, does not achieve the RAOs and 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 hypothetical pathway for maintenance worker exposure to the groundwater contamination, and potential groundwater impacts to Goose Prairie Creek and Central Creek would not be addressed.

Alternatives 2, 3, and 4 all satisfy the RAOs for LHAAP-35B (37) and LHAAP-67. Alternatives 2, 3 and 4 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-35B(37) and LHAAP-67 to its potential beneficial uses as a drinking water, wherever practicable, and to document that the plumes are contained and prevented from impacting Goose Prairie Creek and Central Creek at levels that could present a risk to human health and the environment. Furthermore, LUCs would protect human health by preventing access to the contaminated groundwater until contaminants in the groundwater attain the Safe Drinking Water Act MCLs for all contaminants above the MCLs and attain the MCLs for all contaminants by-products (daughter contaminants) above the MCLs.

2. Compliance with ARARs

Section 121(d) of CERCLA and NCP §300.430(f)(1)(ii)(B) requires 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).

Because contaminated groundwater has the potential to discharge to Central Creek and Goose Prairie Creek, downgradient 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 ppb), PCE (5 ppb) and 1,1-DCE (1.63 ppb) for LHAAP-35B (37), and TCE, 1,1-DCE, and 1,2-DCA (5 ppb) for LHAAP-67. 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, 3, and 4 all return the contaminated shallow groundwater zone at LHAAP-35B(37) and LHAAP-67 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 Safe Drinking Water Act (SDWA) MCLs to the extent practicable, and consistent with 40 C.F.R. § 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 Goose Prairie Creek and Central Creek and monitoring would be used to confirm it. Alternatives 3 and 4 also comply with surface water chemical specific ARARs because they are active remedial processes that will reduce contaminant levels in groundwater to levels below water quality standards prior to discharge as baseflow into surface water.

Location-specific and action-specific MCLs would not apply to Alternative 1 since no remedial activities would be conducted. Alternatives 2, 3, and 4 comply with all location-specific and action-specific ARARs.

3. Long-Term Effectiveness and Permanence

Alternative 1 would be the least effective and permanent in the long term because no contaminant removal or treatment would take place and no measures would be implemented to control exposure risks posed by contaminated site groundwater. Also, there is a concern that the potential exists for contaminated groundwater to migrate toward and discharge into Goose Prairie Creek and Central Creek and then subsequently into Caddo Lake, a drinking water supply. The results of plume migration modeling indicate that through MNA the maximum concentrations of the COCs within Goose Prairie Creek and Central Creek if such discharge occurred would be below groundwater MCLs and surface water ARARs, which also would be protective of Caddo Lake. Alternatives 3 and 4 are also active treatments that would permanently reduce contaminant levels in groundwater over time with Alternatives 2 and 4 taking the longest and approximately equal amount of time and Alternative 3 taking the least amount of time.

Although different mechanisms are prevailing at LHAAP-35B (37) and LHAAP-67, MNA effectively controls plume migration and has stabilized the size of the areas exhibiting COC concentrations exceeding MCL values. Alternatives 3 and 4 would also work to control plume migration through contaminant reduction. However, uncertainty exists regarding the ability of in situ bioremediation or groundwater extraction to reduce contaminant concentrations beyond what would naturally occur, and therefore further evaluation would be required. Should in situ bioremediation or groundwater extraction be considered ineffective after implementation, the remedy may need to be reevaluated. Alternatives 2, 3 and 4 rely on LUCs for the protection of human health until the MCLs are achieved. For purposes of this ROD, the long-term protection of human health and the environment will be served by returning the contaminated groundwater to its potential beneficial uses, which includes the attainment of the Safe Drinking Water Act

MCLs for all contaminants above the MCLs and attainment of MCLs for all contaminants by-products (daughter contaminants) above the MCLs.

The time period to achieve the groundwater remediation levels is the most significant difference between Alternative 3 versus Alternatives 2 and 4. Alternative 3 is expected to take less time to achieve RAOs, provided treatability testing for in situ bioremediation is favorable. The implementation of Alternatives 2 and 4 would require a significant amount of more time than Alternative 3 in returning the contaminated groundwater to its potential beneficial use as drinking water, wherever practicable.

4. Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 1 does not employ treatment and would not result in a reduction of toxicity, mobility, or volume of contaminants.

MNA, in situ biodegradation, and groundwater extraction are irreversible treatment processes that would permanently reduce the mass and concentration of contaminants and, therefore, the volume, toxicity and mobility of the contaminants. Alternatives 2 and 3, however, include the generation of daughter products that may temporarily increase toxicity or mobility of the contaminant plume, with in situ biodegradation working in a shorter time frame, but with MNA at a lower cost. Both alternatives include monitoring so that daughter products would be quantified, documented, and evaluated.

Alternative 4 could provide the greatest degree of permanent reduction in toxicity, mobility and volume of the groundwater contaminants because no daughter products are generated in situ since the contaminant plume is extracted and treated ex situ.

It is noted, however, that pre-design testing and further evaluations of in situ bioremediation or groundwater extraction will be required to evaluate the potential effectiveness of these alternatives.

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 the construction and operation of the remedy until cleanup levels are achieved.

Alternative 1 does not involve any remedial measures and, therefore, 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 3 and 4 both involve potential short-term negligible risks to workers associated with exposure to contaminated groundwater and operation of drilling/construction equipment.

Additionally, because there is no current use of groundwater as drinking water and contaminated groundwater does not currently impact surface water, none of the alternatives present a short-term risk to the community and the environment.

6. Implementability

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 Army would be responsible for long-term maintenance and enforcement of LUCs, long-term evaluation of MNA, long-term sampling; and long-term maintenance and operation of sampling equipment.

Alternatives 3 and 4 are also technically implementable, although less so than Alternative 2 because of the uncertainties associated with the ability of in situ bioremediation or groundwater extraction to further lower contaminant levels beyond what is achievable with Alternative 2. Alternative 3 would be somewhat more difficult to implement than Alternative 4 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.

7. Cost

Cost estimates are used in the CERCLA FS 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 +50 to -30 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 7 percent.

The progression of present worth costs from the least expensive alternative to the most expensive alternative is as follows: Alternative 1, Alternative 2, Alternative 3, and Alternative 4. 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 remedial alternatives. The present worth cost for Alternatives 2 and 3 is lower than that of Alternative 4, primarily due to O&M of the groundwater extraction system under Alternative 4. The highest capital cost is associated with Alternative 3 primarily due to the activities associated with the injection phase of in situ bioremediation.

8. State/Support Agency Acceptance

The USEPA and TCEQ have reviewed the Proposed Plan. Comments received from the USEPA and TCEQ during the Proposed Plan development have been incorporated as appropriate. The USEPA and TCEQ concur with the selected remedy.

9. Community Acceptance

Community acceptance is an important consideration in the final evaluation of the remedy. There were no public comments received during the 30-day public comment period held from June 17 to July 16, 2008 and no public comments were made at the June 23, 2008 public meeting. The Proposed Plan comment period was re-opened from March 8 to April 22, 2010. No public comments were made at the March 9, 2010 public meeting. Written comments from an individual were received by the U.S. Army within the public comment period. The comments expressed reservations about the Proposed Plan. Responses to concerns have been provided and can be found in the Responsiveness Summary (**Section 3.0** of the ROD) and the U.S. Army's response to written comments that have been filed in the Administrative Record.

2.11 Principal Threat Wastes

Contaminated groundwater at LHAAP-35B (37) and LHAAP-67 is not a principal threat waste. It does not serve as a contaminant source, nor is there any other identifiable non-aqueous free phase material or contaminated soil that functions as a source for contaminant migration to soil, groundwater, surface water, or air. There is no indication that the existing groundwater plume will serve as a source for surface water or air contaminant migration above applicable standards or pose a risk to human health or the environment. (See Sections 2.5.1 and 2.7.) The feasibility study nonetheless considered various levels of active and passive treatment alternatives for groundwater.

2.12 The Selected Remedy

2.12.1 Summary of Rationale for the Selected Remedy

Alternative 2, LUCs with MNA, is the preferred alternative for LHAAP-35B (37) and LHAAP-67 and is consistent with the intended future use of the sites as a wildlife refuge. This alternative satisfies the RAOs for the sites through MNA and LUCs. MNA and LUCs serve to protect human health and the environment by monitoring the contaminated groundwater to ensure that

MNA returns the contaminated groundwater at LHAAP-35B(37) and LHAAP-67 to its potential beneficial use as drinking water, wherever practicable, and to document that the plumes are contained and prevented from impacting Goose Prairie Creek and Central Creek at levels that could present a risk to human health and the environment. Furthermore, LUCs would protect human health by preventing access to the contaminated groundwater until contaminants in the groundwater attain the Safe Drinking Water Act MCLs for all contaminants above MCLs and attain the MCLs for all contaminant by-products (daughter contaminants) above the MCLs. The selected alternative offers a high degree of long-term effectiveness, can be easily and immediately implemented, and costs less than the other alternatives.

Based on information currently available, the U.S. Army believes the preferred alternative meets the threshold criteria and provides the best balance of tradeoffs among the other alternatives with respect to the CERCLA criteria used to evaluate remedial alternatives.

The Army intends to present details of the LUCs implementation plan, groundwater monitoring plan, and MNA remedy implementation in a RD for the two sites.

2.12.2 Description of the Selected Remedy

The standards required by the preferred alternative are to monitor the contaminated groundwater to ensure that MNA returns the contaminated groundwater at LHAAP-35B(37) and LHAAP-67 to its potential beneficial use as drinking water, wherever practicable, and to document that the plumes are contained and prevented from impacting Goose Prairie Creek and Central Creek at levels that could present a risk to human health and the environment. Furthermore, LUCs would protect human health by preventing access to the contaminated groundwater until contaminants in the groundwater attain the Safe Drinking Water Act MCLs for all contaminants above MCLs and attain the MCLs for all contaminant by-products (daughter contaminants) above the MCLs. MNA constitutes a passive remedial action that relies on natural biological, chemical, and physical processes that act to reduce the mass and concentration of groundwater COCs under favorable conditions. These natural attenuation processes include biodegradation, dispersion, dilution, adsorption, volatilization, and abiotic destruction of contaminants.

Based on groundwater modeling, groundwater MCLs are expected to be met through natural attenuation in 28 to 38 years for PCE, 39 to 43 years for TCE, and 16 to 21 years for 1,1-DCE at LHAAP-35B (37) (Shaw, 2007e; U.S. Army, 2008b). Considering the lithologic variability, particularly the lateral and vertical change from sand to clay, the times to MCL may range to an order of magnitude greater. For LHAAP-67, MCLs would be met through natural attenuation in 17 to 66 years for TCE, 20 to 34 years for 1,1-DCE, and 21 to 43 years for 1,2-DCA. Although the times to MCL for 1,1,1-TCA and 1,1,2-TCA were originally modeled to be 22 and 20 years respectively, these two VOCs are no longer detected above MCLs at LHAAP-67 (Shaw, 2007b; U.S. Army, 2008b). 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.

This alternative includes LUCs to prevent human exposure to residual groundwater contamination presenting an unacceptable risk to human health. The LUC objective is:

- Ensure no withdrawal or use of LHAAP-35B (37) and LHAAP-67 groundwater for other than environmental monitoring and testing.

The U.S. Army would be responsible for implementation, maintenance, inspection, reporting, and enforcement of the LUCs. Although the Army may transfer these responsibilities to another party through property transfer agreement or other means, the Army will remain 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 LUCs 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 EPA and the 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 C.F.R. §300.435 and 40 C.F.R. §300.430(f)(4)(iii)(B).

LUC implementation and maintenance actions would be described in the RD for LHAAP-35B (37) and LHAAP-67. The selected LUCs will prevent human exposure to chlorinated solvents-contaminated groundwater through the restriction of groundwater use. The groundwater restriction component of the LUCs 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-35B (37) and LHAAP-67. LUCs would be included in the property transfer documents. In addition, the Texas Department of Licensing and Regulation 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 LUCs 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 contaminants to levels below MCLs.

Long-term operational requirements under this alternative would include maintenance of the LUCs. The need for continued monitoring will be evaluated every five years during the reviews. Sampling frequency and analytical requirements will be presented as an appendix to the RD for LHAAP-35B (37) and LHAAP-67.

2.12.3 Summary of the Estimated Remedy Costs

Table 2-14 and **Table 2-15** present detailed cost estimates for the preferred alternative, Alternative 2. The information in this cost estimate summary table is based on the best available information regarding the anticipated scope of the remedial alternative. Changes in the cost elements are likely to occur as a result of new information and data collected during the course of implementation of the remedial alternative. The costs included in this ROD are estimated to be within +50 to -30 percent of the actual project cost. The total project present worth cost of this alternative is approximately \$282,000 and \$316,000 for LHAAP-35B (37) and LHAAP-67, respectively. The total direct capital cost is estimated at \$79,000 and \$47,000 for LHAAP-35B (37) and LHAAP-67, respectively. No indirect capital costs are required for this alternative. The total O&M cost is estimated at approximately \$393,000 and \$607,000 for LHAAP-35B (37) and LHAAP-67, respectively. The O&M cost includes evaluation of MNA, maintenance of LUCs, and long-term monitoring through year 30. The long-term monitoring would support the required CERCLA Five-Year Reviews.

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, compliant with ARARs, 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 remedy does not satisfy the statutory preference for treatment as a principle 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 principle threats will be addressed within the scope of this action. The following sections discuss how the selected remedy meets the statutory requirements.

Protection of Human Health and the Environment

The selected remedy, Alternative 2, will achieve the RAOs for LHAAP-35B (37) and LHAAP-67. 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. At LHAAP-35B (37) and LHAAP-67, the evaluation of historical groundwater contaminant trends provides strong evidence that natural attenuation processes have contributed to a significant reduction in contaminant concentrations and prevented plume

migration. This alternative provides adequate 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-35B(37) and LHAAP-67 to its potential beneficial uses as a drinking water, wherever practicable, and to document the effectiveness of MNA.

LUCs would prevent human access to the contaminated groundwater. The results of plume migration modeling for LHAAP-35B (37) indicated that the maximum concentrations of the COCs at the point of entry of the groundwater into Goose Prairie Creek, after plume impact, would be below surface water ARARs, which would also be protective of Caddo Lake. Therefore, based on these modeling results, contaminants present in groundwater at the site will not adversely impact Goose Prairie Creek surface water. In addition, plume migration modeling results for LHAAP-67 indicated that the maximum concentrations of the COCs were below their respective MCLs where groundwater discharges into Central Creek. Furthermore, calculated dilution within Central Creek indicated that the resultant concentrations of the COCs in Central Creek after dilution were less than 3 percent of their respective MCLs. Therefore, based on these modeling calculations, contaminants present in the groundwater at LHAAP-67 will not adversely impact Central Creek which also would be protective of Caddo Lake. The monitoring activities associated with LUCs 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.

Hazardous substances detected in soil at these sites were considered to represent a low threat to the environment, and it was determined that no remediation for the protection of ecological receptors was necessary at LHAAP-35B (37) and LHAAP-67.

Compliance with ARARs

Chemical-Specific ARARs

This alternative will return the contaminated shallow groundwater zone at LHAAP-35B(37) and LHAAP-67 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 Safe Drinking Water Act (SDWA) MCLs to the extent practicable, and consistent with 40 C.F.R. § 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. This alternative will comply with surface water ARARs as recent modeling results indicate MNA has contributed to a significant reduction of COC concentrations in groundwater and will likely continue reducing COC concentrations to below their respective MCLs. 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.

Location-Specific ARARs

There are no location-specific ARARs associated with this alternative.

Action-Specific ARARs

There are no action-specific ARARs applicable to this alternative.

Cost-Effectiveness

Alternative 2 has the lowest present worth and capital costs of the remedial alternatives. Alternative 2 offers a high degree of long-term effectiveness, and costs less than the other alternatives.

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 LUCs 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 LUCs, evaluation of MNA, and sampling would be required. Alternative 2 has the lowest present worth and capital costs of the remedial alternatives. The community supports the selected remedy (Alternative 2) as detailed in the Proposed Plan.

Preference for Treatment as a Principal Element

The remedy does not satisfy the statutory preference for treatment as a principle 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 principle threats will be addressed within the scope of

this action. The selected remedy of MNA reduces the toxicity, mobility, or volume of contaminants in the groundwater through a passive remedial action. There is no known principal threat material in the groundwater.

Five-Year Review Requirements

Section 121(c) of CERCLA and NCP§300.430(f)(5)(iii)(c) provide the statutory and legal bases for conducting Five-Year Reviews. Because this remedy will result in contaminants that remain on site above levels that allow unlimited use and unrestricted exposure, a review will be conducted at least 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-35B (37) and LHAAP-67 was released for public comments in June 2008. The Proposed Plan identified Alternative 2, LUC and MNA as the Preferred Alternative for the chlorinated solvent contaminated groundwater. No comments were received during the public comment period. No significant changes to the remedy, as originally identified in the Proposed Plan, were necessary or appropriate.

The Proposed Plan for LHAAP-35B (37) and LHAAP-67 was reopened for public comments in March 2010 for 45 days. The Proposed Plan identified Alternative 2, LUC and MNA as the Preferred Alternative for the chlorinated solvent contaminated groundwater. The U.S. Army reviewed the written comments submitted during the public comment period. After careful consideration it was determined that no significant changes to the remedy, as identified in the original Proposed Plan, were necessary or appropriate.

Table 2-1
Summary of Soil Analytical Data LHAAP-35B (37)

Parameter/Units	Minimum Concentration Detected	Maximum Concentration Detected	Date Sampled	Location	Frequency of Detections
Volatile Organic Compounds (µg/kg)					
Acetone	21	21	6/23/93	LH-WRS19-01	1/9
Semivolatile Organic Compounds (µg/kg)					
Benzo(a)anthracene	420	420	7/27/98	35BSB01	1/8
Benzo(a)pyrene	390	390	7/27/98	35BSB01	1/8
Benzo(b)fluoranthene	530	530	7/27/98	35BSB01	1/8
Benzo(g,h,i)pyrene	250	250	7/27/98	35BSB01	1/8
Chrysene	450	450	7/27/98	35BSB01	1/8
Fluoranthene	760	760	7/27/98	35BSB01	1/10
Indeno(1,2,3-c,d)pyrene	350	350	7/27/98	35BSB01	1/10
Phenanthrene	370	370	7/27/98	35BSB01	1/10
Pyrene	560	560	7/27/98	35BSB01	1/10
Bis(2-ethylhexyl)phthalate	49J	560J	1/11/95	LHS-330	5/10
Metals (mg/kg)					
Aluminum	2250	13,000	7/27/98	35BSB01	10/10
Arsenic	1.05	7.5J	1/11/95	LHS330	10/10
Barium	33.2	190	10/05/94	LHSMW59	8/10
Beryllium	0.593J	0.845	9/25/06	WRS019-SB01	4/10
Cadmium	0.115	7.5	1/11/95	LHS330	3/10
Calcium	444	51,800	9/25/06	WRS019-SB01	10/10
Chromium (total)	3.75	42.9J	1/11/95	LHS330	10/10
Cobalt	2.65	24.1	10/05/94	LHSMW59	8/10
Copper	3.3	10.8	1/11/95	LHS330	7/10
Iron	6,200	73,100	9/25/06	WRS019-SB01	10/10
Lead	8.03	62.4	6/23/93	LH-WRS-19-01	9/10
Magnesium	113	1940	9/25/06	WRS019-SB01	7/8
Manganese	2.34	1,860	10/05/94	LHSMW59	8/8
Mercury	0.0186	0.60	1/11/95	LHS330	4/10
Nickel	6.9J	18.2	9/26/06	WRS019-SB01	5/5
Potassium	115	810	7/27/98	35BSB01	9/10
Selenium	0.21	4.12	7/27/98	35BSB01	7/10
Sodium	15.7J	120	9/25/06	WRS019-SB01	2/5
Strontium	6.3	31.9	1/11/95	LHS330	5/8
Thallium	0.0265	0.0828	9/25/06	WRS019-SB01	2/8
Vanadium	25J	62.5	9/25/06	WRS019-SB01	5/5
Zinc	7	1,100	1/11/95	LHS330	10/10
Pesticides (µg/kg)					
Aldrin	170	170	7/27/98	35BSB01	1/3
p,p-DDE	11	130J	7/27/98	35BSB01	3/3
p,p-DDT	6.1J	37J	7/27/98	35BSB01	2/3
Dioxins (ng/kg)					
Octachlorodibenzo-p-dioxin	133.977	6,692.92	8/07/98	35BSB01	3/3
Heptachlorinated dibenzo-p-dioxins (total)	3.553	69.33	7/27/98	35BSB01	4/4
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	2.063	33.263	7/27/98	35BSB01	5/5
Hexachlorinated dibenzo-p-dioxins (total)	0.574	11.141	7/27/98	35BSB01	3/5

Table 2-1 (Continued)
Summary of Soil Analytical Data LHAAP-35B (37)

Parameter/Units	Minimum Concentration Detected	Maximum Concentration Detected	Date Sampled	Location	Frequency of Detections
Furans (ng/kg)					
Octachlorodibenzofuran	0.626	15.485	7/27/98	35BSB01	4/5
Heptachlorinated dibenzofurans (total)	0.584	6.02	7/27/98	35BSB01	4/5
1,2,3,4,6,7,8-Heptachlorodibenzofuran	0.236	5.765	7/27/98	35BSB01	5/5
Hexachlorinated dibenzofurans (total)	0.234	5.299	7/27/98	35BSB01	4/5
1,2,3,4, 7,8-Pentachlorodibenzofurans	0.219	0.373	7/27/98	35BSB01	2/5
Pentachlorinated dibenzofurans (total)	1.017	6.501	7/27/98	35BSB01	2/5
1,2,3,7,8-Pentachlorodibenzofuran	0.259	2.008	7/27/98	35BSB01	2/5
Tetrachlorinated dibenzofurans (total)	0.506	2.56J	7/27/98	35BSB01	3/5
2,3,7,8-Tetrachlorodibenzofuran	0.273	0.506	7/27/98	35BSB01	3/7

Notes:

J The analyte was not positively identified: the associated numerical value is the approximate concentration of the analyte in the sample.

Frequency of detections shown varies because the different lists of analytes specified by the various groundwater sampling efforts described in the Jacobs (2003) risk assessment, and subsequent sampling events.

*μg/kg micrograms per kilogram
mg/kg milligrams per kilogram
ng/kg nanograms per kilogram*

Table 2-2
Summary of Groundwater
Analytical Data LHAAP-35B (37)

Parameter/Units	Minimum Concentration Detected	Maximum Concentration Detected	Date Sampled	Location for Maximum Concentration	Frequency of Detections
Volatile Organic Compounds (µg/L)					
1,1,1-Trichloroethane	0.96	37	12/11/94	LHSMW58	5/26
1,2,4-Trichlorobenzene	1.5	1.5	8/21/96	LHSMW58	1/33
1,1-Dichloroethane	0.436	2.1	8/21/96	LHSMW58	4/25
1,1-Dichloroethene	2.11	58	12/11/94	LHSMW58	9/26
1,2-Dichloroethane (total)	0.24J	7	12/11/94	LHSMW58	3/28
cis-1,2-Dichloroethene	0.52	2.1	8/21/96	LHSMW58	8/23
1,3 Dinitrobenzene	0.1J	0.1J	2/10/96	LHSMW59	1/10
Acetone	2.4	8.31	12/14/06	35BWW06	4/23
Benzene	3J	3J	12/11/94	LHSMW58	1/25
Carbon Disulfide	8	8	9/10/04	35BWW03	1/23
Chlorobenzene	0.152	2.6	8/21/96	LHSMW58	7/26
Chloroform	0.356	0.38	8/21/96	LHSMW58	3/26
Chloromethane	0.347J	0.347J	12/16/06	35BWW03	1/25
Ethylene	0.571	3.44	12/16/06	35BWW03	1/25
Tetrachloroethene	0.955	34	12/11/94	LHSMW58	20/32
Toluene	0.533J	0.533J	12/14/06	35BWW05	1/25
Trichloroethene	9	330	5/20/98	LHSMW59	17/27
Trichlorofluoromethane	2.3	2.7	8/21/96	LHSMW59	2/9
Xylenes (total)	0.594J	0.594J	9/14/07	35BWW08	1/22
Semivolatile Organic Compounds (µg/L)					
Di-n-octylphthalate	1.6	3.6	8/21/96	LHSMW58	3/20
Bis(2-ethylhexyl)phthalate	1J	1.4	2/10/96	LHSMW59	3/10
Metals (mg/L)					
Aluminum	106J	4,700	12/11/94	LHSMW59	7/9
Antimony	55J	80J	8/21/96	LHSMW58	2/10
Barium	70J	299	2/10/96	LHSMW59	6/10
Cadmium	0.3	0.3	2/10/96	LHSMW58	1/10
Calcium	3,300	43,100J	8/21/96	LHSMW59	8/10
Chromium (total)	4.3	25	12/11/94	LHSMW58	5/10
Copper	3.3	23	2/10/96	LHSMW59	4/10
Iron	45J	7,300	12/11/94	LHSMW58	10/10
Lead	3.7	3.9	12/11/94	LHSMW59	2/10
Magnesium	1,400	19,000	5/20/98	LHSMW59	7/10
Manganese	16	380	12/11/94	LHSMW59	10/10
Mercury	0.04J	0.04J	8/21/96	LHSMW58	1/10
Nickel	23J	68	2/10/96	LHSMW59	3/8
Potassium	670	2,500	12/11/94	LHSMW59	5/10
Selenium	2.4	2.4	2/10/96	LHSMW59	1/10
Sodium	7,900	92,000	5/20/98	LHSMW59	3/4
Strontium	96	1,900	5/20/98	LHSMW59	8/10
Thallium	1.8J	98J	8/21/96	LHSMW58	2/10
Vanadium	3.2	3.2	2/10/96	LHSMW58	1/8
Zinc	21	40	12/11/94	LHSMW58	7/10
Explosive Compounds (µg/L)					
1,3-dinitrobenzene	0.1J	0.1J	2/10/96	LHSMW59	1/11
Tetryl	0.072J	0.41	2/10/96	LHSMW58	2/10

**Table 2-2 (Continued)
Summary of Groundwater
Analytical Data LHAAP-35B (37)**

Parameter/Units	Minimum Concentration Detected	Maximum Concentration Detected	Date Sampled	Location for Maximum Concentration	Frequency of Detections
Furans (pg/L)					
1,2,3,4,7,8-Hexachlorodibenzofuran	10.051	10.051	8/26/96	LHSMW59	1/1
Hexachlorinated dibenzofurans (total)	5.225J	5.225J	8/26/96	LHSMW59	1/1

Notes:

J The analyte was not positively identified: the associated numerical value is the approximate concentration of the analyte in the sample.

Frequency of detections shown varies because the different lists of analytes specified by the various groundwater sampling efforts described in the Jacobs (2003) risk assessment, and subsequent sampling events.

µg/L micrograms per liter

mg/L milligrams per liter

pg/L picograms per liter

Table 2-3
Summary of Soil Analytical Data LHAAP-67

Parameter/Units	Minimum Concentration Detected	Maximum Concentration Detected	Date Sampled	Location	Frequency of Detections
Volatile Organic Compounds (µg/kg)					
Methylene chloride	2BJ	5.9	12/6/00	67SB01	4/11
Metals (mg/kg)					
Aluminum	6,360	15,800J	12/6/00	67SB02	9/9
Arsenic	2.24	8.86	12/6/00	67SB01	9/9
Barium	45.1J	837J	12/7/00	67SB03	9/9
Beryllium	0.478	1.28	12/6/00	67SB01	9/9
Cadmium	0.164J	0.298	12/6/00	67SB01	4/9
Calcium	510	9,460	12/7/00	67SB03	9/9
Chromium	11	32.3J	12/14/00	67SB02	9/9
Cobalt	3.2	8.86	12/6/00	67SB02	9/9
Copper	3.46	6.26	12/6/00	67SB02	9/9
Iron	9,280	27,400	12/14/00	67SB02	9/9
Lead	10.6	55.8	12/6/00	67SB01	9/9
Magnesium	406J	1,620J	12/6/00	67SB02	9/9
Manganese	31.1	271J	12/14/00	67SB02	9/9
Nickel	3.61J	14.7	12/7/00	67SB03	9/9
Potassium	246J	536J	12/7/00	67SB03	9/9
Selenium	0.599J	1.09J	12/6/00	67SB01	7/9
Silver	0.145J	0.297J	12/14/00	67SB01	3/9
Sodium	142J	452	12/7/00	67SB03	5/9
Strontium	9.62	40.7	12/7/00	67SB03	9/9
Vanadium	17.4	40.5	12/14/00	67SB02	9/9
Zinc	14.3	34.9	12/6/00	67SB01	9/9

Notes:

J The analyte was not positively identified: the associated numerical value is the approximate concentration of the analyte in the sample.

Frequency of detections shown varies because the different lists of analytes specified by the various groundwater sampling efforts described in the Jacobs (2003) risk assessment, and subsequent sampling events.

µg/kg micrograms per kilogram
mg/kg milligrams per kilogram

**Table 2-4
Summary of Groundwater
Analytical Data LHAAP-67**

Parameter/Units	Minimum Concentration Detected	Maximum Concentration Detected	Date Sampled	Location for Maximum Concentration	Frequency of Detections
Volatile Organic Compounds (µg/L)					
1,1,1-Trichloroethane	100	1800	12/8/98	67WW03	3/30
1,1,2-Trichloroethane	0.28J	33	12/8/98	67WW01	6/30
1,1-Dichloroethane	0.236J	14	12/8/98	67WW01	6/26
1,1-Dichloroethene	2.4	380	12/8/98	67WW01	6/30
1,2-Dichloroethene (total)	1.62J	27	12/8/98	67WW01	9/30
cis-1,2-Dichloroethene	0.71J	1J	9/12/04	67WW01	5/30
Acetone	2.82J	10	12/8/98	G4SB01	5/30
2-Butanone	55	61	12/8/98	67WW01	2/30
Chloroform	2.83	2.83	12/19/00	67WW06	1/30
Methylene chloride	1JB	1.37	12/19/00	67WW06	2/30
Naphthalene	0.59J	7.5	11/9/98	G4SB02	3/23
Toluene	9.3	91	12/8/98	67WW03	3/30
Trichloroethene	0.14J	6.3	12/8/98	67WW01	8/30
Vinyl chloride	1J	2.34J	12/18/06	67WW01	3/30
Metals (mg/L)					
Aluminum	0.114	6	12/8/98	67WW01	7/7
Barium	0.13	3.31	12/19/00	67WW07	4/7
Beryllium	0.0006	0.0008	12/19/00	67WW07	3/7
Cadmium	0.0008	0.0026	12/19/00	67WW07	2/7
Calcium	90.7	373	12/19/00	67WW06	9/9
Chromium	0.02	0.09	12/19/00	67WW05	6/7
Cobalt	0.025	0.12	12/19/00	67WW06	3/7
Copper	0.026	0.027J	12/19/00	67WW07	2/7
Iron	0.53	9.6	12/8/98	67WW02	7/7
Lead	0.0035	0.007	12/8/98	67WW01	3/7
Magnesium	46.7	190	12/19/00	67WW06	7/7
Manganese	0.41	3.45	12/19/00	67WW06	7/7
Nickel	0.05	0.18J	12/19/00	67WW07	7/7
Potassium	1.2J	7.5	12/19/00	67WW06	3/7
Selenium	0.011	0.014	12/19/00	67WW06	3/7
Sodium	450	870	12/8/98	67WW03	7/7
Strontium	0.99	7.6	12/8/98	67WW03	7/7
Thallium	0.0012	0.0021	12/8/98	67WW03	2/7
Zinc	0.011J	0.054J	12/19/00	67WW07	7/7
Anions (mg/L)					
Chloride	818	2,360	8/9/06	67WW03	15/15
Sulfate (as SO ₄)	12.3	297	12/18/06	67WW03	15/15

Notes:

J The analyte was not positively identified: the associated numerical value is the approximate concentration of the analyte in the sample.

Frequency of detections shown varies because the different lists of analytes specified by the various groundwater sampling efforts described in the Jacobs (2003) risk assessment, and subsequent sampling events.

µg/L micrograms per liter
mg/L milligrams per liter
pg/L picograms per liter

**Table 2-5
Occurrence, Distribution, and Selection of Chemicals of Concern
LHAAP-35B (37) Groundwater**

Scenario Timeframe:		Current and Future					
Medium:		Groundwater					
Exposure Medium:		Groundwater					
Chemical	Concentration Detected		Units	Frequency of Detection	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
	Min	Max					
<i>Volatile Organic Compounds</i>							
1,1-Dichloroethene	2.11E-03	5.80E-02	mg/L	9 / 15	5.80E-02	mg/L	max
Tetrachloroethene	1.00E-03	3.40E-02	mg/L	14 / 16	3.40E-02	mg/L	max
Trichloroethene	9.40E-03	3.30E-01	mg/L	13 / 15	3.30E-01	mg/L	max
<i>Metals</i>							
Antimony	5.50E-02	8.00E-02	mg/L	2 / 11	8.00E-02	mg/L	max
Thallium	1.20E-03	9.80E-02	mg/L	3 / 11	9.80E-02	mg/L	max
<i>Dioxin/Furans</i>							
2,3,7,8-TCDD TEQ	NA	NA	mg/L	NA	4.59E-09	mg/L	max

Notes:

QC samples were utilized during the risk assessment if the values (QC) were higher than the actual field sample results.

max maximum value

mg/L milligrams per liter

min minimum value

NA not applicable.

TCDD tetrachlorodibenzo-p-dioxin

TEQ toxicity equivalent concentration

**Table 2-6
Occurrence, Distribution, and Selection of Chemicals of Concern
LHAAP-67 Groundwater**

Scenario Timeframe:		Current and Future					
Medium:		Groundwater					
Exposure Medium:		Groundwater					
Chemical	Concentration Detected		Units	Frequency of Detection	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
	Min	Max					
<i>Volatile Organic Compounds</i>							
1,1,1-Trichloroethane	1.00E-01	1.80E+00	mg/L	4 / 9	1.80E+00	mg/L	max
1,1,2-Trichloroethane	5.90E-03	3.30E-02	mg/L	4 / 9	3.30E-02	mg/L	max
1,1-Dichloroethene	2.40E-03	3.80E-01	mg/L	3 / 9	3.80E-01	mg/L	max
1,2-Dichloroethane	2.28E-03	2.70E-02	mg/L	4 / 9	2.70E-02	mg/L	max
Trichloroethene	1.40E-04	6.30E-03	mg/L	3 / 9	6.30E-03	mg/L	max
<i>Metals</i>							
Barium	1.33E-01	3.31E+00	mg/L	5 / 9	3.31E+00	mg/L	max
Manganese	3.88E-01	3.48E+00	mg/L	9 / 9	3.48E+00	mg/L	max
Strontium	9.93E-01	7.60E+00	mg/L	9 / 9	7.60E+00	mg/L	max
Thallium	1.20E-03	2.10E-03	mg/L	3 / 9	2.10E-03	mg/L	max

Notes:

QC samples were utilized during the risk assessment if the values (QC) were higher than the actual field sample results.

max maximum value

mg/L milligrams per kilogram

min minimum value

NA not applicable

TCDD tetrachloro-p-dibenzodioxin toxicity equivalent concentration

Table 2-7
Cancer Toxicity Data Summary - LHAAP-35B (37) and LHAAP-67

Pathway: Ingestion, Dermal						
Chemical of Concern	Oral Cancer Slope Factor	Dermal Cancer Slope Factor	Slope Factor Units	Weight of Evidence/ Cancer Guideline Description	Source	Date (YYYY)
Metals						
Barium	NC	NC	-	D	EPA IRIS	2001
Manganese	NC	NC	-	D	EPA IRIS	2001
Strontium	NTV	NTV	-	not classified	-	-
Thallium	NC	NC	-	not classified	-	-
Volatile Organics						
1,1,1-Trichloroethane	NC	NC	-	D	EPA IRIS	2001
1,1,2-Trichloroethane	5.70E-02	7.04E-02	(mg/kg-day) ⁻¹	C	EPA IRIS	2001
1,1-Dichloroethene	6.00E-01	6.00E-01	(mg/kg-day) ⁻¹	C	EPA IRIS	2001
1,2-Dichloroethane	9.10E-02	9.10E-02	(mg/kg-day) ⁻¹	B2	EPA IRIS	2001
Tetrachloroethene	5.20E-02	5.20E-02	(mg/kg-day) ⁻¹	B2	EPA NCEA EPA IRIS	2001
Trichloroethene	1.10E-02	1.10E-02	(mg/kg-day) ⁻¹	B2	EPA NCEA EPA IRIS	2001
Dioxin/Furan						
2,3,7,8-TCDD	1.50E+05	3.00E+05	(mg/kg-day) ⁻¹	not classified	EPA HEAST	1997

Table 2-7 (Continued)
Cancer Toxicity Data Summary - LHAAP-35B (37) and LHAAP-67

Pathway: Inhalation							
Chemical of Concern	Unit Risk Factor	Units	Inhalation Cancer Slope Factor	Units	Weights of Evidence/Cancer Guideline Description	Source	Date (YYYY)
<i>Metals</i>							
Barium	NC	—	—	—	D	EPA IRIS	2001
Manganese	NC	—	—	—	D	EPA IRIS	2001
Strontium	NTV	—	—	—	not classified	—	—
Thallium	NC	—	—	—	not classified	—	—
<i>Volatile Organics</i>							
1,1,1-Trichloroethane	NC	—	—	—	D	EPA IRIS	2001
1,1,2-Trichloroethane	1.60E-05	(mg/m ³) ⁻¹	—	—	C	EPA IRIS	2001
1,1-Dichloroethene	5.00E-02	(mg/m ³) ⁻¹	—	—	C	EPA IRIS	2001
1,2-Dichloroethane	2.60E-02	(mg/m ³) ⁻¹	—	—	B2	EPA IRIS	2001
Tetrachloroethene	5.80E-07	(mg/m ³) ⁻¹	—	—	B2	EPA NCEA EPA IRIS	2001
Trichloroethene	1.70E-03	(mg/m ³) ⁻¹	—	—	B2	EPA NCEA EPA IRIS	2001
<i>Dioxin/Furan</i>							
2,3,7,8-TCDD	3.30E+04	(mg/m ³) ⁻¹	—	—	not classified	EPA HEAST	1997

Key

— : No information available
 EPA: U.S. Environmental Protection Agency
 IRIS: Integrated Risk information System, EPA
 mg/kg-day: milligrams per kilogram per day
 mg/m³: milligrams per cubic meter
 NC: Chemical not classified as a carcinogen
 NCEA: National Center for Environmental Assessment
 NTV: no toxicity value available
 TCDD: tetrachlorodibenzo-p-dioxin

EPA Group:
 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
 D - Not classifiable as a human carcinogen

References

EPA-IRIS, 2001. United States Environmental Protection Agency Online Database for Toxicity Information Hazardous Chemicals.
 EPA-NCEA, 2001. EPA Region II Risk-Based Concentration Tables (5/8/2001). Referenced values from National Center for Environmental Assessment (NCEA).
 EPA-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.
 EPA, 1993. Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons, Office of Research and Development, EPA/600/R-93/089, July.

Table 2-8
Non-Cancer Toxicity Data Summary – LHAAP-35B (37) and LHAAP-67

Pathway: Ingestion, Dermal									
Chemical of Concern	Chronic/ Subchronic	Oral RfD Value	Oral RfD Units	Dermal RfD	Dermal RfD Units	Primary Target Organ	Combined Uncertainty/ Modifying Factors	Source of RfD Target Organ	Dates of RfD: Target Organ (YYYY)
Metals									
Barium	chronic	7.00e-02	mg/kg-day	4.90E-03	mg/kg-day	kidney	3/1	EPA-IRIS	2001
Manganese	chronic	4.70E-02	mg/kg-day	2.82E-03	mg/kg-day	CNS	1/1	EPA-IRIS	2001
Strontium	chronic	6.00E-01	mg/kg-day	1.20E-01	mg/kg-day	bone	300/1	EPA-IRIS	2001
Thallium	chronic	8.00E-05	mg/kg-day	8.00E-05	mg/kg-day	blood	3000/1	EPA-IRIS	2001
Volatile Organics									
1,1,1-Trichloroethane	chronic	2.80E-01	mg/kg-day	2.52E-01	mg/kg-day	NA	NA	EPA-NCEA	2001
1,1,2-Trichloroethane	chronic	4.00E-03	mg/kg-day	3.24E-03	mg/kg-day	blood	1000/1	EPA-IRIS	2001
1,1-Dichloroethene	chronic	9.00E-03	mg/kg-day	9.00E-03	mg/kg-day	liver	1000/1	EPA-IRIS	2001
1,2-Dichloroethane	chronic	3.00E-02	mg/kg-day	3.00E-02	mg/kg-day	NA	NA	EPA-NCEA	2001
Tetrachloroethene	chronic	1.00E-02	mg/kg-day	1.00E-02	mg/kg-day	liver	1000/1	EPA-IRIS	2001
Trichloroethene	chronic	6.00E-03	mg/kg-day	6.00E-03	mg/kg-day	NA	NA	-	-
Dioxin/Furan									
2,3,7,8-TCDD	-	NTV	-	NTV	NTV	skin	-	EPA-NCEA	2001

Table 2-8 (Continued)
Non-Cancer Toxicity Data Summary – LHAAP-35B (37) and LHAAP-67

Pathway: Inhalation									
Chemical of Concern	Chronic/ Subchronic	Inhalation RfC	Inhalation RfC Units	Inhalation RfD	Inhalation RfD Units	Primary Target Organ	Combined Uncertainty/ Modifying Factors	Source of RfC/RfD Target Organ	Dates (YYYY)
Metals									
Barium	chronic	0.00049	mg/kg-day	-	-	fetus	1000/1	EPA-HEAST	1997
Manganese	chronic	0.00005	mg/kg-day	-	-	CNS	1000/1	EPA-NCEA	2001
Strontium	NTV	-	-	-	-	-	-	-	-
Thallium	chronic	0.0001	mg/kg-day	-	-	NA	NA	TCEQ	2001
Volatile Organics									
1,1,1-Trichloroethane	chronic	2.205	mg/kg-day	-	-	NA	NA	EPA-NCEA	2001
1,1,2-Trichloroethane	NTV	-	-	-	-	-	-	-	-
1,1-Dichloroethene	NTV	-	-	-	-	-	-	-	-
1,2-Dichloroethane	chronic	0.005	mg/kg-day	-	-	NA	NA	EPA-NCEA	2001
Tetrachloroethene	chronic	0.049	mg/kg-day	-	-	NA	NA	EPA-NCEA	2001
Trichloroethene	NTV	-	-	-	-	-	-	-	-
Dioxin/Furan									
2,3,7,8-TCDD	NTV	-	-	-	-	-	-	-	-

Key

—: No information available
 CNS: Central nervous system
 EPA: U.S. Environmental Protection Agency
 IRIS: Integrated Risk Information System, EPA
 mg/kg-day: milligrams per kilogram per day
 NA: Information not available
 NC: Chemical not classified as a carcinogen
 NCEA: National Center for Environmental Assessment
 NTV: no toxicity value available
 RfD: Reference dose
 TCDD: tetrachlorodibenzo-p-dioxin
 TCEQ: Texas Commission on Environmental Quality

Summary of Toxicity Assessment

This table provides carcinogenic risk information relevant to the contaminants of concern in ground water. The chronic toxicity data available for chronic exposures have been taken from U. S. EPA or TCEQ sources.

References

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

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

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

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

TCEQ, 2001. Update to 1998 Consistency Memorandum. Toxicity Factors Table, 15 March, 2001.

Summary of Toxicity Assessment

This table provides non-carcinogenic risk information relevant to the contaminants of concern in ground water. The chronic toxicity data available for chronic exposures have been taken from U. S. EPA or TCEQ sources.

Table 2-9
Risk Characterization Summary – LHAAP-35B (37)
Carcinogens in Surface Soil and Groundwater

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
Surface Soil (0 to 0.5 feet bgs)				Total Soil Risk =			5E-06
Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogen Risk			
				Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater		<i>Dioxin/Furan</i>				
		Ingestion or Showering	2,3,7,8-TCDD	2.6E-06	NE	2.1E-05	2.4E-05
			<i>Volatile Organic Compounds</i>				
		Ingestion or Showering	1,1-Dichloroethene	1.2E-04	1.8E-04	1.6E-04	4.6E-04
		Ingestion or Showering	Tetrachloroethene	6.2E-06	1.2E-09	2.5E-05	3.1E-05
	Ingestion or Showering	Trichloroethene	1.3E-05	3.4E-05	1.7E-05	6.3E-05	
				Total Groundwater Risk =			6E-04
				Total Soil + Groundwater Risk =			6E-04

Key

NE Not evaluated through this exposure pathway. Chemical is not identified as a volatile

References

EPA, *Risk Assessment Guidance for Superfund, Vol. I: Human Health Evaluation Manual, (Part A)*, OSWER Directive 9285.7-01a, Office of Emergency and Remedial Response, Washington, DC, 1989.

EPA, *National Oil and Hazardous Substances Pollution Contingency Plan, Final Rule, 40 CFR Part 300*, March 8, 1990.

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

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, Saunder's Branch, Central Creek, and Caddo Lake), Longhorn Army Ammunition Plant, Karnack, Texas*, June.

Summary of Risk Characterization

Calculated cancer risks for potential exposure to chemicals of concern in soil at LHAAP-35B(37) are 5E-06, rounded to 1 significant figure as specified in EPA guidance (EPA, 1989). The calculated cancer risk from all chemicals in soil by all exposure pathways is within the 1E-06 to 1E-04 acceptable range (EPA, 1990).

Calculated cancer risks for potential exposure to chemicals of concern in groundwater are 6E-04. The calculated cancer risk from exposure to all chemicals in groundwater by all exposure pathways is above the 1E-06 to 1E-04 acceptable range (EPA, 1990). The risk is predominantly associated with exposure to 1,1-dichloroethene (4.6×10^{-4}) by the direct contact pathway, which is above the acceptable range. Additional risk was estimated for tetrachloroethene, trichloroethene, and 2,3,7,8-TCDD, with a cumulative risk above 1×10^{-4} , although estimates for the individual chemicals are within the acceptable range. Significant risk was associated with inhalation exposures to 1,1-dichloroethene and trichloroethene.

**Table 2-10
Risk Characterization Summary – LHAAP-35B (37)
Non-Carcinogens in Surface Soil and Groundwater**

Scenario Timeframe:		Future					
Receptor Population:		Maintenance Worker					
Receptor Age:		Adult					
Medium	Exposure Medium	Exposure Point	Chemical of Concern	Non-Carcinogenic Hazard Quotient			
				Ingestion	Inhalation	Dermal	Exposure Routes Total
Subsurface Soil (0 to 0.5 feet bgs)				Total Soil Noncancer Hazard Index (HI) =			1E-01
Medium	Exposure Medium	Exposure Point	Chemical of Concern	Non-Carcinogenic Hazard Quotient			
				Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater		<i>Metals</i>				
		Ingestion or Showering	Antimony	2.0E+00	NE	NE (Kp<=0.01)	2.0E+00
		Ingestion or Showering	Thallium	1.2E+01	NE	NE (Kp<=0.01)	1.2E+01
			<i>Volatile Organic Compounds</i>				
		Ingestion or Showering	Trichloroethene	5.3E-01	NTV	7.1E-01	1.2E+00
						Total Groundwater Noncancer Hazard Index (HI) =	2E+01
						Total Soil + Groundwater Noncancer Hazard Index (HI) =	2E+01

Key	
NE	Not evaluated through this exposure pathway. Chemical is not identified as a volatile
NE (Kp<=0.01)	Based on EPA 6 guidance, COCs with a Kp<=0.01 were not evaluated for dermal contact while showering (EPA, 1995).
NTV	No toxicity value available to quantitatively address this exposure

References	
EPA, <i>Risk Assessment Guidance for Superfund, Vol. I: Human Health Evaluation Manual, (Part A)</i> , OSWER Directive 9285.7-01a, Office of Emergency and Remedial Response, Washington, DC, 1989.	
EPA, <i>National Oil and Hazardous Substances Pollution Contingency Plan, Final Rule, 40 CFR Part 300</i> , March 8, 1990.	
EPA, <i>Supplemental Region VI Risk Assessment Guidance, May 5, 1995</i> .	
Jacobs, 2003, <i>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, Saunder's Branch, Central Creek, and Caddo Lake), Longhorn Army Ammunition Plant, Karnack, Texas</i> , June.	

Summary of Risk Characterization	
<p>Calculated noncancer hazards for potential exposure to chemicals of concern in soil at LHAAP-35B (37) are 0.1, rounded to 1 significant figure as specified in EPA guidance (EPA, 1989). The calculated HI for all chemicals by all exposure pathways is below the acceptable value of 1 (EPA, 1990).</p>	
<p>Calculated noncancer hazard index for potential exposure to chemicals of concern in groundwater are 20. The calculated HI from all chemicals in groundwater all exposure pathways is above the acceptable value of 1 (EPA, 1990). The HI is predominantly associated with exposure to thallium and antimony by the groundwater ingestion route. Additional HI above the acceptable value of 1 is associated with trichloroethene by the combined exposures by groundwater ingestion and dermal contact while showering.</p>	

Table 2-11
Risk Characterization summary – LHAAP-67
Carcinogens in Surface Soil and Groundwater

Scenario Timeframe:		Future					
Receptor Population:		Maintenance Worker					
Receptor Age:		Adult					
Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogen Risk			Exposure Routes Total
				Ingestion	Inhalation	Dermal	
Surface Soil (0 to 0.5 feet bgs)			Total Soil Risk =				3E-07
Groundwater	Groundwater	Ingestion or Showering	1,1-Dichloroethene	8.0E-04	1.2E-03	1.1E-03	3.0E-03
						Total Groundwater Risk =	3E-03
						Total Soil + Groundwater Risk =	3E-03

References

EPA, *Risk Assessment Guidance for Superfund, Vol. I: Human Health Evaluation Manual, (Part A)*, OSWER Directive 9285.7-01a, Office of Emergency and Remedial Response, Washington, DC, 1989.

EPA, *National Oil and Hazardous Substances Pollution Contingency Plan, Final Rule, 40 CFR Part 300*, March 8, 1990.

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

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, Saunder's Branch, Central Creek, and Caddo Lake), Longhorn Army Ammunition Plant, Karnack, Texas*, June.

Summary of Risk Characterization

Calculated cancer risks for potential exposure to chemicals of concern in soil at LHAAP-67 are 3E-07, rounded to 1 significant figure as specified in EPA guidance (EPA, 1989). The calculated cancer risk from all chemicals in soil by all exposure pathways is below the 1E-06 to 1E-04 acceptable range (EPA, 1990).

Calculated cancer risks for potential exposure to chemicals of potential concern in groundwater are 3E-03, which is above the 1E-06 to 1E-04 acceptable range. The risk is predominantly associated with exposure to 1,1-dichloroethene inhalation and dermal contact pathways while showering. The cancer risk associated with 1,1-dichloroethene ingestion of groundwater is also above the EPA acceptable cancer risk level. Cancer risks from exposures to all other compounds in groundwater are within the acceptable risk range.

Table 2-12
Risk Characterization Summary – LHAAP-67
Non-Carcinogens in Surface Soil and Groundwater

Scenario Timeframe:		Future						
Receptor Population:		Maintenance Worker						
Receptor Age:		Adult						
Medium	Exposure Medium	Exposure Point	Chemical of Concern	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	
Surface Soil (0 to 0.5 feet bgs)			Total Soil Hazard Index (HI) =				0E+00	
Groundwater	Groundwater		<i>Metals</i>					
		Ingestion or Showering	Barium	4.6E-01	NE	NE (Kp<=0.01)	4.6E-01	
		Ingestion or Showering	Manganese	7.2E-01	NE	NE (Kp<=0.01)	7.2E-01	
		Ingestion or Showering	Strontium	1.2E-01	NE	NE (Kp<=0.01)	1.2E-01	
		Ingestion or Showering	Thallium	2.6E-01	NE	NE (Kp<=0.01)	2.6E-01	
			<i>Volatile Organic Compounds</i>					
		Ingestion or Showering	1,1,1-Trichloroethane	6.3E-02	1.4E-01	1.0E-01	3.0E-01	
		Ingestion or Showering	1,1,2-Trichloroethane	8.1E-02	NTV	7.3E-02	1.5E-01	
		Ingestion or Showering	1,1-Dichloroethene	4.1E-01	NTV	5.5E-01	9.6E-01	
		Ingestion or Showering	1,2-Dichloroethane	8.8E-03	9.2E-01	4.1E-03	9.4E-01	
		Total Groundwater Hazard Index (HI) =						4E+00
		Total Soil + Groundwater Hazard Index (HI) =						4E+00

Key

NE	Not evaluated through this exposure pathway. Chemical is not identified as a volatile
NE (Kp<=0.01)	Based on EPA 6 guidance, chemicals of potential concern with a Kp<=0.01 were not evaluated for dermal contact while showering (EPA, 1995).
NTV	No toxicity value available to quantitatively address this exposure

References

EPA, *Risk Assessment Guidance for Superfund, Vol. I: Human Health Evaluation Manual, (Part A)*, OSWER Directive 9285.7-01a, Office of Emergency and Remedial Response, Washington, DC, 1989.

EPA, *National Oil and Hazardous Substances Pollution Contingency Plan, Final Rule, 40 CFR Part 300*, March 8, 1990.

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

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, Saunder's Branch, Central Creek, and Caddo Lake), Longhorn Army Ammunition Plant, Karnack, Texas*, June.

Summary of Risk Characterization

The calculated noncancer HI for potential exposure to chemicals of potential concern in soil at LHAAP-67 is 0, which is below the EPA acceptable HI value of 1 (EPA, 1990).

The calculated noncancer HI for potential exposure to chemicals of potential concern in groundwater is 4E+00, which is above the acceptable HI value of 1. The HI is predominantly associated with exposure to 1,1-dichloroethene, 1,2-dichloroethane, 1,1,1-trichloroethane, and 1,1,2-trichloroethane by inhalation and dermal contact pathways while showering. The noncancer HI associated with barium, manganese, strontium, and thallium exposure by groundwater ingestion is also above the EPA acceptable level.

**Table 2-13
Comparative Analysis of Alternatives**

Criteria	Alternative 1 No Action,	Alternative 2 Land Use Controls and Monitored Natural Attenuation	Alternative 3 In-Situ Bioremediation, Land Use Controls (Short Term)	Alternative 4 Groundwater Extraction, Surface Water Discharge, and Land Use Controls (Short Term)
Overall protection of human health and the environment	No protection. Does not achieve RAOs.	Achieves RAOs. Protection of human health and environment provided by maintenance of land use controls. Monitoring activities would demonstrate that surface water is not impacted by groundwater contaminants. MNA would return groundwater to beneficial use, where practicable.	Achieves RAOs. Protection of human health and environment provided by remediation of groundwater COCs to MCLs. Protection of surface water provided by groundwater return to beneficial use, where practicable.	Achieves RAOs. Protection of human health and environment provided by remediation of groundwater COCs to MCLs. Protection of surface water provided by groundwater return to beneficial use, where practicable.
Compliance with ARARs	No compliance with ARARs.	Complies with all ARARs.	Complies with all ARARs.	Complies with all ARARs.
Long-term effectiveness and permanence	Not effective.	Land use controls would be effective and reliable so long as they are maintained until natural attenuation processes reduce COCs to their respective MCLs.	Should be effective and permanent; however, uncertainty exists concerning the effectiveness of in-situ biological treatment for reducing groundwater contaminant concentrations to remediation levels. Treatability and pilot studies would be required to further assess the effectiveness of this treatment method.	Should be effective and permanent, but uncertainty exists whether groundwater extraction would sufficiently lower contaminant concentrations to remediation levels. A pre-design study would be required to determine the optimum extraction technique/configuration.
Reduction of toxicity, mobility, or volume through treatment	No active reduction.	Passively reduces the volume, toxicity, and mobility of the contaminants.	Provides permanent and irreversible reduction only if the results of biological treatability and pilot studies prove favorable.	Extraction and treatment of contaminated groundwater reduces toxicity, mobility, and volume of groundwater contaminants in this area.

**Table 2-13 (Continued)
Comparative Analysis of Alternatives**

Criteria	Alternative 1 No Action,	Alternative 2 Land Use Controls and Monitored Natural Attenuation	Alternative 3 In-Situ Bioremediation, Land Use Controls (Short Term)	Alternative 4 Groundwater Extraction, Surface Water Discharge, and Land Use Controls (Short Term)
Short-term effectiveness	No short-term impacts from the Alternative. Continued risk to community and environment through No Action.	No short term impacts to the community and the environment and negligible impacts to workers, from short-term activities. Provides almost immediate protection.	No short term impacts to the community and the environment and negligible impacts to workers from short-term activities. Provides almost immediate protection.	No short term impacts to the community and the environment and negligible impacts to workers from short-term activities. Provides almost immediate protection.
Implementability	Inherently implementable.	Readily implemented.	Implementable, but uncertainty exists whether in-situ bioremediation would sufficiently lower contaminant concentrations to remediation levels. Further studies would be required. Specialized knowledge required for implementation.	Implementation straightforward, but uncertainty exists whether groundwater extraction would sufficiently lower contaminant concentrations to remediation levels. A pre-design study would be required.
Cost* LHAAP-35B (37)				
• Capital	\$0	\$79,000	\$2,535,000	\$1,271,000
• O&M	\$0	\$393,000	\$317,000	\$1,764,000
Estimated Duration** (years)	—	30	6	30
• Present worth	\$0	\$282,000	\$2,664,000	\$2,095,000
Cost* LHAAP-67				
• Capital	\$0	\$47,000	\$1,691,000	\$1,211,000
• O&M	\$0	\$607,000	\$367,000	\$1,904,000
Estimated Duration** (years)	—	30	6	30
• Present worth	\$0	\$316,000	\$1,793,000	\$1,957,000

Notes and Abbreviations:

- *Costs have been rounded off to three significant figures.
- ARAR applicable or relevant and appropriate requirement
- COC chemical of concern
- FS feasibility study
- LHAAP Longhorn Army Ammunition Plant
- MCL maximum contaminant level
- MNA monitored natural attenuation

NA *not applicable*
O&M *operation and maintenance*
RAO *remedial action objective*

Table 2-14
Remediation Cost Table – LHAAP-35B (37)
Alternative 2

WBS	Summary Description	Costs
Capital Costs		
1.20.10	Regulatory Documents	
1.20.20	Remedial Design	
1.20.20.10	Remedial Design Documents	
1.20.20.20	Treatability Studies	
	Subtotal Indirect Costs	\$0
1.20.30 Remedial Action		
1.20.30.10	General Contractor Construction Management	
1.20.30.20 Remediation		
1.20.30.20.10 Groundwater Remediation Cost		
1.20.30.20.10.10	Land Use Controls (Access Controls)	\$16,035
1.20.30.20.10.20	Groundwater Extraction System Installation	
1.20.30.20.10.30	In Situ Bioremediation	
1.20.30.20.10.40	Monitoring Well Installation	\$62,983
	Subtotal Direct Costs	\$79,018
	Subtotal Capital Cost	\$79,018
Operations and Maintenance		
1.20.40 O&M		
1.20.40.10 Groundwater Treatment O&M Cost		
1.20.40.10.10	Long Term Monitoring	\$393,109
1.20.40.10.20	Extraction Wells O&M	
	Subtotal O&M Cost	\$393,109
Total Cost		\$472,127
Present Value for Capital		\$79,018
Present Value for O&M		\$203,444
Present Value Total		\$282,462

**Table 2-15
Remediation Cost Table - LHAAP-67
Alternative 2**

WBS	Summary Description	Costs
Capital Costs		
1.20.10	Regulatory Documents	
1.20.20	Remedial Design	
1.20.20.10	Remedial Design Documents	
1.20.20.20	Treatability and Pilot Studies	
	Subtotal Indirect Costs	\$0
1.20.30	Remedial Action	
1.20.30.10	General Contractor Construction Management	
1.20.30.20	Remediation	
1.20.30.20.10	Groundwater Remediation Cost	
1.20.30.20.10.10	Institutional Controls (Access Controls)	\$16,035
1.20.30.20.10.20	Groundwater Extraction System Installation	
1.20.30.20.10.30	In Situ Bioremediation	
1.20.30.20.10.40	Monitoring Well Installation	\$31,111
	Subtotal Direct Costs	\$47,146
	Subtotal Capital Cost	\$47,146
Operations and Maintenance		
1.20.40	O&M	
1.20.40.10	Groundwater Treatment O&M Cost	
1.20.40.10.10	Long Term Monitoring with MNA Analyses	\$606,976
1.20.40.10.20	Extraction Well O&M	
	Subtotal O&M Cost	\$606,976
Total Cost		\$654,122
Present Value for Capital		\$44,062
Present Value for O&M		\$271,560
Present Value Total		\$315,622

Note: WBS is work breakdown structure

**Figure 2-1
Location of Longhorn Army Ammunition Plant**

**Figure 2-2
Site Location Map, LHAAP-35B(37) and LHAAP-67**

**Figure 2-3
Sampling Locations LHAAP-35B(37)**

**Figure 2-4
Site Map with Sampling Locations, Record of Decision, LHAAP-67, Group 4**

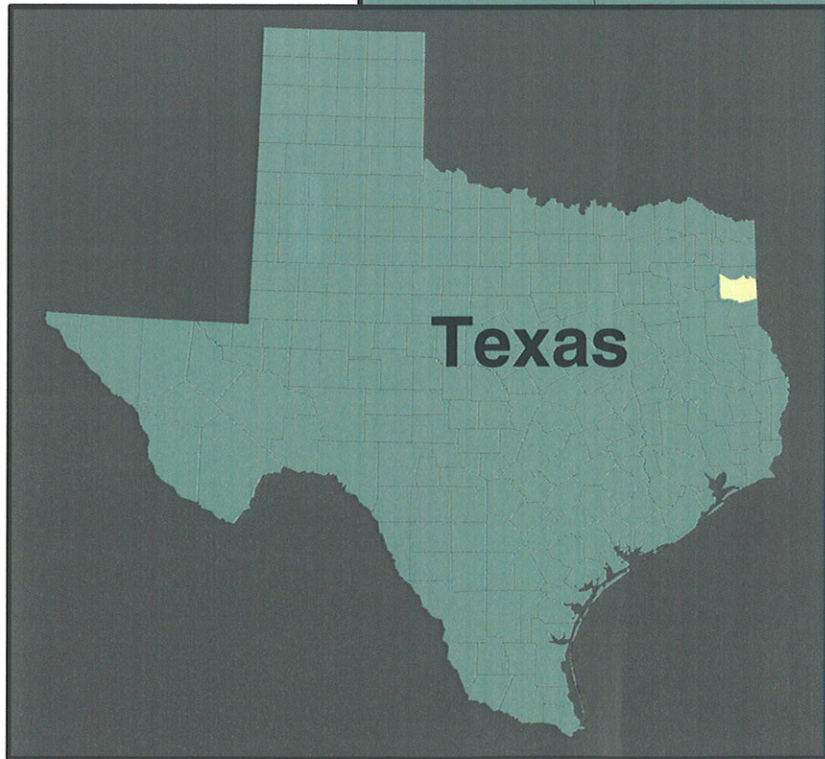
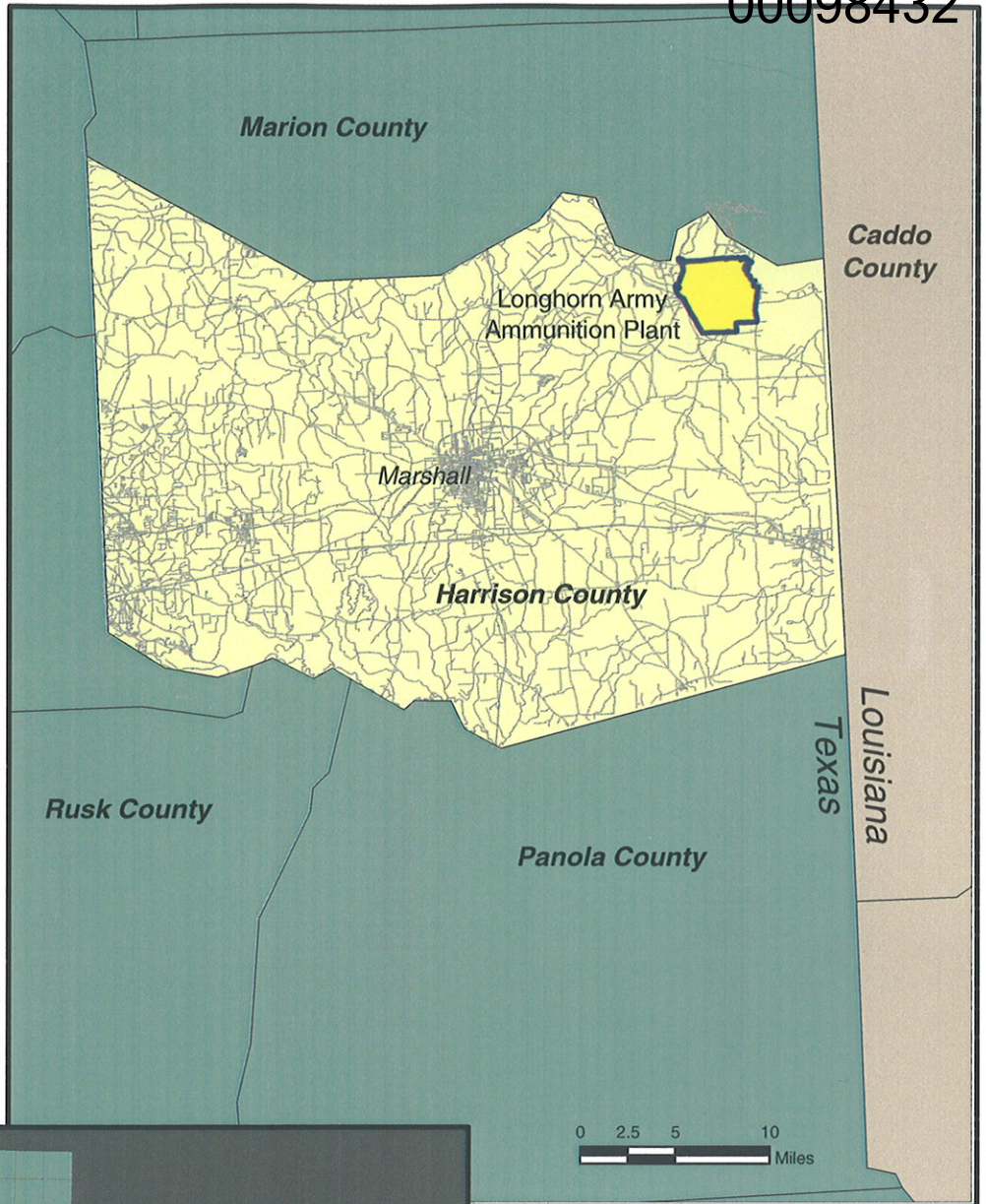
**Figure 2-5
Groundwater Elevation Map, Shallow Zone, Record of Decision, LHAAP-35B(37), Group 4**


**Figure 2-6
Groundwater Elevation Map, Shallow Zone, Record of Decision, LHAAP-67, Group 4**

**Figure 2-7
Conceptual Site Model, Record of Decision, LHAAP-35B(37), Group 4**

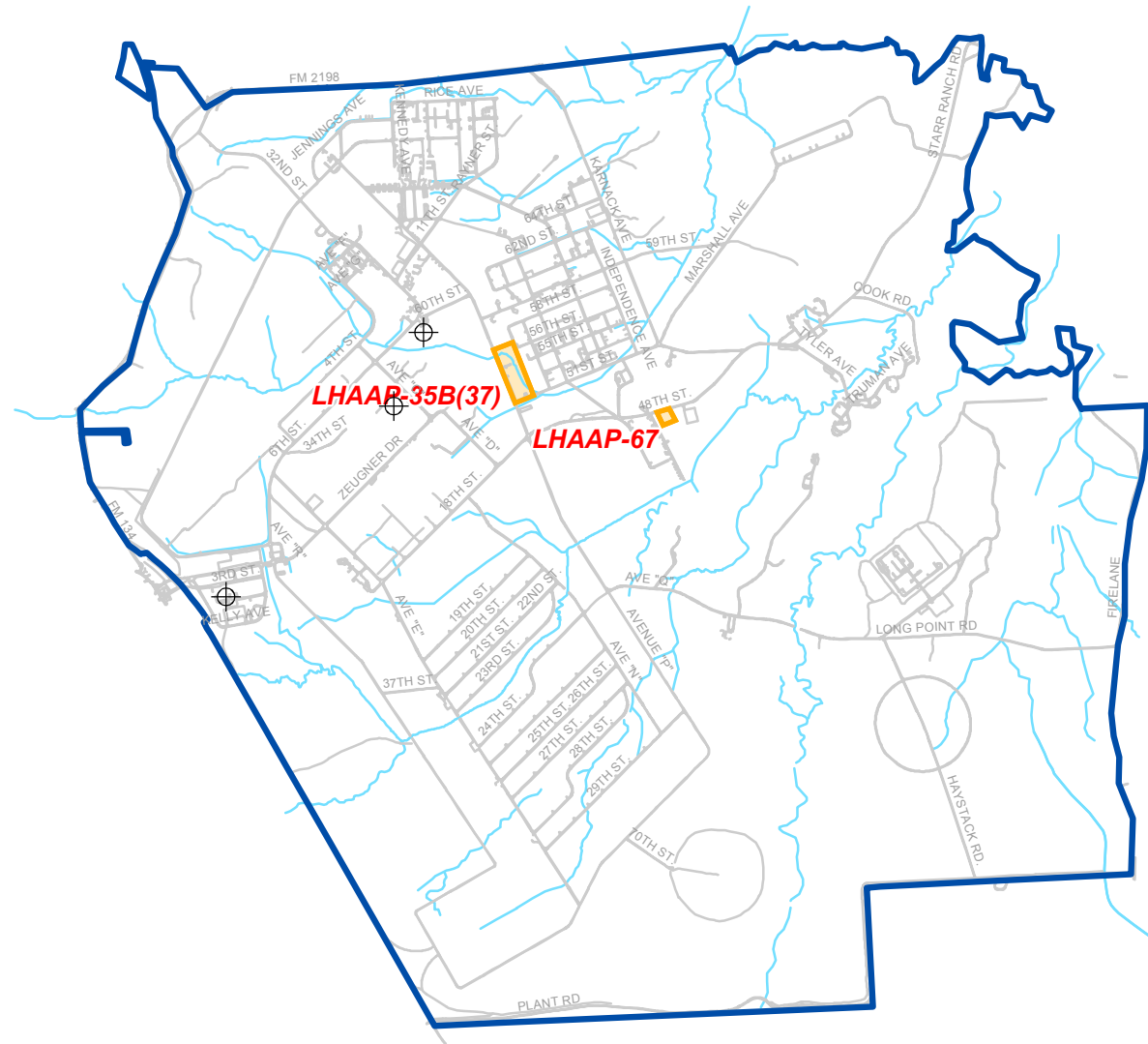
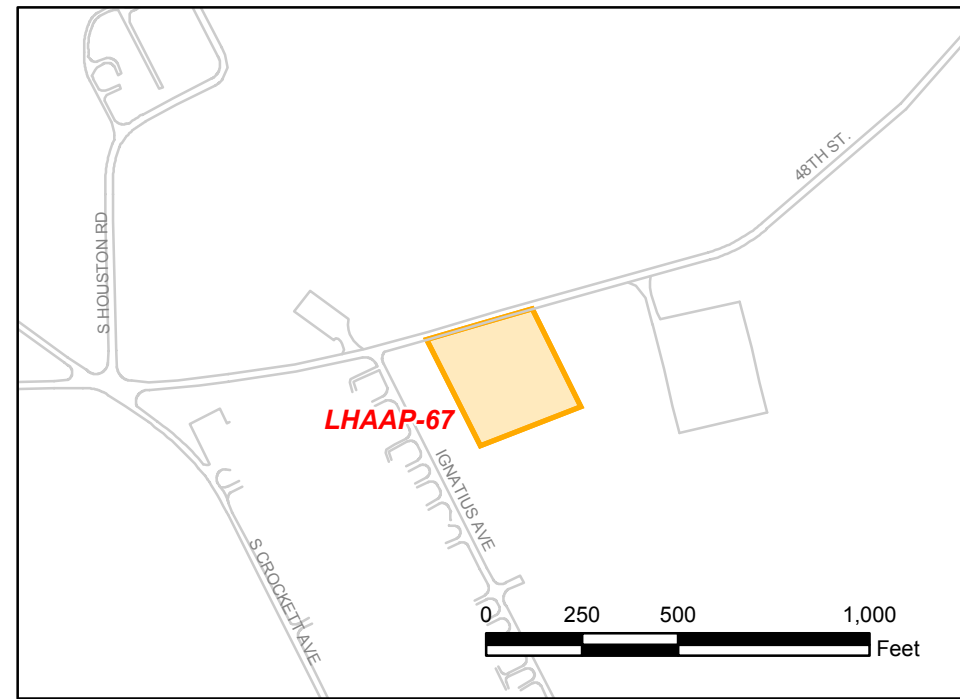
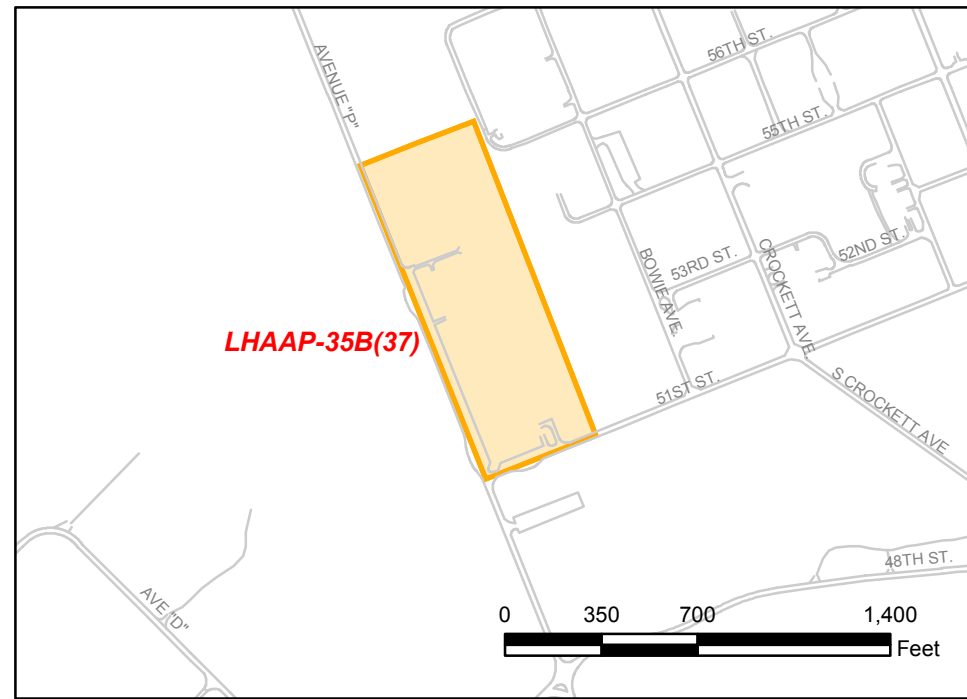
**Figure 2-8
Conceptual Site Model, Record of Decision, LHAAP-67, Group 4**

OFFICE	DRAWN BY	CHECKED BY	APPROVED BY	FILE PATH
Houston, TX	P.Pace	A. Mayila	P. Srivastav	X:\Longhorn\GIS\workspace\BLU\MXD\Transfer1.mxd
	02/27/04	12/22/04	06/30/05	



	U.S. ARMY CORPS OF ENGINEERS TULSA DISTRICT TULSA, OKLAHOMA
	FIGURE 2-1 LOCATION OF LONGHORN ARMY AMMUNITION PLANT, HARRISON COUNTY, TEXAS LONGHORN ARMY AMMUNITION PLANT KARNACK, TEXAS

OFFICE Houston, TX
 DRAWN BY B. Lu 10/12/07
 CHECKED BY N. Olson 10/31/07
 APPROVED BY P. Srivastav 10/31/07
 FILE PATH T:\GIS\Longhorn\MXD\ST35B67\ROD\SiteLocs.mxd



LEGEND

- Road
- Stream
- Site
- Approximate LHAAP Boundary
- ⊕ LHAAP Water Supply Well

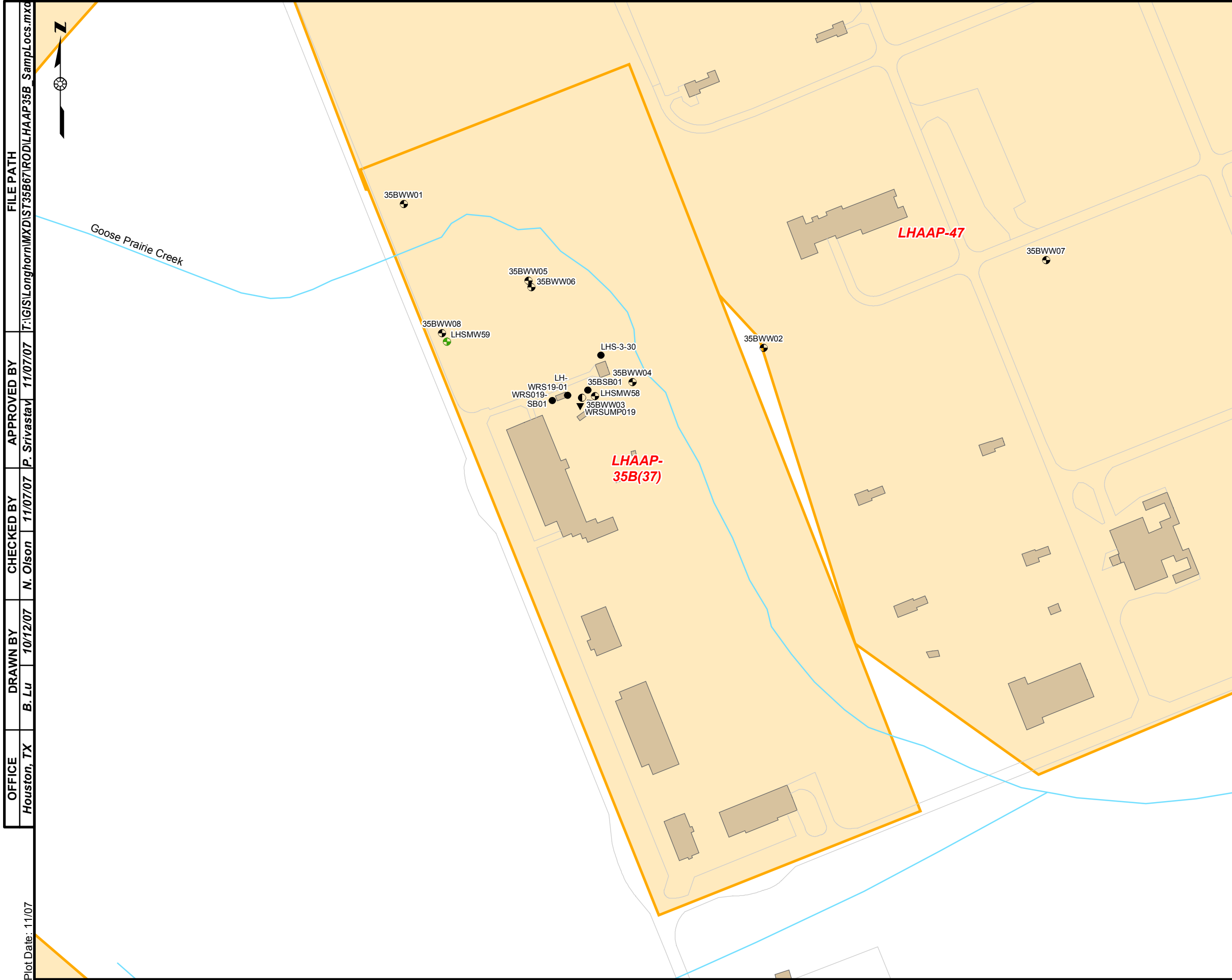
LEGEND

- Approximate LHAAP Boundary
- Road
- Stream
- Site
- ⊕ LHAAP Water Supply Well

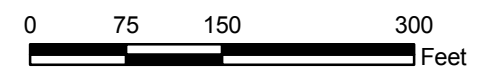


U.S. ARMY CORPS OF ENGINEERS
 TULSA DISTRICT
 TULSA, OKLAHOMA

FIGURE 2-2
 SITE LOCATION MAP
 RECORD OF DECISION
 LHAAP-35B(37) AND LHAAP-67, GROUP 4
 LONGHORN ARMY AMMUNITION PLANT
 KARNACK, TEXAS



- Legend**
- Soil Boring
 - ▼ Sump
 - ⊕ Shallow Monitoring Well
 - ⦿ Intermediate Monitoring Well
 - ⊕ Abandoned Shallow Monitoring Well
 - Stream
 - Road
 - Former Building or Concrete Slab
 - Site



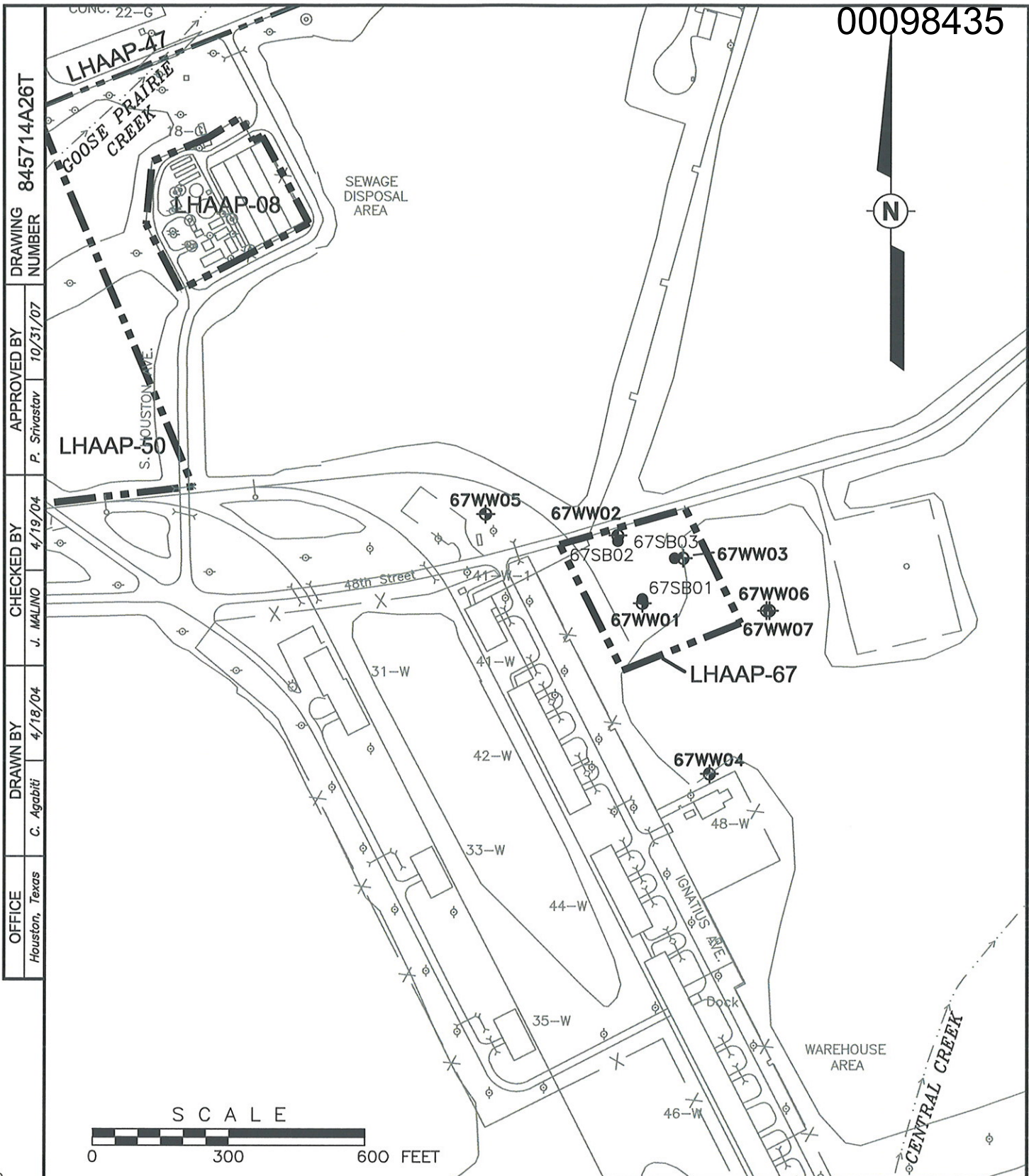
FILE PATH T:\GIS\Longhorn\MXD\ST35B67\ROD\LHAAP35B_SampLocs.mxd
 APPROVED BY P. Srivastay 11/07/07
 CHECKED BY N. Olson 11/07/07
 DRAWN BY B. Lu 10/12/07
 OFFICE Houston, TX

Plot Date: 11/07



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

FIGURE 2-3
 SITE MAP WITH SAMPLING LOCATIONS
 RECORD OF DECISION
 LHAAP-35B(37), GROUP 4
 LONGHORN ARMY AMMUNITION PLANT
 KARNACK, TEXAS



OFFICE Houston, Texas	DRAWN BY C. Agabiti	CHECKED BY J. MALINO	APPROVED BY P. Srivastav	DRAWING NUMBER 845714A26T
	4/18/04	4/19/04	10/31/07	



Legend

-  Shallow Monitoring Well
-  Soil Boring Location
-  Site Boundary
-  Creek/Bayou


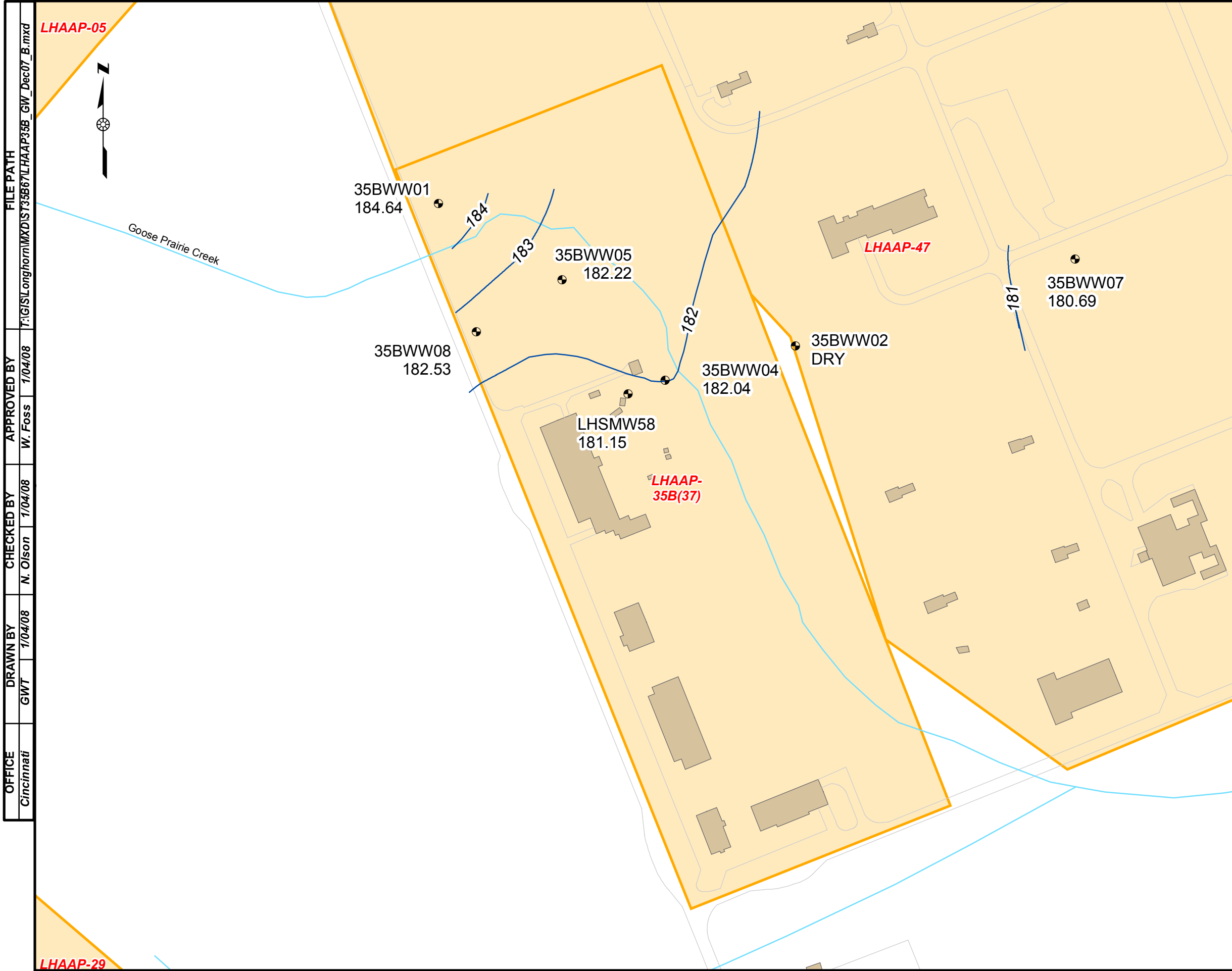
	U.S. ARMY CORPS OF ENGINEERS TULSA DISTRICT TULSA, OKLAHOMA
--	---

FIGURE 2-4
SITE MAP WITH SAMPLING LOCATIONS
RECORD OF DECISION, LHAAP-67,
GROUP 4
 LONGHORN ARMY AMMUNITION PLANT
 KARNACK, TEXAS

K:\PROJECT\845714\845714A26T.DWG
 Plot Date/Time: 010/12/07
 Plotted by: colette.agabiti



OFFICE	Cincinnati	DRAWN BY	GWT	1/04/08	CHECKED BY	N. Olson	1/04/08	APPROVED BY	W. Foss	1/04/08	FILE PATH	T:\GIS\Longhorn\MXD\IST35B67\LHAAP35B_GW_Dec07_B.mxd
--------	------------	----------	-----	---------	------------	----------	---------	-------------	---------	---------	-----------	--

Legend

- Upper Shallow Zone Monitoring Well
- Groundwater Elevation Contours (1 Ft)
- ~ Stream
- Road
- Former Building or Concrete Slab
- Site

0 75 150 300 Feet

Shaw

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

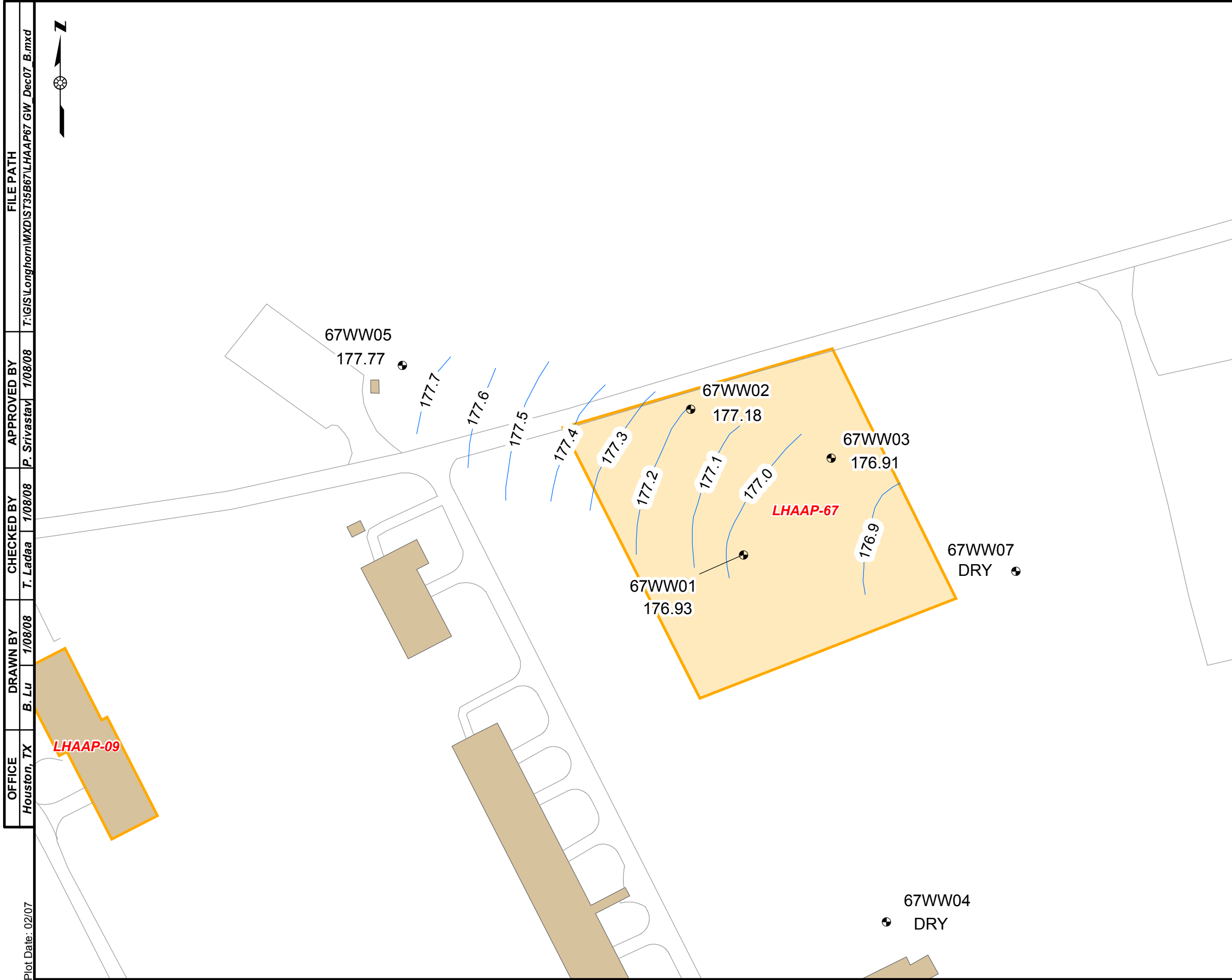
FIGURE 2-5
GROUNDWATER ELEVATION MAP,
SHALLOW ZONE, RECORD OF DECISION,
LHAAP-35B(37), GROUP 4
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

LHAAP-29

LHAAP-05

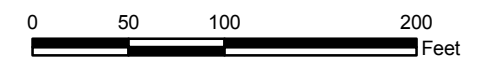

LHAAP-47

LHAAP-35B(37)



OFFICE	DRAWN BY	CHECKED BY	APPROVED BY	FILE PATH
Houston, TX	B. Lu 1/08/08	T. Ladaa 1/08/08	P. Srivastay 1/08/08	T:\GIS\Longhorn\MXD\ST35B67\LHAAP67_GW_Dec07_B.mxd

- Legend**
- Shallow Monitoring Well
 - Groundwater Elevation Contours (0.1ft)
 - Stream
 - Road
 - Former Building or Concrete Slab
 - Site

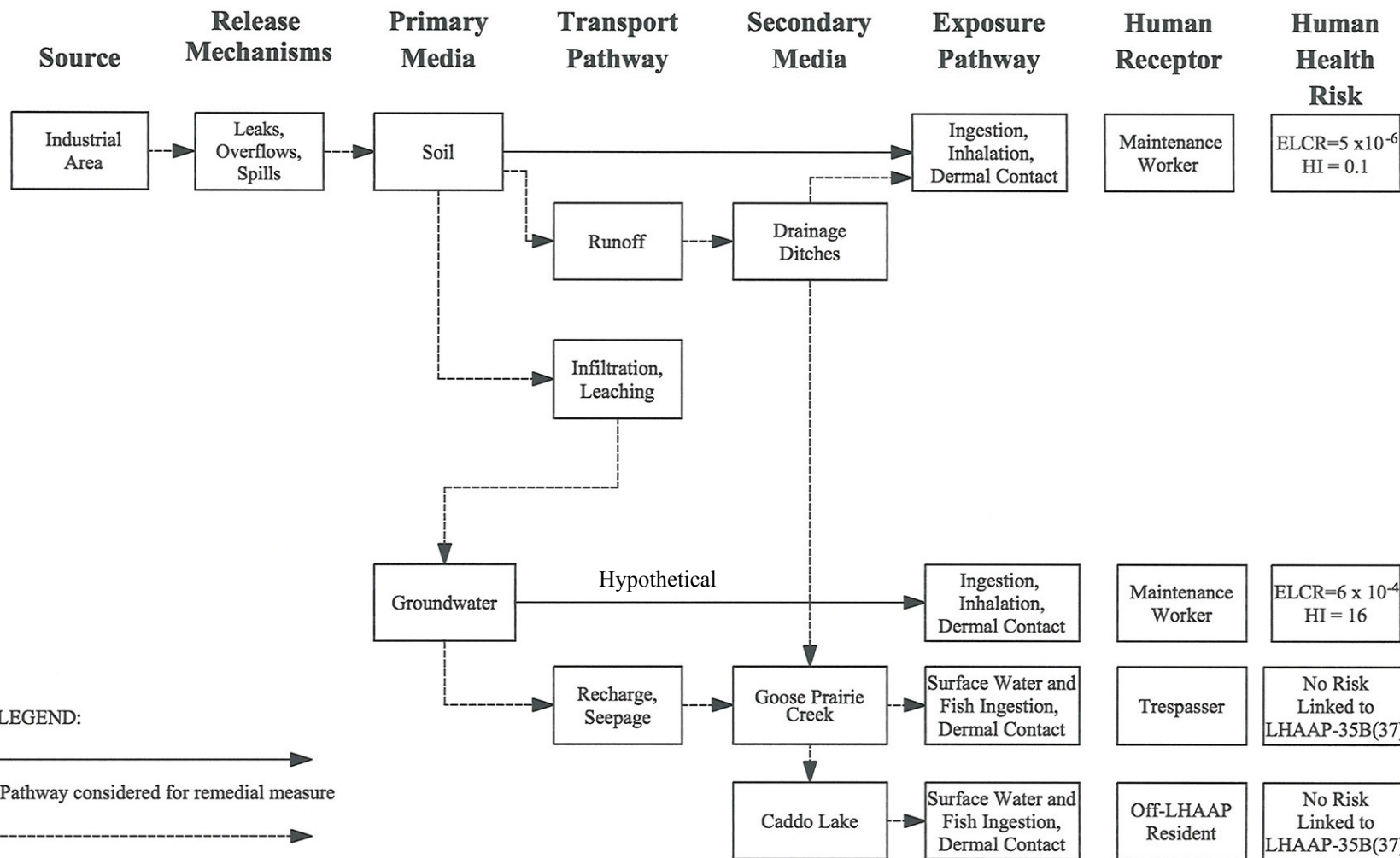
U.S. ARMY CORPS OF ENGINEERS
TULSA DISTRICT
TULSA, OKLAHOMA

FIGURE 2-6
GROUNDWATER ELEVATION MAP,
SHALLOW ZONE, RECORD OF DECISION,
LHAAP-67, GROUP 4
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

Plot Date: 02/07

PLOT DATE: 11/12/07
 FORMAT REVISION 5/13/02

IMAGE	X-REF	OFFICE	DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER			
---	---	Houston, Texas	J. RDZ	10/29/04	J. MALINO	11/01/04	P. SRIVASTAV	10/31/07	845714-A30



LEGEND:

- > Pathway considered for remedial measure
- - - - -> Pathway *not* considered for remedial measure

ELCR EXCESS LIFETIME CANCER RISK

HI HAZARD INDEX


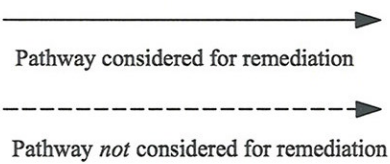
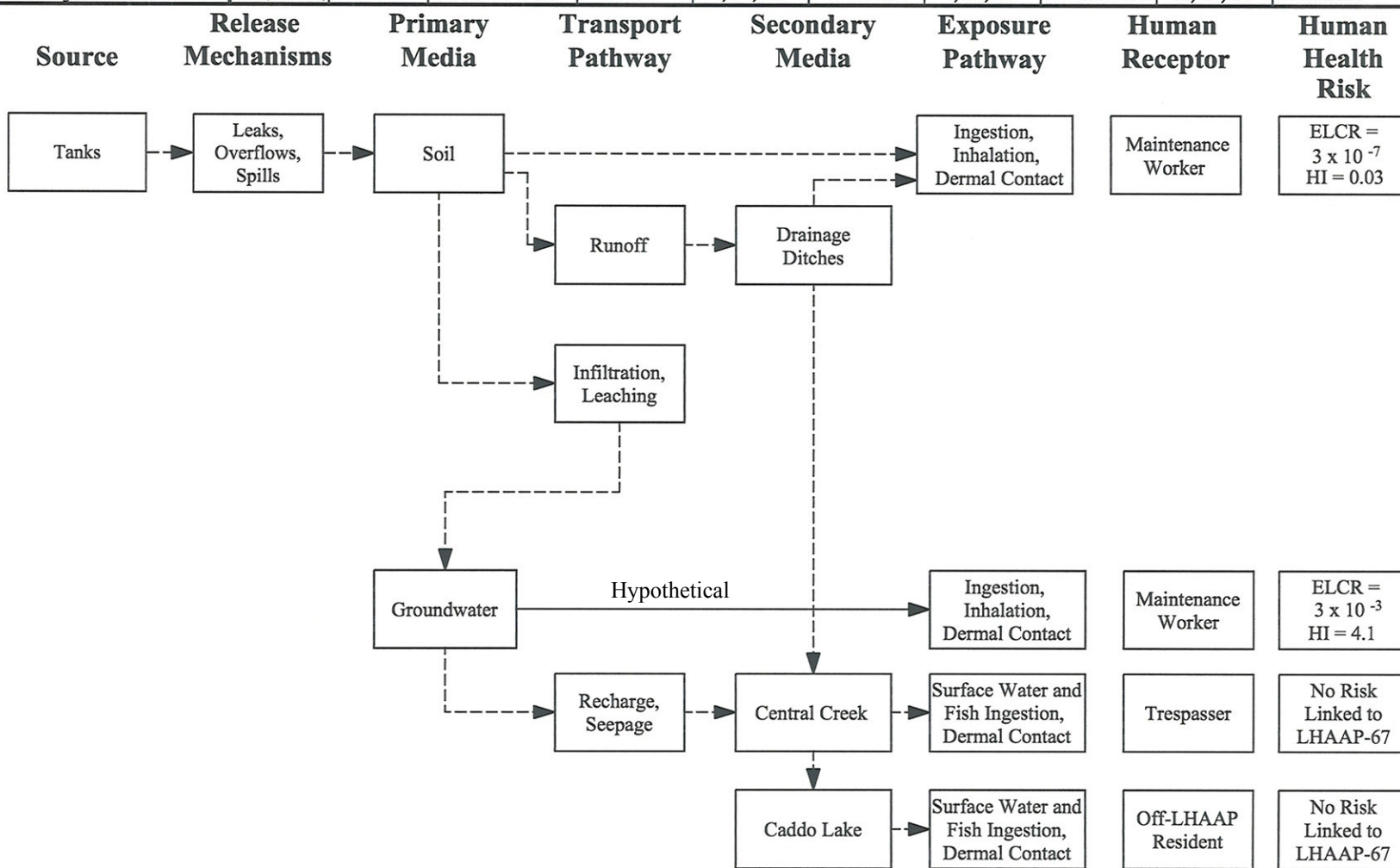
	U.S. CORPS OF ENGINEERS TULSA DISTRICT TULSA, OKLAHOMA
---	--


FIGURE 2-7
 CONCEPTUAL SITE MODEL
 RECORD OF DECISION, LHAAP-35B(37),
 GROUP 4
 LONGHORN ARMY AMMUNITION PLANT
 KARNACK, TEXAS

K:\PROJECT\845714\845714A25T.DWG
 Plot Date/Time: 10/12/07
 Plotted by: colette.agabiti

IMAGE	X-REF	OFFICE	DRAWN BY		CHECKED BY		APPROVED BY		DRAWING NUMBER
TYLER(250_000)	---	Houston, Texas	J. RDZ	4/18/04	J. MALINO	4/19/04	P. SRIVASTAV	10/31/07	845714-A25T



ELCR - EXCESS LIFETIME CANCER RISK
 HI - HAZARD INDEX



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

FIGURE 2-8
 CONCEPTUAL SITE MODEL
 RECORD OF DECISION, LHAAP-67,
 GROUP 4
 LONGHORN ARMY AMMUNITION PLANT
 KARNACK, TEXAS

3.0 References

Jacobs, 2002a, *Final Remedial Investigation Report for the Group 4 Sites, Sites 35A, 35B, 35C, 46, 47, 48, 50 60, and Goose Prairie Creek, Longhorn Army Ammunition Plant, Karnack, TX, January.*

Jacobs, 2002b, *Final Remedial Investigation Report Addendum for the Group 4 Sites (Sites 04, 08, 67) at the Longhorn Army Ammunition Plant, Karnack, Texas, February.*

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, Saunder's Branch, Central Creek, and Caddo Lake), Longhorn Army Ammunition Plant, Karnack, Texas, June.*

Maley, Don, 1988, *Potential Hazardous Waste Site Preliminary Assessment, EPA Form 2070-12, April.*

Shaw Environmental Inc. (Shaw), 2005a, *Final Feasibility Study, LHAAP-67, Aboveground Storage Tank Farm, Group 4, Longhorn Army Ammunition Plant, Karnack, Texas, August.*

Shaw 2005b, *Final Feasibility Study, LHAAP-35B (37), Chemical Laboratory, Group 4,, Longhorn Army Ammunition Plant, Karnack, Texas, October.*

Shaw 2007a, *Final Natural Attenuation Evaluation LHAAP-12, LHAAP-35B (37), and LHAAP-67, Longhorn Army Ammunition Plant, Karnack, Texas, June.*

Shaw 2007b, *Final Results of Modeling for Natural Attenuation of Chlorinated Solvents in Groundwater at LHAAP-35B (37) and LHAAP-67, Longhorn Army Ammunition Plant, Karnack, Texas, July.*

Shaw 2007c, *Installation-Wide Baseline Ecological Risk Assessment, Longhorn Army Ammunition Plant, Karnack, Texas, Steps 3 through 8 Report, Houston, Texas, November.*

Shaw 2007d, *Final Data Gaps Investigation Report, Longhorn Army Ammunition Plant, Karnack, Texas, April.*

Shaw 2007e, *Final Modeling Report, Derivation of Soil and Groundwater Concentrations Protective of Surface Water and Sediment, Longhorn Army Ammunition Plant, Karnack, Texas, February.*

U.S. Army, 2004, *Memorandum of Agreement Between the Department of the Army and the Department of the Interior for the Interagency Transfer of Lands at the Longhorn Army Ammunition Plant for the Caddo Lake National Wildlife Refuge, Harrison County, Texas, Signed by the Department of the Interior on April 27, 2004 and the Army on April 29, 2004.*

U.S. Army, 2008a, *Final Proposed Plan for LHAAP-35B(37), Chemical Laboratory and LHAAP-67, Aboveground Storage Tank Farm, Longhorn Army Ammunition Plant, Karnack, Texas*, June.

U.S. Army, 2008b, Letter with enclosures from LHAAP Site Manager, Rose M. Zeiler, to TCEQ Remediation Division Project Manager, Fay Duke, *Revised MNA Modeling Results for Time to MCL, LHAAP-35B (37) and LHAAP-67, Longhorn Army Ammunition Plant, Karnack, Texas*, June 5.

U.S. Army Environmental Hygiene Agency (USAEHA), 1987, *Final Groundwater Contamination Survey No. 38-26-0851-89, Evaluation of Solid Waste Management Units, Longhorn Army Ammunition Plant, Karnack, Texas*, May.

U.S. Environmental Protection Agency (USEPA), 1989, *Risk Assessment Guidance for Superfund, Vol. I: Human Health Evaluation Manual, (Part A)*, OSWER Directive 9285.7-01a, Office of Emergency and Remedial Response, Washington, DC.

USEPA, 1990, *National Oil and Hazardous Substances Pollution Contingency Plan, Final Rule, 40 CFR Part 300*, March.

U.S. Army Toxic and Hazardous Materials Agency (USATHAMA), 1980, *Installation Assessment of Longhorn Army Ammunition Plant, Report No. 150*, February.

4.0 Responsiveness Summary

The Responsiveness Summary serves three purposes. First, it provides the U.S. Army, USEPA, and TCEQ with information about community concerns with preferred alternative for LHAAP-35B (37) and LHAAP-67 presented in the Proposed Plan. Second, it shows how the public's comments were factored into the decision-making process for selection of the final 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-35B(37) and LHAAP-67 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-35B(37) and LHAAP-67, 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
- Questions and comments from the public during the public comment period, and the response to comments from the U.S. Army dated June 3, 2010.

This Community Responsiveness Summary provides written responses to comments submitted by the community regarding the Proposed Plan of Action for the final remedy for the Chemical Laboratory (LHAAP-35B (37)) and the former aboveground storage tank farm (LHAAP-67) at Longhorn Army Ammunition Plant, Karnack, Texas. The summary is presented in two sections:

- Background of Community Involvement
- Summary and Responses to Comments Received

BACKGROUND OF COMMUNITY INVOLVEMENT

Community interest in LHAAP-35B (37) and LHAAP-67 dates back to 1992 when local officials and community members in the technical review committee began holding quarterly meetings at LHAAP. Beginning December 2004, the technical reviews have been conducted by the Restoration Advisory Board.

SUMMARY OF COMMENTS RECEIVED DURING THE PUBLIC COMMENT PERIOD AND U.S. ARMY RESPONSES

Summary of Questions/Comments: The community presented four main concerns related to the proposed remedial action at LHAAP-35B(37) and LHAAP-67: sampling, time required for

maintenance of LUCs, metals (antimony and thallium) and remedial design. The questions/comments can be summarized as: 1) The Army should establish a regular monitoring schedule and should not use reporting limits that are greater than MCLs or other values established to protect human health or the environment. 2) It is not reasonable to propose plans that could require the maintenance of LUCs for such lengths of time. 3) Several wells were never sampled for antimony and thallium and the Army's rationale for not considering antimony and thallium to be COCs is weak. 4) It is difficult to evaluate effectiveness of any proposed plan without also evaluating the Remedial Design (RD).

Responses:

Sampling frequency and reporting limits: The preferred remedial action (MNA) in the proposed plan will include a monitoring schedule, to be established in the remedial design, but likely will be similar to: quarterly monitoring for two years, semi-annual monitoring for 3 years and annual monitoring until the next five-year review. The results from monitoring will be reviewed during the Five-Year Review to determine if more or less frequent monitoring is required for the sites. For reporting limits, it should be noted that method detection limits have improved with decreases over the years as laboratory methods and equipment evolve. As detection limits decrease, in many cases, the values protective of human health and the environment also decrease. Results that are estimated and flagged with J and have reporting limits greater than twice the detection limits can occur for several reasons; reporting limits adjusted for dilution factors and sample size, the duplicate relative percent difference (RPD) >20% or differences greater than the reporting limit. Despite the value being estimated and the high reporting limit, the detections were still considered in the remedial investigation.

Maintenance of LUCs: Several factors are evaluated to determine a reasonable timeframe for a remedy. Maintenance of the LUCs for groundwater use restrictions would require minimal effort and be reasonable for extended lengths of time. The land use controls will include a county recordation that will restrict access to the groundwater until MCLs are met. The maintenance of the LUCs are believed to be reasonable for the following reasons: 1) access of groundwater through well installation requires a permit from the Texas Department of Licensing and Regulation or Texas Water District authority, the department will be provided a copy of the LUC on the groundwater at the site as required by the ROD, 2) the Army will conduct reviews every five years, which is required by law and the ROD and at which time the protectiveness and effectiveness of the remedies applied, including the LUCs, will be evaluated by Army for regulatory review and approval, 3) the property is proposed for transfer into a national wildlife refuge, which by its very nature includes physical access and use restrictions and is subject to control and continual inspection by Refuge personnel, and 4) the property is intended to remain under ownership and management of a federal government agency.

Antimony and Thallium: (Sampling Wells) The historical uses for sites LHAAP-35B(37) and LHAAP-67 do not identify an operation that would include Antimony or Thallium. No munitions production took place in these two areas. LHAAP-35B(37), Chemical Laboratory Waste Pad (Building 29-A), served as a collection point for spent solvents from the Chemical Lab (Building 29-A) from 1985-1997. The suspected/reported contaminants for LHAAP-35B(37) are VOCs; 1,1-dichloroethene and trichloroethene. LHAAP-67, Above Ground Storage Tanks, consisted of seven ASTs containing No.2 fuel oil, kerosene, or solvents that have been removed. The suspected/reported contaminants for LHAAP-67 are POL and solvents; 1,1-dichloroethene. In addition, at LHAAP-35B(37), monitoring wells 35BWW03-06 were installed after the decision was made in 2002 that antimony and thallium were not groundwater contaminants. Therefore metals were not included as analytes in subsequent sampling.

(COCs) The rationale for not considering antimony and thallium to be COCs for LHAAP-35B(37) is based on conclusions drawn in the remedial investigation report from 2002. These conclusions state that while only 2 of 10 groundwater samples had detections of antimony and thallium in 1996, neither of these metals were detected in samples from wells taken in 1998. Additionally see response to sampling wells above, the use of site LHAAP-35B(37) does not identify historical uses of antimony or thallium, nor were they detected in soil samples. Thus, the 1994, 1996 and 1998 sampling events were considered sufficient for metals analyses for nature and extent. However, in reviewing the data for LHAAP-35(B)37, the basis for the 2002 decision was found not fully documented. Therefore, groundwater sampling for antimony and thallium will be integrated into the Remedial Design phase for LHAAP-35B(37) in order to confirm the previous decision not to include these two metals as COCs.

(COCs) The rationale for not considering antimony and thallium to be COCs for LHAAP-(67) is based on conclusions drawn in the remedial investigation report from 2002. Of the three monitoring wells sampled in 1998, one well detected thallium at 0.1 ug/L above the MCL, which is not significant enough to consider thallium as a COC. Follow-on sampling of three monitoring wells in 2000 did not detect thallium. The results from 1998 and 2000 sampling concluded that no metals or anion results exceeded the MCL. Additionally see response to sampling wells above, the use of site LHAAP-67 does not identify historical uses of antimony or thallium and thus does not warrant sampling or consideration of metals as COCs for the site.

Remedial Design: The Army will provide the public with updates on remedial design (RD) and remedial action status through the RAB meeting and any concerns can be addressed through this forum. The RD will include performance objectives, schedule and other design criteria and will follow established regulatory guidance for MNA.

Appendix A contains the public announcements for the public comment period as well as the reopening of the public comment period. These announcements also provide notification of the Open House on June 23, 2008 and the Public Meeting on March 9, 2010.

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.

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 cancer risk (1 in 10,000 exposed individuals) or the calculated numerical limit of 1 for noncancer effects, a value proposed by the USEPA.

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 – 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.

Human Health Risk Assessment – A study conducted as part of a remedial investigation to determine the risk posed to human health by site-related chemicals.

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.

Record of Decision – 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 remedial investigation/feasibility study and consideration of public comments on the statement of basis/proposed plan and community concerns.

Remedial Investigation – 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 includes responses to these comments. The responsiveness summary is a key part of a ROD highlighting community concerns.

Screening-Level Ecological Risk Assessment – The initial phase of a baseline ecological risk assessment in which conservative concentrations of site chemicals are quantitatively compared to chemical- and media-specific generic effect levels. Those chemicals selected as chemicals of potential ecological concern are further refined through quantitative comparison to chemical- and species-specific effect doses, as well as qualitative examination. Those chemicals identified as chemicals of concern may be investigated further, remediated, or left in place per the decision of the risk managers.

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 and 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.

Surface Media – The soil (surface or subsurface), surface water, and sediment present at a site as applicable. The source material in the surface media may be contributing to groundwater contamination.

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 Announcements

PUBLIC NOTICE
OPEN HOUSE ON JUNE 23, 2008
THE UNITED STATES ARMY INVITES PUBLIC COMMENT
ON THE PROPOSED PLAN FOR ENVIRONMENTAL SITES LHAAP-35B (37) and -67,
LONGHORN ARMY AMMUNITION PLANT, TEXAS

The U.S. Army, as 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, has developed a proposed plan for the following sites: LHAAP-35B (37) and LHAAP-67. An open house forum for the public to view information and ask questions will be held on Monday, June 23, 2008 from 6:00 to 8:00 p.m. at the Karnack Community Center, Highway 134 and Spur 449, Karnack, Texas. The meeting will be an open house format with no set or formal presentations.

LHAAP-35B (37), the Chemical Laboratory, is located in the north-central portion of LHAAP and covers an area of 12.2 acres. LHAAP-35B (37) was built during the construction of Plant 3 (1953-1955) and was originally used to support the production activities at LHAAP. These support activities included research and testing of materials used in the production processes and quality assurance testing. Also, one waste rack sump was located at the site. In 1998, the site was used as a staging area in support of investigation activities. LHAAP-35B (37) was active through 1999.

LHAAP-67, a former aboveground storage tank farm, is located in the central portion of LHAAP and covers an area of approximately 1.9 acres. When operational, LHAAP-67 consisted of seven aboveground storage tanks of unknown sizes. The tanks were surrounded with earthen dikes designed to contain potential spills. Site personnel indicated that the tanks were used for solvent storage. The tanks have been removed and the only structure remaining at the site is a railroad bed.

The Proposed Plan identifies the selected remedy for LHAAP-35B (37) and LHAAP-67 which includes utilizing land use controls (LUCs) and Monitored Natural Attenuation (MNA). The remedy meets the remedial action objectives (RAOs) developed for these sites to protect human health and the environment by preventing human exposure to chlorinated solvents-contaminated groundwater and preventing chlorinated solvents-contaminated groundwater from migrating into nearby surface water bodies.

The U.S. Army is soliciting public review and comment on the selected remedy for LHAAP-35B (37) and LHAAP-67. Copies of the Proposed Plan and supporting documentation are available for public review at the Marshall Public Library, 300 S. Alamo, Marshall, Texas, 75670.

The U.S. Army encourages the public to participate in the decision-making process by offering comments on the Proposed Plan. Public comment period begins June 17, 2008 and concludes July 16, 2008. The public information forum will be held on Monday, June 23, 2008 from 6:00 – 8:00 p.m. at the Karnack Community Center, Highway 134 and Spur 449, Karnack, Texas 75661. Interested parties are invited to attend. For further information, contact: Dr. Rose M. Zeiler, Longhorn Army Ammunition Plant, P.O. Box 220, Ratcliff, Arkansas, 72951; phone number 903-679-3192 or e-mail rose.zeiler@us.army.mil.

PUBLIC NOTICE
THE UNITED STATES ARMY INVITES PUBLIC COMMENT
ON THE PROPOSED PLAN FOR ENVIRONMENTAL SITES LHAAP-35B (37) and -67,
LONGHORN ARMY AMMUNITION PLANT, TEXAS
PUBLIC MEETING AT KARNACK COMMUNITY CENTER MARCH 9, 2010

The U.S. Army, as 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, has reopened a proposed plan comment period for the following sites: LHAAP-35B (37) and LHAAP-67.

Although the Proposed Plan identifies the preferred remedy for each of the sites, the U.S. Army welcomes the public's review and comments. The public comment period begins March 8, 2010 and concludes April 8, 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 remedy for these sites and to ask questions and provide comments on the Proposed Plan. Questions, comments, and responses on the Proposed Plan 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 Plan 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-35B (37), the Chemical Laboratory, is located in the north-central portion of LHAAP and covers an area of 12.2 acres. LHAAP-35B (37) was built during the construction of Plant 3 (1953-1955) and was originally used to support the production activities at LHAAP. These support activities included research and testing of materials used in the production processes and quality assurance testing. Also, one waste rack sump was located at the site. In 1998, the site was used as a staging area in support of investigation activities. LHAAP-35B (37) was active through 1999.

LHAAP-67, a former aboveground storage tank farm, is located in the central portion of LHAAP and covers an area of approximately 1.9 acres. When operational, LHAAP-67 consisted of seven aboveground storage tanks of unknown sizes. The tanks were surrounded with earthen dikes designed to contain potential spills. Site personnel indicated that the tanks were used for solvent storage. The tanks have been removed and the only structure remaining at the site is a railroad bed.

Four alternatives were evaluated for addressing the contaminated groundwater at sites LHAAP-35B (37) and LHAAP-67: 1) no action; 2) MNA and LUCs; 3) in situ bioremediation and LUCs; and 4) groundwater extraction, on-site treatment, and LUCs. Based on available information, the preferred remedy at this time is the second alternative. The Proposed Plan identifies the selected remedy for LHAAP-35B (37) and LHAAP-67 which includes utilizing land use controls (LUCs) and Monitored Natural Attenuation (MNA). The remedy meets the remedial action objectives (RAOs) developed for these sites to protect human health and the environment by preventing human exposure to chlorinated solvents-contaminated groundwater, preventing chlorinated solvents-contaminated groundwater from migrating into nearby surface water bodies, and returning groundwater to its potential beneficial use as drinking water, wherever practicable.

The U.S. Army is soliciting public review and comment on the selected remedy for LHAAP-35B (37) and LHAAP-67. Copies of the Proposed Plan and supporting documentation are available for public review at the Marshall Public Library, 300 S. Alamo, Marshall, Texas, 75670.

The U.S. Army encourages the public to participate in the decision-making process by offering comments on the Proposed Plan. Public comment period begins March 8, 2010 and concludes April 8, 2010. The public information forum will be held on Tuesday, March 9, 2010 from 7:00 – 9:00 p.m. at the Karnack Community Center, Highway 134 and Spur 449, Karnack, Texas 75661. Interested parties are invited to attend. 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. E-mailed comments must be submitted by close of business on April 8, 2010.