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

April 10, 2017

DAIM-ODB-LO

Mr. Rich Mayer
US Environmental Protection Agency
Federal Facilities Section R6
1445 Ross Avenue
Dallas, TX 75202-2733

Re: LHAAP-04 Final Record of Decision, October 2016
Longhorn Army Ammunition Plant, Karnack, Texas

Dear Mr. Mayer,

The above-referenced document is being transmitted to you for your records.

The point of contact for this action is the undersigned. I may be contacted at 479-635-0110, or by email at rose.m.zeiler.civ@mail.mil.

Sincerely,

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

Copies furnished:
A. Palmie, TCEQ, Austin, TX
P. Bruckwicki, Caddo Lake NWR, TX
R. Smith, USACE, Tulsa District, OK
A. Williams, USACE, Tulsa District, OK
N. Smith, USAEC, San Antonio, TX
E. Sharp, AECOM – Austin, TX (for project files)

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

April 10, 2017

DAIM-ODB-LO

Ms. April Palmie
Texas Commission on Environmental Quality Superfund Section, MC-136
12100 Park 35 Circle, Bldg D
Austin, TX 78753

Re: LHAAP-04 Final Record of Decision, October 2016
Longhorn Army Ammunition Plant, Karnack, Texas

Dear Ms. Palmie,

The above-referenced document is being transmitted to you for your records.

The point of contact for this action is the undersigned. I may be contacted at 479-635-0110, or by email at rose.m.zeiler.civ@mail.mil.

Sincerely,

Rose M. Zeiler

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Longhorn AAP Site Manager

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R. Mayer, USEPA Region 6, Dallas, TX
P. Bruckwicki, Caddo Lake NWR, TX
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FINAL
RECORD OF DECISION
LHAAP-04
FOR
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

Prepared For:

U.S. Army Corps of Engineers

Prepared By:

AECOM

AECOM Technical Services

October 2016

FINAL
RECORD OF DECISION
LHAAP-04

LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

Prepared For:

U.S. Army Corp of Engineers

Tulsa District

Prepared By:

AECOM Technical Services

Contract No. W912DY-09-D-0059

Task Order No. DS01

October 2016

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Acronyms and Abbreviations

µg/L	micrograms per liter
ACE	Anderson Columbia Environmental
ARARs	Applicable or Relevant and Appropriate Requirements
AST	aboveground storage tank
BERA	Baseline Ecological Risk Assessment
bgs	below ground surface
BHHRA	Baseline Human Health Risk Assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	contaminant of concern
CSM	Conceptual Site Model
cy	cubic yards
ECP	Environmental Condition of Property
EE/CA	Engineering Evaluation/Cost Analysis
EPC	exposure point concentration
ESD	Explanation of Significant Differences
FFA	Federal Facility Agreement
FS	Feasibility Study
GWP-Ind	soil medium specific concentration for protection of groundwater for industrial use
HHRA	Human health risk assessment
HI	hazard index
HQ	hazard quotient
ISB	in-situ bioremediation
LHAAP	Longhorn Army Ammunition Plant
LTM	Long-Term Monitoring
LUC	Land Use Control
MCL	maximum contaminant level
MNA	Monitored Natural Attenuation
MOA	Memorandum of Agreement
MSC	medium specific concentration
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priorities List
O&M	operation and maintenance

PCB	polychlorinated biphenyl
PCL	Protective Concentration Level
PW	present worth
RAB	Restoration Advisory Board
RAO	Remedial Action Objectives
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RFA	RCRA Facility Assessment
RfD	Reference Dose
RI	Remedial Investigation
ROD	Record of Decision
SAI-Ind	soil medium specific concentration for industrial use based on inhalation, ingestion, and dermal contact
SDWA	Safe Drinking Water Act
STEP	Solutions To Environmental Problems
SVOC	semi-volatile organic compound
TAC	Texas Administrative Code
TCDD	tetrachlorodiobenzodioxin
TCEQ	Texas Commission on Environmental Quality
TNRCC	Texas Natural Resource Conservation Commission
TNT	Trinitrotoluene
TRRP	Texas Risk Reduction Program
U.S. Army	U.S Department of the Army
USC	U.S. Code
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
VOC	volatile organic compound

1 THE DECLARATION

1.1 Site Name and Location

Longhorn Army Ammunition Plant (LHAAP) -04, Former Pilot Wastewater Treatment Plant
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 presents the selected remedy for LHAAP-04, Former Pilot Wastewater Treatment Plant, located at LHAAP in Karnack, Texas. The remedy was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), Code of Federal Regulations (CFR) Title 40 §300.

The remedy selection was based on work completed and documented in the Administrative Record for the site, including a Remedial Investigation (RI) (Jacobs Engineering Group, Inc. [Jacobs], 2002), baseline Human Health Risk and Screening Ecological Risk Assessment Report (Jacobs, 2003), Removal Action Completion Report for Soil (Shaw, 2011), Final Engineering Evaluation/Cost Analysis (EE/CA) (Shaw, 2009a), Final Action Memorandum (Shaw, 2009b), Feasibility Study (FS) (Shaw, 2012), and Proposed Plan (AECOM, 2012) for LHAAP-04.

This document is issued by the U.S. Department of the Army (U.S. Army), the lead agency for this installation. The U.S. Army, USEPA, and the Texas Water Commission (currently known as the TCEQ) entered into the FFA for remedial activities at LHAAP which became effective on December 30, 1991. 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 LHAAP cleanup program. Under 40 CFR § 300.430(f)(4)(iii), the U.S. Army, as the lead agency, and the USEPA have selected the remedy. TCEQ concurs with the selected remedy.

1.3 Assessment of the Site

The response action selected in this Record of Decision (ROD) is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances, pollutants, or contaminants into the environment.

1.4 Description of the Selected Remedy

The selected remedy for LHAAP-04 includes in-situ bioremediation (ISB), long-term monitoring of the groundwater and land use controls (LUCs). The LUCs consist of land use restrictions and prohibition of potable use of groundwater above cleanup levels until the contaminant of concern (COC), perchlorate, is at levels that allow for unlimited use and unrestricted exposure.

The selected remedy for LHAAP-04 protects human health and the environment by preventing exposure of a hypothetical future maintenance worker to unacceptable concentrations of

perchlorate in groundwater via ingestion of groundwater contaminated with perchlorate, by returning the groundwater to its potential beneficial use, wherever practicable, and by preventing perchlorate-contaminated groundwater from migrating into surface water (Goose Prairie Creek, located approximately 700 feet to the south of LHAAP-04 site). The human health risk scenarios evaluated were based on the hypothetical future maintenance worker. Perchlorate is the only COC in the groundwater. The soil does not pose unacceptable risk or hazard to human health based on exposure pathway for an industrial worker and the migration pathway of constituents from soil to groundwater. The components of the selected remedy are summarized below.

- ISB of groundwater in an area in the vicinity of monitoring well 04WW04. Multiple injections of substrate may be needed based on effectiveness of the ISB. Bioaugmentation using appropriate microbial culture to facilitate ISB may be performed, if necessary. Prior to ISB, additional shallow zone and intermediate zone monitoring wells are planned to refine the perchlorate plume configuration.
- Long-term Monitoring (LTM) to confirm the protection of human health and the environment by documenting the return of groundwater to the cleanup level (maximum contaminant level [MCL] or Protective Concentration Level (PCL)) through reduction of the contaminant mass, and by preventing the perchlorate-contaminated groundwater plume from migrating into surface water.
- The LUC objectives include maintaining the integrity of any current or future remedial or monitoring systems, and preventing the use of groundwater contaminated above cleanup levels as a potable water source. The groundwater treatment and LTM remedial components include a groundwater monitoring system that will be used to characterize the condition of the groundwater during the period the groundwater remedy is in place until the groundwater remediation goals are achieved, and to demonstrate achievement of the groundwater remediation goals when the groundwater remedy is complete. As a part of this groundwater remedy, the Army will maintain the remedial and monitoring systems associated with the groundwater remedies until these components of the remedy are no longer needed to achieve cleanup levels, and cleanup levels have been achieved. During the period of operation of the groundwater remedy, if any of the elements of the remedial and groundwater monitoring systems are damaged, destroyed, or become ineffective, they will be repaired or replaced with suitable components to assure that the remedial and groundwater monitoring systems are able to provide data of the quality necessary to determine the progress of and eventual completion of this component of the remedy. The actions to be taken to implement these LUC objectives and requirements will be provided through modifying the "Comprehensive Land Use Control (LUC) Management Plan, Former Longhorn Army Ammunition Plant, Karnack, Texas" and detailed in the LUC RD.
- The LUC for prohibition of groundwater use (except for monitoring and testing) shall be implemented and shall remain in place at the Site until the levels of COCs (i.e. including all hazardous substances, pollutants and contaminants found at the Site at cleanup levels as listed in Table 2-3) in surface and subsurface soil and groundwater are reduced below levels that would support unlimited use and unrestricted exposure. A LUC RD will be finalized as the land use component of the Remedial Design. Within 21 days of the issuance of the ROD, the Army will propose deadlines for completion of the RD Work Plan, RD and Remedial Action Work Plan. The documents will be prepared and submitted to the EPA

and the TCEQ pursuant to the FFA. The LUC RD will contain implementation and maintenance actions, including periodic inspections. The long-term monitoring groundwater plan will also be presented in the RD. The recordation notification for the Site which will be filed with Harrison County, will include a description of the LUCs. The preliminary boundary for the groundwater LUC is shown on Figure 2-7.

- CERCLA five-year reviews until the levels of COCs (i.e., including all hazardous substances, pollutants and contaminants found at the Site at cleanup levels as listed in Table 2-3) in groundwater allow for unlimited use and unrestricted exposure.

A LUC Remedial Design (RD) will be finalized as the land use component of the RD. Within 21 days of the issuance of the ROD, the U.S. Army will propose deadlines for completion of the RD Work Plan, RD, and Remedial Action Work Plan. The documents will be prepared and submitted to EPA and TCEQ pursuant to the Federal Facility Agreement (FFA). The LUC RD will contain implementation and maintenance actions, including periodic inspections. The ISB performance monitoring plan and the LTM plan will also be presented in the RD.

The Army will implement, maintain, monitor, report on and enforce land use controls at Army-owned property. The Army shall perform those actions related to land use control activities described in this ROD and in the Remedial Design for the ROD. For portions of the Site subject to land use controls that are not owned by the Army, the Army will monitor and report on the implementation, maintenance, and enforcement of land use controls, and coordinate with federal, state, and local governments and owners and occupants of properties subject to land use controls. The Army will provide notice of the groundwater and soil (surface and subsurface) contamination and any land use restrictions referenced in the ROD. The Army will send these notices to the federal, state and local governments involved at this site and the owners and occupants of the properties subject to those use restrictions and land use controls. The Army shall provide the initial notice within 90 days of ROD signature. The frequency of subsequent notifications will be described in the Remedial Design for the ROD. The Army remains responsible for ensuring that the remedy remains protective of human health and the environment. The Army will fulfill its responsibility and obligations under CERCLA and the NCP as it implements, maintains, and reviews the selected remedy.

Upon transfer of Army-owned property, the Army will provide written notice of the LUCs to the transferee of the groundwater and soil (surface and subsurface) contamination and any land use restrictions referenced in the ROD. Within 15 days of transfer, the Army shall provide EPA and the TCEQ with written notice of the division of implementation, maintenance, and enforcement responsibilities unless such information has already been provided in the LUC RD. The LUC RD will address the procedures to be used by the Army and the transferee to document compliance with the LUCs described in this ROD. In the event property is transferred out of Federal control, the land use controls relating to property and groundwater restrictions shall be recorded in the deed and shall be enforceable by the United States and the state of Texas.

The 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 management strategy at LHAAP is to approach each site separately to address human health issues and to approach the sites by sub-area to address ecological risk. Thus, the implementation of this remedy at LHAAP-04 is independent of any other remedial action at LHAAP to address

human health issues. To address ecological risk, LHAAP-04 was grouped with several other sites as part of the Industrial Sub-Area. The Baseline Ecological Risk Assessment (BERA) concluded that no unacceptable risk was present in the Industrial Sub-Area (Shaw, 2007b) and therefore, no further action is needed at LHAAP-04 for the protection of ecological receptors. The proposed remedy at LHAAP-04 is identified in the proposed plan (AECOM, 2012) that has been reviewed and approved by the regulatory agencies. The proposed plan is in the Administrative Record file for LHAAP.

1.5 Statutory Determinations

The final selected remedy is protective of human health and the environment, complies with Federal and State requirements that are applicable or relevant and appropriate to the remedial action, and is cost-effective. In addition, the remedy offers long-term effectiveness through the implementation of ISB and LUCs which will minimize the potential risk to the hypothetical future maintenance worker posed by the contaminated groundwater. Furthermore, LTM will document the progress and effectiveness of the final selected remedy. The final selected remedy is easily and immediately implementable. The ISB component of the selected remedy does satisfy the statutory preference for treatment as a principal element of the remedy.

Because hazardous substances, pollutants, or contaminants may remain at the site above levels that allow for unlimited use and unrestricted exposure, reviews will be conducted every 5 years to ensure protection of human health and the environment under CERCLA §121(c), U.S. Code (USC) Title 42 §9621(c). In accordance with 30 Texas Administrative Code (TAC) §335.566, a notification will be recorded in Harrison County records stating that the site is restricted to nonresidential use until it is demonstrated that surface and subsurface soil and groundwater COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-3) are at levels that allow for unlimited use and unrestricted exposure; that a prohibition of groundwater use (except for environmental monitoring and testing) as a potable source will remain in place until the levels of COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-3) in soil and groundwater allow for unlimited use and unrestricted exposure; and, that the integrity of any current or future remedial or monitoring systems will remain in place until the levels of COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table-2-3) in groundwater are met. Although the Army may later pass these procedural responsibilities to the transferee by property transfer agreement, the Army shall retain ultimate responsibility for remedy integrity, per the FFA and CERCLA §121.

1.6 ROD Data Certification Checklist

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

- Current and reasonably anticipated future land use assumptions and current and potential future beneficial uses of groundwater as identified in the baseline risk assessment and ROD (**Section 2.6**).
- Potential land and groundwater use that will be available at the site as a result of the selected remedy (**Section 2.6**).

- COC and its concentration (**Section 2.7**).
- Baseline risk represented by the COC (**Section 2.7**).
- Cleanup level established for the COC and the basis for the levels (**Sections 2.7.4** and **2.8**).
- How perchlorate- and mercury-contaminated soil constituting the principal threat waste was removed from the site prior to the ROD (**Section 2.11**).
- Key factor(s) that led to selecting the remedy (**Section 2.12**).
- Estimated capital, annual operation and maintenance (O&M), and total present worth costs, discount rate, and the number of years over which the remedy cost estimates are projected (**Section 2.12**).

1.7 Authorizing Signatures

As the lead agency, the U.S. Army issues this ROD for LHAAP-04 which documents the final selected remedy. The undersigned is the appropriate approval authority for this decision.

Thomas E. Lederle — 15 DECEMBER 2016

(Name) (Date)
Thomas E. Lederle
Division Chief
Base Realignment and Closure Division
Assistant Chief of Staff for Installation Management
U.S. Army

The U.S. Environmental Protection Agency approves the final selected remedy as provided in the ROD for LHAAP-04.

Pam Phillips, Actg for — 3/30/17

(Name) (Date)
Carl E. Edlund, P.E.
Director
Superfund Division
U.S. Environmental Protection Agency
Region 6

2 DECISION SUMMARY

2.1 Site Name, Location, and Description

LHAAP-04, Former Pilot Wastewater Treatment Plant Longhorn Army Ammunition Plant, Karnack, Texas

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

Lead Agency: U.S. Army, Department of Defense

Support Agencies: USEPA Region 6, TCEQ

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

Site Type: Industrial Facility

The former LHAAP is an inactive, government-owned, formerly contractor operated and maintained, Department of Defense facility located in central east Texas (see **Figure 2-1**) in the northeast corner of Harrison County. LHAAP is approximately 14 miles northeast of Marshall, Texas, and approximately 40 miles west of Shreveport, Louisiana. The installation occupies approximately 1,400 of its former 8,416 acres between State Highway 43 at Karnack, Texas, and the western shore of Caddo Lake. The facility can be accessed via State Highways 43 and 134.

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

LHAAP-04, known as Site 04 or the former pilot wastewater treatment plant, is approximately 0.5 acres and is located in the central portion of LHAAP at the northwest corner of 6th and 60th Streets near the former fire station (**Figure 2-2**). LHAAP-04 is surrounded by light duty roads. Wastewater treatment operations began at LHAAP-04 in 1984.

The demolition of the former pilot wastewater treatment facility structures, tanks, and piping, and the disposal of the associated wastes were completed in the summer of 1997 as part of the Resource Conservation and Recovery Act (RCRA) closure of the plant. Under the CERCLA program, excavation of soil impacted with mercury and perchlorate at the LHAAP-04 site was completed in 2009 along the southern edge of the slab, which formerly housed storage tanks for the former pilot wastewater treatment facility.

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. The LHAAP facility was reactivated with the opening of Plant 2, where pyrotechnic ammunition, such as photoflash bombs, simulators, hand signals, and tracers for 40 millimeter ammunition, were produced until 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 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.

In 1984, the former pilot wastewater treatment plant began operation. Wastewater from sumps throughout LHAAP was trucked to the plant for treatment. After the wastewater settled, it was transferred to one of two storage tanks, and then pumped through a heat exchanger to an evaporation tower. Solids were shipped off site for disposal. Sludge from the settling tanks was blown down and drummed weekly, then burned at Burning Ground No. 3 (LHAAP-18/24) (Plexus Scientific Corporation [Plexus], 2005).

The RCRA closure activities at the LHAAP-04 site completed in the summer of 1997 were limited to the demolition and disposal of the former pilot wastewater treatment facility and its associated hazardous waste. Under these RCRA closure activities, four aboveground storage tanks (ASTs) were emptied, cleaned, and removed in September 1997 (Plexus, 2005). The concrete slab on the north side of LHAAP-04 was left in place. According to the LHAAP installation plan, the former pilot wastewater treatment facility was removed and closed under a conditional approval letter from Texas Natural Resource Conservation Commission (TNRCC), now TCEQ. The TCEQ's conditional approval letter was limited to closure of the former wastewater treatment facility, RCRA-regulated structures, equipment, and waste contained therein, and deferred remediation of contaminated soil to the CERCLA program. The perchlorate and mercury contaminated soils were addressed in the EE/CA (Shaw, 2009a) and Action Memorandum (Shaw, 2009b), and the perchlorate and mercury contaminated soil removal action is documented in the Completion Report (Shaw, 2011). A monitoring well (04WW04) was installed after the soil removal to sample the groundwater beneath the backfilled excavation area. The results indicated perchlorate was present in groundwater at a concentration exceeding the Texas Risk Reduction Program (TRRP) Tier 1 Groundwater Residential PCL of 17 micrograms per liter (µg/L). Perchlorate was not detected at concentrations exceeding the TRRP Tier 1 Groundwater Residential PCL at another monitoring well (04WW05) installed downgradient of 04WW04.

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:

- Record Search - In 1980, U.S. Army Toxic and Hazardous Materials Agency conducted a record search to assess the impact of the LHAAP installation activities including usage, storage, treatment, and disposal of toxic and hazardous materials on the environment, and defined conditions that may have adversely affected human health and the environment.
- Contamination Survey – In 1982 as part of the LHAAP contamination survey, Environmental Protection Systems, Inc. (EPS) collected six groundwater samples for laboratory analyses (EPS, 1984). This document can be found in Volume 1 of 16 in year 2011 of the Administrative Record.
- RCRA Facility Assessment (RFA) – In 1988, a preliminary RFA was conducted by the Texas Water Commission (Texas Water Commission, 1988). Waste areas and pollutant dispersal pathways were visually identified, but no samples were collected during the RFA. This document can be found in Volume 2 of 2 in year 1988 of the Administrative Record. This RFA captured and referenced U.S. Army Environmental Hygiene Agency (USAEHA) information developed in 1987 as part of the RCRA permit application process, and as a continuation of the 1982 EPS contamination survey, where all solid waste management unites at LHAAP were identified, described and evaluated (USAEHA, 1988).
- Installation-Wide Perchlorate Investigation. A plant-wide perchlorate investigation was conducted in 2001 by Solutions to Environmental Problems (STEP) to collect supplemental information for sites suspected of or identified as having perchlorate contamination (STEP, 2005). This document can be found in Volume 4 of 5 in year 2005 of the Administrative Record.

In addition to installation-wide investigations, several sampling events specific to LHAAP-04 were conducted 1993 through 2008 to assess contamination from past operations and its impact to the soil and/or groundwater (U.S. Army, 1993; Shaw, 2012).

- RCRA Closure. RCRA closure of the former pilot wastewater treatment facility at the LHAAP-04 site was conducted in 1997. Subsequent to the closure of the facility, soil samples were collected around the concrete pad, below the pipe leading from the former facility to the 40,000 gallon AST, and around the AST. Samples were analyzed for semi-volatile organic compounds (SVOCs), total petroleum hydrocarbons (TPH), metals, polychlorinated biphenyls (PCBs), pesticides and herbicides. Mercury concentrations in three soil borings (SB-11, SB-12, and SB-13) adjacent to the concrete slab near the two tanks, exceeded the TCEQ soil medium specific concentration (MSC) for industrial use based on inhalation, ingestion, and dermal contact (SAI-Ind). Samples collected from borings associated with the sumps had no mercury detections. Therefore, the area of mercury contaminated soil was localized to a small area adjacent to the concrete slab. The LHAAP-04 site was approved for closure according to 30 TAC 335 Subchapter S, Risk Reduction Rule Standard 2 in 1998 with the stipulation that the remaining soil contamination be addressed under CERCLA (Shaw, 2009a).

- Site Investigation and RI. Soil and groundwater samples were collected from LHAAP-04 as part of the site investigation and RI conducted by Jacobs between 1995 and 2000 (Jacobs, 2002). During Phase I of the RI, soil samples up to five feet below ground surface (bgs) from the sump areas were analyzed for volatile organic compounds (VOCs), SVOCs, metals, and explosive compounds. During the subsequent investigations (Phase III), additional soil samples from sump areas were analyzed for selected metals (beryllium, nickel, and vanadium), dioxins/furans, and pesticides/PCBs. During investigation of perchlorate impacts, soil samples were collected and analyzed for perchlorate. During additional Phase III work, soil samples were analyzed for VOCs, SVOCs, metals, explosive compounds, dioxins/furans, perchlorate, and pesticides/PCBs. Groundwater samples were also analyzed for the same suite of parameters (Jacobs, 2003).
- Data Gaps Investigation. Additional investigation was performed in 2004 as part of a Data Gaps Investigation (Shaw, 2007a). Additional soil sampling was proposed to better delineate the vertical extent of the perchlorate contaminated soil to be used to develop a remediation plan (Shaw, 2006). Soil samples were collected in 2006 and 2007 to better define the vertical extent of perchlorate. Additionally, groundwater samples were collected from two wells in 2007 and 2008 and analyzed for perchlorate. Perchlorate was detected at a low concentration at one well in 2008.
- Soil Removal Action. An area of soil contaminated with mercury above the SAI-Ind level was located within the perchlorate contaminated soil area at LHAAP-04 site (TCEQ, 2006). An EE/CA was prepared for the LHAAP-04 site (Shaw, 2009a) and an Action Memorandum was signed by the U.S. Army (Shaw, 2009b) to address the soil with perchlorate exceeding the GWP-Ind value and mercury exceeding the SAI-Ind value. The removal of soil in the vadose zone, contaminated with perchlorate and mercury was conducted in 2009 under CERCLA removal authority, eliminating the principal threat waste at the site.

  The concrete slab, which formerly housed storage tanks for the former pilot wastewater treatment facility, was penetrated in six locations near the tank pad/foundation (see Figure 2-2 of the Final Removal Action Work Plan) (Shaw, 2009c). Based on perchlorate results from soil samples taken from under the slab, a section of the concrete was removed and soil was excavated to a depth of five feet below top of concrete in section FL08 and to a depth of 12 feet below top of concrete in section FL07. See Figure 2-1 and Figure 2-8 of the Final Completion Report (Shaw, 2011). Perchlorate concentrations in final floor confirmation samples from FL07 and FL08 were less than the GWP-Ind MSC.

  Additional contaminated soil was excavated from along the southern edge of the slab. A total of approximately 3,406 cubic yards (cy) of contaminated soil was removed and disposed off-site (Shaw, 2011). The depths of excavation ranged from 4 feet to 14 feet bgs with an average excavation depth of approximately 10 feet (Shaw, 2011). All contaminated soil exceeding cleanup levels in the vadose zone was removed during the soil removal action.

  As part of the removal action, a well (04WW04) was installed to sample groundwater beneath the backfilled excavation area. The results indicated that perchlorate was present in groundwater at a concentration exceeding the TRRP Tier 1 Groundwater Residential

PCL for perchlorate. A second well (04WW05) was installed downgradient of 04WW04 and did not detect perchlorate exceeding the TRRP Tier 1 Groundwater Residential PCL.

A Feasibility Study Report (Shaw 2012) was prepared to evaluate remedial alternatives using CERCLA criteria to provide a basis for selecting a preferred alternative for addressing perchlorate impacts in groundwater.

2.2.3 History of CERCLA Enforcement Activities

Due to the releases of chemicals from facility operations, the USEPA placed LHAAP 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 §120 FFA for remedial activities at LHAAP. The FFA became effective December 30, 1991.

In accordance with the EE/CA (Shaw, 2009a), approximately 3,406 cy of soil was excavated from LHAAP-04 and disposed off-site under CERCLA removal authority. The FS (Shaw, 2012), presenting an analysis of remedial alternatives for LHAAP-04, was issued in August 2012. The Proposed Plan (AECOM, 2012) was issued in December 2012. This ROD follows that Proposed Plan and precedes the more detailed RD document.

2.3 Community Participation

The U.S. Army, the USEPA, the TCEQ and the LHAAP Restoration Advisory Board (RAB) have provided public outreach to the surrounding community concerning LHAAP-04 and other environmental sites at LHAAP. The outreach program has included fact sheets, site visits, invitations to attend quarterly RAB meetings, and public meetings consistent with its public participation responsibilities under Sections 113(k)(2)(B), 117(a), and 121(f)(1)(G) of CERCLA.

The Proposed Plan (AECOM, 2012) for the selection of the remedy for LHAAP-04 was made available to the public for review and comment on December 1, 2012. The notice of availability of the Proposed Plan and other related documents in the Administrative Record file was published in the *Marshall News Messenger* on December 6, 2012. The newspaper notice for the public meeting is provided in **Appendix A**. The public comment period for the Proposed Plan began on January 1, 2013, and ended January 31, 2013. A public meeting was held on January 9, 2013 in a formal format and with a court reporter. The transcript for the meeting is part of the Administrative Record. The significant comments (oral or written) are addressed in the Responsiveness Summary, which is included in this ROD as **Section 3.0**. The Administrative Record may be found locally at the information repository maintained at the following location:

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

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

2.4 Scope and Role of Response Action

This is the second and final Response Action for the LHAAP-04 site. Contaminated soil was removed in 2009 under CERCLA removal authority, eliminating the principal threat waste at the site. This decision document addresses groundwater contamination and is the final remedy for contamination at the LHAAP-04 site. The recommended action at LHAAP-04 will prevent potential risks associated with exposure of the hypothetical future maintenance worker to contaminated groundwater. The groundwater COC is perchlorate. The remedial action will include ISB to reduce COC concentrations in groundwater to meet the cleanup level, bioaugmentation, if necessary, and LUCs.

The recommended action at LHAAP-04 will prevent potential risks associated with exposure to contaminated groundwater. Although groundwater at LHAAP is not currently being used as drinking water, nor may it be used in the future based on its reasonably anticipated use as a national wildlife refuge, when establishing the Remedial Action Objectives (RAOs) for this response action, the U.S. Army has considered the NCP's expectation to return usable groundwaters to their potential beneficial uses wherever practicable and has also considered the State of Texas designation of all groundwater as potential drinking water, unless otherwise classified, and consistent with 30 TAC 335.563(h)(1) [background total dissolved solids content less than or equal to 10,000 milligrams per liter and that occurs within a geologic zone that is sufficiently permeable to transmit water to a pumping well in usable quantities]. To the extent practicable, the U.S. Army intends to return the contaminated groundwater at LHAAP-04 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, and consistent with 40 CFR § 300.430(e)(2)(i)(B&C). In the absence of federal drinking water standards, cleanup levels will be based on the TRRP Tier 1 Groundwater Residential PCL. 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 perchlorate plume in groundwater at the LHAAP-04 site is small and it is approximately 700 feet from Goose Prairie Creek.

The selected remedy will protect human health and the environment. The human receptor evaluated was the hypothetical future maintenance worker. ISB will treat/remediate and reduce contaminant mass and lower contaminant concentrations in groundwater. The selected remedy will also ensure that the perchlorate-contaminated groundwater does not migrate into nearby surface water, which could ultimately affect Caddo Lake.

2.5 Site Characteristics

This section of the ROD presents a brief comprehensive overview of LHAAP-04 site characteristics with respect to the conceptual site model (CSM), physical site features, known or suspected sources of contamination, types of contamination, and affected media. Known or potential routes of contaminant migration are also discussed. Detailed information about the site characteristics can be found in the RI (Jacobs, 2002).

2.5.1 Conceptual Site Model

Figure 2-3 illustrates the conceptual site model for LHAAP-04. The model presents those pathways that are being selected for remediation and pathways that are incomplete and therefore are not selected for remediation.

The former pilot wastewater treatment plant was the source for the perchlorate released into the environment. Prior to the plant's removal, the conceptual model assumes perchlorate was released via overflows, spills, and leaks to the soil. After the pilot wastewater treatment plant was removed, there was no longer a release mechanism for overflows, spills, and leaks. Perchlorate had been released to the soil, however, and prior to the soil removal action in 2009, sufficient perchlorate levels existed in the soil to act as a source of groundwater contamination or to be potentially released into surface water during storm events. (Shaw, 2011).

Because all perchlorate-contaminated vadose zone soil above cleanup levels was removed in 2009, it is not expected that LHAAP-04 will contribute to surface water contamination (Shaw, 2011). Soil pathways have therefore been eliminated from consideration.

Surface water samples collected in 2010 and 2011 were below the perchlorate TRRP Tier 1 Groundwater Residential PCL of 17 micrograms per liter. Table 2-1 lists the results of surface water sampling events in 2010 and 2011. Based on these data, the conceptual model does not include any current impact to surface water from groundwater. The groundwater to surface water migration pathway is not complete under current conditions. Protection of surface water will be confirmed with groundwater monitoring and evaluation of plume behavior with implementation of the groundwater remedy.

Groundwater at monitoring well 04WW04 currently exceeds the perchlorate TRRP Tier 1 Groundwater Residential PCL of 17 µg/L. Thus, the only pathway considered for remediation is the hypothetical future industrial groundwater use and the TRRP Tier 1 Groundwater Residential PCL is the cleanup level.

2.5.2 Overview of the Site

LHAAP-04 encompasses an area of approximately 0.5 acre and is located in the central portion of LHAAP. The demolition of the former pilot wastewater treatment facility structures, tanks, and piping, and the disposal of the associated wastes were completed in the summer of 1997 as part of the RCRA closure of the plant. Soil excavation at LHAAP-04 was completed in 2009 along the southern edge of the remaining slab, which formerly housed storage tanks for the former pilot wastewater treatment facility.

2.5.3 Geology and Hydrogeology

LHAAP-04 is situated on the outcrop of the Wilcox Group which generally consists of a few feet of residually derived soils overlying interbedded silts and clays. Based on the site lithology, the shallow zone water bearing sand at monitoring well 04WW04 appears to be only one to two feet thick, and surrounding monitoring wells mostly show clay or silt layers at the same depth. It has not been confirmed through borings if the intermediate zone water bearing sand (60 to 83 feet bgs) and the deep zone water bearing sand (121 to 128 feet bgs) in the firehouse well exist beneath the LHAAP-04 site; however, the intermediate and deep zone wells across LHAAP have reliably encountered sands at similar depths; so they likely exist under LHAAP-04 site (Shaw, 2012).

The depth to groundwater across the facility varies with typical depths being 12 to 16 feet in the shallow zone. The regional groundwater flow direction beneath the facility is generally east-northeast towards Caddo Lake but varies by site location (Jacobs, 2002).

Shallow groundwater at LHAAP-04 has been assessed via seven monitoring wells installed near LHAAP-04 to depths of approximately 20 feet bgs. There are no monitoring wells completed in the intermediate or deep saturated zones. Based on the 2007 potentiometric surface map for LHAAP production area, the groundwater flow direction in the shallow saturated zone below LHAAP-04 is radially away from 04WW02 as shown on **Figure 2-4** within an overall movement to the east-northeast as shown on **Figure 2-2**. Based on the 2010 potentiometric surface map as shown on **Figure 2-5**, the groundwater flow direction in the shallow saturated zone below LHAAP-04 is radially away from 04WW02 and 04WW04 within an overall gradient to the northeast as shown on **Figure 2-2**.

Rising head slug tests were performed on one well near LHAAP-04 to calculate hydraulic conductivity values using the Bouwer-Rice method. The hydraulic conductivity value for the shallow saturated zone was 3.5×10^{-5} centimeters per second at well LHSMW01 (Shaw, 2012).

Goose Prairie Creek runs approximately 700 feet to the south of LHAAP-04 site as shown on **Figure 2-2A**. Based on the network of monitoring wells located at the site, perchlorate-impacted groundwater in the shallow zone does not appear to have migrated more than 200 feet from the source area, indicating no threat to Goose Prairie Creek. Groundwater modeling also concluded there should be no impact to surface water from shallow zone groundwater (Shaw, 2007b). The modeling was conservative, utilizing a perchlorate concentration in groundwater at the source (78,200 ug/L) that was more than ten times the highest actual groundwater concentration measured at LHAAP 04 (5,410 ug/L). Finally, perchlorate concentrations in recent surface water samples collected were less than the TRRP Tier 1 Groundwater Residential PCL.

2.5.4 Sampling Strategy and History

Various sampling events were conducted at LHAAP-04 since 1993 to assess contamination from the operations at LHAAP-04 (testing for perchlorate began in 2000). The sampling included installation and sampling of groundwater monitoring wells and sampling of the soil at various depths and locations. The sampling events provided data for the Final Feasibility Study Report (Shaw, 2012):

- Phase I. U.S. Army Corps of Engineers (USACE) completed two borings at one sump location and collected five soil samples in 1993;
- RCRA Closure of Former Pilot Wastewater Treatment Plant. Anderson Columbia Environmental (ACE) collected soil samples for RCRA closure in 1997;
- Phase III. Jacobs completed one boring at one sump location and collected two soil samples in 1998;
- Perchlorate Investigation. Jacobs completed two borings and collected four soil samples in 2000;
- Phase III Additional Work. In 2000, Jacobs collected 12 soil samples from four locations; installed three monitoring wells and collected groundwater samples from each well;

- Plant-wide Perchlorate Investigation. In 2000 and 2001, STEP collected 48 soil samples from 21 locations; collected 6 groundwater samples from 3 monitoring wells; and collected 4 groundwater samples from 4 direct push technology (DPT) points;
- Final Data Gaps Investigation. Shaw collected 4 groundwater samples from 4 monitoring wells in 2004;
- Soil Excavation (Shaw, 2011): In 2011, Shaw removed 3,406 cy of soil with perchlorate (and mercury in a limited area) from the vadose zone; Collected confirmation soil samples from side walls and bottom of excavation, collected sediment samples and water samples from drain line crossing excavation area, collected three soil samples for perchlorate beyond excavation area to verify horizontal extent;
- Groundwater Investigation for Perchlorate. Shaw installed two monitoring wells and collected groundwater samples from seven wells in 2011

2.5.5 Nature and Extent of Contamination

The former pilot wastewater treatment plant was the most likely source of contaminants being released into the environment (**Figure 2-4**). Since the plant has been removed, there is no longer a potential release mechanism for leaks or spills. Perchlorate was probably released via overflows, spills, and discharges to the soil (AECOM, 2012).

The only groundwater COC for LHAAP-04 identified in the FS (Shaw 2012) is perchlorate. The approximate extent of perchlorate contamination in shallow zone is shown on **Figure 2-6**. The figure shows the current estimated extent of perchlorate as a solid line, and an estimated possible past extent of perchlorate as a dashed line. The February 2001 concentration (81 µg/L) in monitoring well LHSMW01 merits inclusion of that well within the dashed line. The remainder of the dashed contour maintains a similar distance from the currently interpreted 17 µg/L contour with reference to the generally radial groundwater contours of **Figure 2-5**.

The **Figure 2-6** data tables for monitoring wells 04WW01, 04WW05, and LHSMW02 show perchlorate concentrations observed in these wells to be less than the TRRP Tier 1 Groundwater Residential PCL. Data from monitoring wells 04WW04 and LHSMW01 suggests perchlorate concentrations are declining over time. This data lends support to the idea that the current estimated extent of perchlorate in groundwater is smaller than the possible past extent. An intermediate zone monitoring well will be installed near monitoring well 04WW04 to confirm that the groundwater in the intermediate zone is not impacted by perchlorate.

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

LHAAP has been an industrial facility since 1942. Production activities and associated waste management activities continued until the facility was determined to be in excess of the U.S. Army's needs in 1997. The plant area has been relatively dormant since that time. LHAAP is surrounded by a fence (except on the border with Caddo Lake) with an access gate that is locked after daylight hours, which restricts public access. The fence now represents the National Wildlife Refuge boundary. The public can access most of the facility during the day with additional fencing and signage restricting access from environmental sites.

The reasonably anticipated future use of LHAAP-04 is as part of a national wildlife refuge. This anticipated future use is based on a Memorandum of Agreement (MOA) (U.S. Army, 2004) between the USFWS and the U.S. Army. That MOA documents the transfer process of the LHAAP acreage to USFWS to become the Caddo Lake National Wildlife Refuge and will be used to facilitate a future transfer of LHAAP-04. Presently the Caddo Lake National Wildlife Refuge occupies approximately 7,000 acres of the 8,416-acre former installation. In accordance with the National Wildlife Refuge System Administration Act of 1966 and its amendments (16 USC 668dd), the land will remain as a national wildlife refuge unless there is a change brought about by an act of Congress, or the land is part of an exchange authorized by the Secretary of the Interior.

2.6.2 Current and Future Surface Water Uses

There are no surface water bodies present within LHAAP-04. Surface water runoff from LHAAP-04 drains toward the southern branch of Goose Prairie Creek, located approximately 700 feet south of LHAAP-04, and which flows into Caddo Lake, a large recreational lake covering 51 square miles with a mean depth of 6 feet. The watershed of the lake encompasses approximately 2,700 square miles. Caddo Lake is used extensively for fishing and boating and provides drinking water supply to multiple cities/towns. The anticipated future uses of surface water are the same as the current uses.

2.6.3 Current and Future Groundwater Uses

Groundwater in the drinking water aquifer (250-430 feet bgs) under and near LHAAP is currently used as a drinking water source. The drinking water aquifer should not be confused with LHAAP "deep zone" groundwater, which extends only to a depth of approximately 151 feet bgs. The aquifer containing contaminated groundwater and the aquifer utilized for drinking water are likely distinct from each other with no connectivity. TCEQ identifies six active public water supply wells completed in the drinking water aquifer (see **Figure 2-2**). Karnack Water Supply Corporation operates two source wells servicing the town of Karnack. These wells were completed in 1905 to depths of 287 and 285 feet bgs and are located hydraulically upgradient approximately one-quarter mile northwest and one-half mile southwest of the town center, respectively. Caddo Lake Water Supply Corporation operates three source wells located north and northwest of LHAAP that have been in use since 1905. These wells are hydraulically upgradient of LHAAP (Jacobs, 2002) with completion depths of 244, 185 and 310 feet below ground surface. Caddo Lake State Park operates one source well located approximately 1.6 miles northwest upgradient of LHAAP. This well was installed in 1905 with a total depth of 292 feet. Due to the large distance between these wells and LHAAP, water removal from these wells is not expected to affect groundwater flow at the site. In addition, there are several livestock and domestic wells located in the vicinity of LHAAP with depths averaging approximately 250 feet bgs. Because the extent of perchlorate contaminated groundwater is limited, it is not relevant to any of the drinking water wells.

Three water supply wells are located within the boundary of LHAAP itself (**Figure 2-2**). One well is located at the Fire Station with a total depth of 128 feet and a screened interval from 58 to 128 feet bgs; the second well is located upgradient of LHAAP-04 approximately 0.35 miles southwest of the Fire Station. The third well is located north of the USFWS administration building for Caddo Lake National Wildlife Refuge, near the main entrance to LHAAP. Two additional wells previously supplied water to the installation, but these have been plugged and abandoned. None of these three wells are currently used for drinking water at LHAAP, although they may supply water for non-potable uses.

The Fire Station well was installed for the purposes of supplying industrial process water for the groundwater treatment system and is not a public supply well. The taps in or around the firehouse are not used for drinking water and are marked non-potable. Although the anticipated future use of the facility as a national wildlife refuge does not include the use of the groundwater at LHAAP-04 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 screening ecological risk assessments conducted for LHAAP-04 (Jacobs, 2003) and the baseline ecological risk assessment (Shaw, 2007c). The assessments provide the basis for taking action and identify the contaminants and exposure pathways that need to be addressed by the remedial action. The driver for remedial action was identified as the presence of perchlorate in soil at concentrations exceeding TCEQ MSC GWP-Ind value of 7.2 mg/kg and in groundwater at concentrations exceeding TRRP Tier 1 Groundwater Residential PCL of 17 ug/L thereby posing hazards to groundwater via groundwater use and soil leaching to groundwater pathways.

2.7.1 Summary of Human Health Risk Assessment

The 2003 Jacobs risk assessment was based on data collected from investigations prior to 2001. Since that time, additional soil and groundwater has been collected and is discussed in section 2.7.2 below.

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

For the hypothetical future maintenance worker, reasonable soil exposure routes evaluated were: incidental ingestion of the surface soil, dermal contact with the surface soil, and inhalation of particulates. For groundwater, reasonable exposure pathways for the hypothetical future maintenance worker were ingestion/inhalation of groundwater, and dermal contact while showering with contaminated groundwater.

The calculated risk was compared to the USEPA target risk range of 1×10^{-4} to 1×10^{-6} for the excess lifetime cancer risk (ELCR) and a hazard index (HI) of 1 for non-carcinogenic hazards. For soil, the carcinogenic risk was within the acceptable range with a risk value of 1.2×10^{-6}. For groundwater, the total carcinogenic risk was 4.5×10^{-5} (due to exposure to 2,3,7,8-tetrachlorodiobenzodioxin [2,3,7,8-TCDD] toxicity equivalents), and within the acceptable risk

range (see **Table 2-2**). 2,3,7,8-TCDD was eliminated as a COC because its exposure point concentration (EPC) was below its MCL (see **Table 2-2**) (Jacobs, 2003).

The potential COCs identified for the LHAAP-04 groundwater were perchlorate and manganese due to their contributions to HI (exceeding 0.1) as calculated by Jacobs or due to exceedances of their respective TRRP Tier 1 Groundwater Residential PCLs (see **Table 2-3**). Manganese has hazard quotient (HQ) of 0.1 (see **Table 2-3**), but was eliminated as a COC since its concentration was below the LHAAP background concentration for manganese, the HQ is less than or equal to 0.1, and it does not contribute significantly to the HI.

The non-carcinogenic hazard was below 1 (0.28 from soil and 0.18 from groundwater) (see **Table 2-4**). Thus, the HHRA concluded that potential cancer risk and non-cancer hazards estimated for potential exposure of a future maintenance worker to on-site soil and groundwater are within the acceptable limits (Jacobs, 2003).

Perchlorate was identified as chemical of potential concern in soil in the Jacobs risk assessment (Jacobs, 2003). Perchlorate was below detection limit in the groundwater data from the three monitoring wells used in the Jacobs risk assessment (Jacobs, 2003). However, the three monitoring wells (04WW01, 04WW02, and 04WW03) are not located in the close proximity to the former source area. Additionally, soil and groundwater data as summarized in section 2.7.2 below was collected subsequent to the Jacobs risk assessment and was evaluated against the applicable TCEQ risk standards.

2.7.2 Post Risk Assessment Data Evaluation

The Jacobs risk assessment was completed using data from the samples through February 2001 for groundwater and through December 2000 for soil samples. Since that time, additional groundwater and soil samples have been analyzed as discussed below.

As identified in the EE/CA, the Jacobs human health risk assessment was based on soil data collected prior to 2001. Additional data was collected as part of the plant-wide perchlorate investigation by STEP and Shaw investigations (STEP, 2005; Shaw, 2007a). The additional investigations confirmed that perchlorate in on-site surface soil exceeded the soil MSC for industrial use based on groundwater protection (GWP-Ind) of 7.2 mg/kg. Perchlorate exceedance of this standard does not present a risk to human health for industrial use; however, it presents a risk of perchlorate leaching from soil into groundwater. The maximum concentration of perchlorate in soil used in the Jacobs risk assessment (144 mg/kg) is only slightly less than the maximum perchlorate concentration in subsequent investigations (163 mg/kg). The perchlorate concentrations indicate that they exceed the GWP-Ind MSC and thus soil containing perchlorate had the potential to impact groundwater. However, the perchlorate in soil did not pose human health or ecological risks.

In addition, the risk assessment data did not include the data collected during the RCRA closure of the former pilot wastewater treatment facility (ACE, 1997). The review of the data collected during the RCRA closure indicates that mercury in on-site soil exceeded its soil MSC for industrial use (SAI-Ind) (0.15 mg/kg) based on inhalation, ingestion, and dermal contact pathways. The highest detected mercury concentration was 89 mg/kg.

A removal action under CERCLA removal authority was conducted in 2009 (Shaw, 2009b) and soil with perchlorate and mercury concentrations exceeding the GWP-Ind MSC and SAI-Ind MSC,

respectively, were removed and sent to an offsite landfill. The Final Non-Time Critical Removal Action Completion Report documents the excavation, transport and disposal of soil contaminated with perchlorate and mercury, along with additional activities conducted during the contaminated soil removal work (Shaw, 2011). The average depth of excavation was approximately 10 ft bgs and an estimated volume of 3,406 in-place cubic yards (cy) was excavated (Shaw, 2011). The concentrations of mercury in the side walls of the excavation were less than the SAI-Ind MSC (excavation floor confirmation samples were not required for mercury). Perchlorate concentrations in confirmation samples from the side walls and floor of the excavation were less than the GWP-Ind MSC. Inflow of groundwater into the excavation prevented collection of soil samples from the floor of two confirmation grids (FL09 and FL11) (Shaw, 2011). However, the presence of groundwater indicated the excavation had been advanced into the saturated zone in these two areas, resulting in complete removal of all contaminated vadose zone soils.

Perchlorate impacts within saturated zone soils will be addressed under the groundwater remedy.

Thus, the removal of mercury and perchlorate contaminated soil from the LHAAP-04 site during the first response action eliminated risks associated with the soil exposure and soil to groundwater leaching pathways for industrial groundwater use.

2.7.2.1 Groundwater

Since perchlorate concentrations in soil exceeded the GWP-Ind MSC prior to the removal action, additional groundwater samples were collected after the Jacobs' risk assessment and analyzed for perchlorate to determine if it exceeded the TRRP Tier 1 Groundwater Residential PCL. Data from 04WW04 indicated that perchlorate concentrations exceeded the TRRP Tier 1 Groundwater Residential PCL of (17 µg/L). In the area with highest perchlorate concentrations in soil, perchlorate was detected in 04WW04 at concentrations ranging between 2,920 and 5,410 µg/L in 2010, and 1,580 µg/L in 2011. The perchlorate concentrations in the groundwater exceeded the TRRP Tier 1 Groundwater Residential PCL value, so were presumed to pose an unacceptable hazard to human health and perchlorate was retained as a COC in groundwater. To address perchlorate in groundwater, the TRRP Tier 1 Groundwater Residential PCL of 17 µg/L is the cleanup level.

2.7.3 Summary of Ecological Risk Assessment

The ecological risk for LHAAP-04 was addressed in the installation-wide BERA (Shaw, 2007c). 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. The 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. LHAAP-04 lies 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 LHAAP-04 for the protection of ecological receptors. The BERA Addendum included soil sampling at two LHAAP-04 locations to replace data identified as compromised. The results for the soil sampling at the two locations were non-detect and there was no change in the BERA conclusions for LHAAP-04 (AGEISS, 2014).

2.7.4 Basis of Action

The remedial action selected in this ROD is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances, pollutants, or contaminants into the environment. Actions for the groundwater are necessary to address the potential for human health risks in the unlikely event there is an attempt to use groundwater as a potable water source. Perchlorate is the only COC identified for groundwater at LHAAP-04. In the absence of federal drinking water standards, cleanup levels will be based on the TRRP Tier 1 Groundwater Residential PCL. There are no COCs in soil based on exposure pathway for an industrial worker (Shaw, 2012).

2.8 Remedial Action Objectives

The RAOs for LHAAP-04, which addresses contamination associated with perchlorate contaminated groundwater and take into account the future uses of LHAAP land and groundwater are:

- Protect human health by preventing ingestion of groundwater contaminated with perchlorate;
- Return groundwater to its potential beneficial use, wherever practicable, within a reasonable time period given the particular site circumstances; and
- Prevent groundwater contaminated with perchlorate from migrating into nearby surface water.

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

Per the ROD's RAOs, and consistent with the NCP, groundwater will be returned to its beneficial uses as drinking water. The groundwater cleanup level for perchlorate at the Site is the TRRP PCL residential groundwater cleanup level, 17 ug/L, and is protective of human health and the environment.

2.9 Description of Alternatives

Five alternatives (including No Further Action) have been evaluated. This section introduces the remedy components, identifies the common elements and distinguishing features of each alternative, and describes the expected outcomes of each.

2.9.1 Description of Remedy Components

Except for the No Action alternative, LUCs, LTM and five-year reviews are common components for all the remedial alternatives. The unique elements of each remedial alternative are identified below.

Alternative 1- No Further 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 groundwater would be left "as is,"

without implementing any containment, removal, treatment, or other mitigating actions. No other actions would be implemented to reduce existing or potential future exposure to human receptors.

There are no costs associated with the No Action alternative.

Estimated Total Direct Capital Cost: $0

Estimated Total O&M Cost: $0

Cost Estimate Duration: - NA

Estimated Total PW Cost: $0

Alternative 2 – Monitored Natural Attenuation (MNA), LUCs

This alternative relies on the natural attenuation of contaminant concentrations in groundwater under an MNA program, combined with maintenance of LUCs as described in the common elements in section 2.9.2. In addition, two shallow monitoring wells and one intermediate monitoring well will be installed for horizontal and vertical delineation of the perchlorate plume. Groundwater monitoring would be performed to determine whether the perchlorate concentrations in groundwater remain stable or continue to degrade via naturally occurring processes. Monitoring well 04WW04 currently provides groundwater data to represent the groundwater contamination. The other existing and proposed new wells will also be used in the monitoring program. The analytical program will consist of perchlorate and chloride speciation. Initially, the following geochemical parameters will also be included in the analytical program, dissolved oxygen (field), redox potential (field), sulfate, nitrate, nitrites, alkalinity, total organic carbon (TOC), and ferrous iron (field). The specific number of wells to be monitored will be determined in the RD. The estimated cleanup time is 12 years and is based on a half life of 1.9 years using limited data from other LHAAP monitoring wells with similar perchlorate concentrations. Actual cleanup time could be higher than this estimate. The water well located at the Fire Station will also be included in the initial monitoring for perchlorate. If perchlorate is not detected in the Fire Station well in the initial sampling, future sampling of the Fire Station well would occur only if the perchlorate data from the expanded LHAAP-04 well field indicates the potential for impact (i.e. wells between LHAAP-04 site and Fire Station show perchlorate exceeding its cleanup level).

The LUCs' performance objectives are to prohibit groundwater use (except for environmental testing and monitoring) as a potable source until the levels of COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-3) in groundwater are met; to restrict land use to nonresidential until it is demonstrated that the surface and subsurface soil and groundwater COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-3) are at levels that allow for unlimited use and unrestricted exposure; and to maintain the integrity of any current or future remedial or monitoring systems until the levels of COCs (i.e., including all hazardous substances, pollutants and contaminants found at the Site at cleanup levels as listed in Table 2-3) in groundwater are met.

The estimated present worth (PW) costs for this Alternative were based on LTM of five wells for 15 years and use a 30-year evaluation period.

Estimated Total Direct Capital Cost: $126,000

Estimated Total O&M Cost: $463,000

Cost Estimate Duration: 30 years

Estimated Total PW Cost: $589,000

Alternative 3 – ISB, LTM, LUCs

This is the preferred alternative. It involves addition of a carbon source into the aquifer to promote naturally occurring biological processes in the subsurface environment. This would reduce perchlorate concentrations to below its cleanup level in a shorter time than MNA. LUCs would be maintained as described in the common elements in section 2.9.2.

ISB is a technology that encourages growth and reproduction of indigenous microorganisms to enhance biodegradation of organic constituents such as perchlorate in the saturated groundwater zone. A substrate will be injected into the target treatment area via injection points/wells. Bioaugmentation will be performed if necessary to introduce the appropriate kind of microbial culture into the subsurface environment.

Prior to implementation of ISB, two shallow monitoring wells and one intermediate monitoring well will be installed for horizontal and vertical delineation of the perchlorate plume. A groundwater monitoring program which will include existing and new proposed wells will be implemented as necessary to monitor the effectiveness and progress of ISB in reducing perchlorate concentrations in groundwater. The specific number of wells to be monitored will be determined in the RD. Assuming the first-order degradation rates and reasonable half-lives, perchlorate in groundwater could be reduced to below its cleanup level in approximately six years. For the purposes of cost estimating, duration of eight years is used for LTM. The water well located at the Fire Station will also be included in the initial monitoring for perchlorate. If perchlorate is not detected in the Fire Station well in the initial sampling, future sampling of the Fire Station well would occur only if the perchlorate data from the expanded LHAAP-04 well field indicates the potential for impact (i.e. wells between LHAAP-04 site and Fire Station show perchlorate exceeding its cleanup level).

The LUCs' performance objectives are to prohibit groundwater use (except for environmental testing and monitoring) as a potable source until the levels of COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-3) in groundwater are met; to restrict land use to nonresidential until it is demonstrated that the surface and subsurface soil and groundwater COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-3) are at levels that allow for unlimited use and unrestricted exposure; and to maintain the integrity of any current or future remedial or monitoring systems until the levels of COCs (i.e., including all hazardous substances, pollutants and contaminants found at the Site at cleanup levels as listed in Table 2-3) in groundwater are met.

The estimated PW costs for this Alternative were based on LTM for 8 years and use a 30-year evaluation period.

Estimated Total Direct Capital Cost: $243,000

Estimated Total O&M Cost: $422,000

Cost Estimate Duration: 30 years

Estimated Total PW Cost: $665,000

Alternative 4 – Extraction and Treatment, LUCs

This alternative is designed to reduce perchlorate contamination in the area of highest concentrations in the groundwater plume via extraction (using extraction wells) and treatment of groundwater for perchlorate to achieve its cleanup level. Plume areas outside the extraction system are also expected to attain the perchlorate cleanup level in a shorter duration after the highest perchlorate concentrations in groundwater are removed.

Prior to implementation of the extraction and treatment system, two shallow monitoring wells and one intermediate monitoring well will be installed for horizontal and vertical delineation of the perchlorate plume. A groundwater monitoring program which will include existing and new proposed wells will be implemented as necessary to monitor the effectiveness and progress of the extraction and treatment system in reducing perchlorate concentrations in groundwater. The specific number of wells to be monitored will be determined in the RD.

It is estimated that the perchlorate cleanup level in the groundwater would be achieved in approximately 15 months of treatment, provided extraction and treatment results are favorable. A trailer mounted treatment system will be used to remove perchlorate from the extracted groundwater using ion exchange resin technology. The treated effluent would be re-injected via four temporary wells back into the shallow zone at the site.

LUCs would be maintained as described in the common elements in section 2.9.2.

It is estimated that the extraction and treatment of perchlorate contaminated groundwater will be performed for a period of 15 months. For the purposes of cost estimating, five years is used for LTM and it includes costs associated with maintenance of LUCs for that period. The water well located at the Fire Station will also be included in the initial monitoring for perchlorate. If perchlorate is not detected in the Fire Station well in the initial sampling, future sampling of the Fire Station well would occur only if the perchlorate data from the expanded LHAAP-04 well field indicates the potential for impact (i.e. wells between LHAAP-04 site and Fire Station show perchlorate exceeding its cleanup level).

The LUCs' performance objectives are to prohibit groundwater use (except for environmental testing and monitoring) as a potable source until the levels of COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-3) in groundwater are met; to restrict land use to nonresidential until it is demonstrated that the surface and subsurface soil and groundwater COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-3) are at levels that allow for unlimited use and unrestricted exposure; and to maintain the integrity of any current or future remedial or monitoring systems until the levels of COCs (i.e., including all hazardous substances, pollutants and contaminants found at the Site at cleanup levels as listed in Table 2-3) in groundwater are met.

Estimated Total Direct Capital Cost: $325,000

Estimated Total O&M Cost: $436,000

Cost Estimate Duration: 30 years

Estimated Total PW Cost: $761,000

Alternative 5 – Interceptor Collection Trenches, Extraction and Treatment, MNA, LUCs

This alternative is designed to reduce perchlorate contamination in the area of highest concentrations in the groundwater plume via extraction using interceptor collection trenches followed by treatment of the extracted groundwater to achieve the perchlorate cleanup level. The extracted water will be treated using an ion exchange resin technology and the treated groundwater will be re-injected into the shallow zone at the site. Because the groundwater in the area with highest perchlorate concentration is removed and treated, perchlorate in portion of the plume located outside the influence of the extraction system is also expected to naturally attain the cleanup level in a shorter duration (Shaw, 2012).

LUCs will be maintained as described in the common elements in section 2.9.2.

Prior to implementation of this alternative, two shallow monitoring wells and one intermediate monitoring well will be installed for horizontal and vertical delineation of the perchlorate plume. A groundwater monitoring program which will include existing and new proposed wells will be implemented as necessary to monitor the effectiveness and progress of this alternative in reducing perchlorate concentrations in groundwater. The specific number of wells to be monitored will be determined in the RD.

The extraction and treatment portion of this alternative is estimated to take approximately six months. For the purpose of cost estimating, five years is used for the LTM and it includes costs associated with maintenance of LUCs for that period. The water well located at the Fire Station will also be included in the initial monitoring for perchlorate. If perchlorate is not detected in the Fire Station well in the initial sampling, future sampling of the Fire Station well would occur only if the perchlorate data from the expanded LHAAP-04 well field indicates the potential for impact (i.e. wells between LHAAP-04 site and Fire Station show perchlorate exceeding its cleanup level).

The LUCs' performance objectives are to prohibit groundwater use (except for environmental testing and monitoring) as a potable source until the levels of COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-3) in groundwater are met; to restrict land use to nonresidential until it is demonstrated that the surface and subsurface soil and groundwater COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-3) are at levels that allow for unlimited use and unrestricted exposure; and to maintain the integrity of any current or future remedial or monitoring systems until the levels of COCs (i.e., including all hazardous substances, pollutants and contaminants found at the Site at cleanup levels as listed in Table 2-3) in groundwater are met.

Estimated Total Direct Capital Cost: $405,000

Estimated Total O&M Cost: $411,000

Cost Estimate Duration: 30 years

Estimated Total PW Cost: $816,000

2.9.2 Common Elements and Distinguishing Features of Each Alternative

Common Elements of Alternatives 2 through 5

LUCs, LTM and five-year review are common to all alternatives except the No Action alternative. These common elements are described below.

Land Use Controls

LUCs are any restriction or control, arising from the need to protect human health and the environment, that limits the use of and/or exposure to any portion of that property, including water resources. The LUCs would be implemented to support the RAO to protect human health.

The LUC for groundwater would prevent human exposure to residual groundwater contamination presenting an unacceptable risk to human health and ensure that there is no withdrawal or use of groundwater beneath the sites for anything other than environmental monitoring and testing. The LUC to prohibit groundwater use (except for environmental testing and monitoring) as a potable source would remain until the levels of COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-3) in groundwater are met; to restrict land use to nonresidential until it is demonstrated that the surface and subsurface soil and groundwater COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-3) are at levels that allow for unlimited use and unrestricted exposure; and to maintain the integrity of any current or future remedial or monitoring systems until the levels of COCs (i.e., including all hazardous substances, pollutants and contaminants found at the Site at cleanup levels as listed in Table 2-3) in groundwater are met.

In addition, within 90 days of signature of this ROD, the U.S. Army shall request the Texas Department of Licensing and Regulation to notify well drillers of groundwater use prohibitions based on a preliminary LUC boundary. A LUC Remedial Design (RD) will be finalized as the land use component of the Remedial Design. Within 21 days of the issuance of the ROD, the U.S. Army will propose deadlines for completion of the RD Work Plan, RD, and Remedial Action Work Plan. The documents will be prepared and submitted to the USEPA and the TCEQ pursuant to the FFA. The LUC RD will contain implementation and maintenance actions, including periodic inspections. Consistent with the dates presented for these documents, the U.S. Army shall: 1) request the Texas Department of Licensing and Regulation to notify well drillers of the final boundary of groundwater use prohibitions; and 2) notify the Harrison County Courthouse of the LUCs to include a map showing the areas of groundwater and non-residential use restrictions, and the monitoring system at the site, in accordance with 30 TAC 335.565.

The U.S. Army will implement, maintain, monitor, report on and enforce land use controls at U.S. Army-owned property. The U.S. Army shall perform those actions related to land use control activities described in this ROD and in the RD for the ROD. For portions of the Site subject to LUCs that are not owned by the U.S. Army, the U.S. Army will monitor and report on the implementation, maintenance, and enforcement of land use controls, and coordinate with federal, state, and local governments and owners and occupants of properties subject to LUCs. The U.S. Army will provide notice of the groundwater and soil contamination and any land use restrictions referenced in the ROD. The U.S. Army will send these notices to the federal, state and local governments involved at this site and the owners and occupants of the properties subject to those use restrictions and land use controls. The U.S. Army shall provide the initial notice within 90 days of ROD signature. The frequency of subsequent notifications will be described in the RD for the ROD. The Army remains responsible for ensuring that the remedy remains protective of human

health and the environment. The U.S. Army will fulfill its responsibility and obligations under CERCLA and the NCP as it implements, maintains, and reviews the selected remedy.

Upon transfer of U.S. Army-owned property, the U.S. Army will provide written notice of the land use controls to the transferee of the groundwater and soil contamination and any land use restrictions referenced in the ROD. Within 15 days of transfer, the U.S. Army shall provide the USEPA and the TCEQ with written notice of the division of implementation, maintenance, and enforcement responsibilities unless such information has already been provided in the LUCs' RD. The LUC RD will address the procedures to be used by the U.S. Army and the transferee to document compliance with the LUCs described in this ROD. In the event property is transferred out of Federal control, the LUCs relating to property and groundwater restrictions shall be recorded in the deed and shall be enforceable by the United States and the state of Texas.

To transfer LHAAP-04, an Environmental Condition of Property (ECP) document would be prepared and the Environmental Protection Provision from the ECP would be attached to the letter of transfer. The ECP would include the LUCs as part of the Environmental Protection Provisions. The property would be transferred subject to the LUCs identified in the ECP. These restrictions would prohibit or restrict property uses that might result in exposure to the contaminated groundwater (e.g., potable use of groundwater above the cleanup level) or soil (e.g. residential land use prohibition).

The U.S. Army and regulators will consult to determine appropriate enforcement actions should there be a failure of a LUC objective at the site after it has been transferred.

Long Term Monitoring

LTM is the monitoring conducted after a remedy is selected and implemented, and is used to evaluate the degree to which the remedial measure achieves its objectives. Alternatives 2 through 5 at the LHAAP-04 site include long-term groundwater monitoring activities. LTM would include monitoring of a select number of groundwater wells to evaluate contaminant migration and ensure that the groundwater COC plume continues to degrade in a manner to achieve attainment of the groundwater cleanup level.

The LTM would be continued as required to demonstrate effectiveness of the remedy, to demonstrate compliance with applicable or relevant and appropriate requirements (ARARs), and to support five-year reviews.

Five-Year Reviews

Five-Year Reviews are intended to evaluate whether the response action remains protective of human health and the environment, is functioning as designed, and necessary O&M is being performed. For the LHAAP-04 site, the Five-Year Review would focus on effectiveness of the remedial action and achievement of specific performance levels established in the ROD. Five-Year Reviews would include document reviews, review of cleanup standards, inspections, technology reviews, and preparation of a report summarizing the findings and recommendations. Five-Year Reviews would be performed until site conditions allow for unlimited use and unrestricted exposure.

Distinguishing Features of Action Alternatives

Alternative 2 utilizes MNA which is a passive remedial technology for groundwater remediation. This alternative is the least intrusive and relies solely on naturally occurring processes in the subsurface environment to degrade the COCs. The anticipated remediation time is 12 years.

The distinguishing feature of Alternative 3 is the inclusion of ISB technology to promote naturally occurring biological processes in the aquifer. This technology uses a carbon source and a bioaugmentation culture, if needed, to create conditions favorable for reductive dechlorination of perchlorate. Treatment under anaerobic conditions is often applied to perchlorate, and microorganisms capable of degrading perchlorate are common in the environment. Anticipated remediation times may be short in the target area with appropriate contact. Assuming first order anaerobic degradation rates and reasonable half-lives, the perchlorate in groundwater could be reduced to below its cleanup level in approximately six years, based on the hot spot treatment.

The distinguishing features of Alternative 4 are the inclusion of ex-situ technologies including an extraction system and an ion exchange resin treatment. It differs from Alternatives 2 and 3 in that contaminated groundwater is physically removed (using a network of extraction wells) from the subsurface environment and treated aboveground. The anticipated remediation time is 15 months which is significantly shorter than that of Alternatives 2 and 3.

Alternative 5 is similar to Alternative 4 except for inclusion of an interceptor trench instead of an extraction to collect groundwater. An interceptor trench can be expected to allow a higher rate of groundwater extraction from the subsurface. At LHAAP-04 with the apparently discontinuous sand layers, this may be necessary to entirely capture the contaminated plume. This alternative has the shortest anticipated remediation time of six months.

2.9.3 Expected Outcomes of Each Alternative

Alternative 1 would allow the site to remain a hazard to human receptors due to the potential ingestion of contaminated groundwater; and to the environment, because no remedial activities would be conducted and there would be no LUCs or LTM. Alternatives 2 through 5 all provide treatment (Alternative 2 provides passive treatment), or removal of the contaminated groundwater to meet perchlorate cleanup level that would be protective of human receptors and the environment. The four action alternatives have very similar outcomes of preventing exposure to contaminated groundwater utilizing either in-situ or ex-situ technology and LUCs. Alternatives 2 and 3 take advantage of naturally occurring processes in the subsurface environment at LHAAP-04, although the progress of COC degradation is expedited through addition of a carbon source and microbial culture under Alternative 3. Alternatives 4 and 5 achieve groundwater cleanup level in less time through utilization of active treatment. The similar outcomes of all action alternatives include restoration of the contaminated groundwater by attainment of the TRRP Tier 1 Groundwater Residential PCL for perchlorate, in the absence of federal drinking water standards. In addition, the LTM associated with Alternatives 2 through 5 would confirm the protection of human health and the environment by documenting the return of groundwater to its beneficial use, if practicable, through reduction of the contaminant mass and shrinking of the plume. The LUC to prohibit groundwater use (except for environmental testing and monitoring) as a potable source until the levels of COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-3) in groundwater are met; to restrict land use to nonresidential until it is demonstrated that the surface and subsurface soil and groundwater COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at

cleanup levels as listed in Table 2-3) are at levels that allow for unlimited use and unrestricted exposure; and to maintain the integrity of any current or future remedial or monitoring systems until the levels of COCs (i.e., including all hazardous substances, pollutants and contaminants found at the Site at cleanup levels as listed in Table 2-3) in groundwater are met.

2.10 Summary of Comparative Analysis of Alternatives

Nine criteria identified in the NCP §300.430(e)(9)(iii) are used to evaluate the different remediation alternatives individually and against each other in order to select a remedy. This section profiles the relative performance of each alternative against the nine criteria, noting how it compares to the other options under consideration. The nine evaluation criteria are discussed below. **Table 2-5** summarizes the comparative analysis of the alternatives.

2.10.1 Overall Protection of Human Health and the Environment

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

Alternative 1, the No Further Action alternative, does not protect human health or the environment because no remedial activities would be conducted and no LUCs would be maintained. Therefore, LHAAP-04 contamination would present unacceptable risks to human health and the environment through ingestion of groundwater. The other four alternatives, collectively referred to as the action alternatives, would provide treatment, or removal to levels protective of human health and the environment.

The four action alternatives would provide access and use restrictions, and long-term groundwater monitoring. LUC would prevent exposure to contaminated groundwater at LHAAP-04. Alternative 2 relies solely on LUCs combined with MNA and does not provide contaminant removal or treatment in groundwater other those occurring under natural conditions. Alternatives 3, 4, and 5 include either in situ or ex situ treatment technologies and also provide overall protection of human health and the environment. Alternative 5 is the most aggressive and would be able to attain ARARs in the shortest time frame.

All action alternatives satisfy the RAOs for LHAAP-04. Action alternatives provide confirmation that human health and the environment will be protected because LTM will be conducted to confirm that active remedies or MNA is returning the contaminated groundwater at LHAAP-04 to its potential beneficial uses, wherever practicable, and ultimately to document reduction in contaminant concentrations to the cleanup level. Furthermore, the LUC for groundwater would protect human health by preventing access to the contaminated groundwater until the levels of the COC (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-3) in soils and groundwater allow for unlimited use and unrestricted exposure.

2.10.2 Compliance with ARARs

Section 121(d) of CERCLA and 40 CFR §300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites attain legally applicable or relevant and appropriate Federal and State requirements,

standards, criteria, and limitations, which are collectively referred to as "ARARs" unless such ARARs are waived under CERCLA Section 121(d)(4). The ARARs that pertain to this ROD are discussed in **Section 2.13.2**.

Alternative 1 does not comply with chemical-specific ARARs as no remedial action would be implemented. The action-specific ARAR does not apply to Alternative 1 since no remedial activities would be conducted. Alternatives 2, 3, 4, and 5 are expected to comply with chemical-specific ARARs and action-specific ARARs. There are no location-specific ARARs.

2.10.3 Long-Term Effectiveness and Permanence

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

Alternative 1 would not be effective in the long term, because the recent data indicates that the current groundwater conditions are not protective of human health and the environment, and no remedial activities would be conducted to address groundwater under this alternative. Alternative 2 offers a moderate degree of long-term effectiveness through implementation of MNA with LUCs, which would minimize the hazard posed by contaminated groundwater, albeit in a longer time than Alternatives 3, 4 and 5. Alternatives 3, 4, and 5 will provide long-term effectiveness and permanence and in addition, they are designed to reduce groundwater contaminant concentrations and achieve clean up levels in a shorter duration. LUCs associated with Alternatives 2, 3, 4, and 5 will be in place until levels that allow for unlimited use and unrestricted exposure are achieved. With the in-situ approach using ISB, Alternative 3 can address potential perchlorate-impacted soil under the sampling grids FL09 and FL11 and therefore, reduce the uncertainty in estimated times to achieve cleanup levels compared to other alternatives.

Monitoring activities associated with all action alternatives would confirm the protection of human health and the environment by documenting the return of the groundwater to its beneficial use as a drinking water supply, by documenting reduction of the contaminant mass and by preventing the perchlorate-contaminated groundwater plume from migrating into surface water.

2.10.4 Reduction of Toxicity, Mobility, or Volume through Treatment

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

Alternative 1 does not include treatment and would not result in a reduction of toxicity, mobility, or volume of contaminants except through natural attenuation processes, although the progress would be unmonitored and undocumented. Alternative 2 does not employ active treatment and will rely on naturally occurring processes to achieve reduction in toxicity, mobility, and volume as contaminants are reduced to concentrations below risk criteria. Alternative 3 provides a reduction in toxicity, mobility, and volume via bioremediation of perchlorate. Alternatives 4 and 5 will reduce the volume of contamination via extraction of impacted groundwater and will provide reduction in toxicity and mobility via treatment of impacted groundwater. The degree of reduction in toxicity and mobility will depend upon the treatment processes.

2.10.5 Short-Term Effectiveness

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

Alternative 1 would not involve any remedial measures; therefore, no short-term risk to workers, the community, or the environment would exist. Through LUCs and engineered controls (e.g., administrative controls, and dust suppression), the four action alternatives would be protective of the community during implementation. Alternative 3 would be the most protective in the short term because no construction is required. Alternatives 4 and 5 are O&M intensive, with greater potential for short-term physical safety risks to on-site workers, and refuge visitors.

2.10.6 Implementability

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

Under Alternative 1, no new remedial action would be taken. Therefore, there would be no difficulties or uncertainties with implementation. Alternatives 2, 3, 4, and 5 can be easily implemented from a technical standpoint as all equipment, materials, and services required are readily available. Alternative 3 would be slightly more difficult to implement than Alternative 2 from a technical standpoint due to the specialized expertise required to design and construct the ISB treatment elements. Overall, all action alternatives are technically and administratively implementable.

2.10.7 Cost

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

The cost estimates include capital costs (including fixed-price remedial construction) and long term O&M costs (post-remediation). PW costs were developed for each alternative assuming a discount rate of 2.7 percent. The progression of PW costs from the least expensive alternative to the most expensive alternative is as follows: Alternative 1 ($0), Alternative 2 ($589,000), Alternative 3 ($665,000), Alternative 4 ($761,000), and Alternative 5 ($816,000). No costs are associated with Alternative 1 because no remedial activities would be conducted. Alternatives 2 and 5 have the lowest and the highest PW cost, respectively.

2.10.8 State/Support Agency Acceptance

The USEPA and the TCEQ have reviewed the Proposed Plan, which presented Alternative 3 as the preferred alternative. Comments received from the USEPA and TCEQ during the Proposed Plan development have been incorporated. Both agencies concur with the selected remedial action.

2.10.9 Community Acceptance

Community acceptance is an important consideration in the final evaluation of the selected remedy. Public comments were received during the 30-day public comment period and during the January 9, 2013 public meeting. The topics of the comments included: defining the extent of groundwater contamination, residual soil contamination and perchlorate cleanup level. The written comments received and their responses are presented in the Responsiveness Summary (**Section 3.0**).

2.11 Principal Threat Waste

Under the RCRA closure, LHAAP-04, the former pilot water treatment plant was demolished in 1997 and the facility structures, tanks, piping and associated wastes were disposed off-site. Subsequently, under the CERCLA removal authority, approximately, 3,406 cy of soil contaminated with mercury and perchlorate constituting the principal threat waste was removed, eliminating the exposure pathway for mercury contaminated soil and the soil leaching to groundwater pathway for perchlorate contaminated soil. Currently, soil at LHAAP-04 does not pose threat to human health or the environment under an industrial land use setting.

2.12 The Selected Remedy

2.12.1 Summary of Rationale for the Selected Remedy

Alternative 3, which includes ISB in the target area, LTM and LUCs, is the selected alternative for LHAAP-04 and is consistent with the intended future use of the site as a national wildlife refuge. This alternative would satisfy the RAOs for the site through the following:

- Treatment of groundwater by ISB in the hot spot area in the vicinity of monitoring well 04WW04. The above selected remedial action employing treatment, will ultimately restore the groundwater to attain groundwater cleanup level for perchlorate.
- The LUC to prohibit groundwater use (except for environmental testing and monitoring) as a potable source will be implemented to ensure protection of human health by preventing exposure to groundwater until the levels of COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-3) in groundwater are met. The LUC restricting land use to nonresidential will be implemented until it is demonstrated that the surface and subsurface soil and groundwater COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-3) are at levels that allow for unlimited use and unrestricted exposure. The LUC to maintain the integrity of any current or future remedial or monitoring systems will be implemented until the levels of COCs (i.e., including all hazardous substances, pollutants and contaminants found at the Site at cleanup levels as listed in Table 2-3) in groundwater are met.
- LTM will be conducted to confirm that perchlorate concentrations in the groundwater plume are declining through treatment to attain groundwater cleanup level.

The selected remedy employing treatment will significantly reduce contaminant concentrations. Monitoring will be continued until it is demonstrated that groundwater has achieved the cleanup level for perchlorate.

Five-year reviews will be performed to document that the remedy remains protective of human health and the environment.

Alternative 3 is readily implementable and has no significant short-term risks to worker health and safety or to the community would be expected. The PW cost of Alternative 3 is lower than the other remedial alternatives (Alternatives 4 and 5) consisting of ex-situ treatment component. The PW of Alternative 3 marginally exceeds that of Alternative 2 but provides a balancing trade-off between cost and other criteria used in the detailed evaluation.

Based on the information currently available, the U.S. Army believes that the selected alternative meets the threshold criteria and provides the best balance of tradeoffs among the other alternatives with respect to the CERCLA §121(b) criteria used to evaluate remedial alternatives. The selected alternative will 1) be protective of human health and the environment; 2) comply with ARARs; 3) be cost-effective; 4) utilize permanent solution; and 5) utilizes treatment as a principal element.

The U.S Army will present details of the ISB, LUC implementation plan, and the LTM plan in the RD for LHAAP-04.

2.12.2 Description of the Selected Remedy

The selected remedy, Alternative 3, was outlined in **Section 2.9**; that description is expanded in the following discussion. The remedy may undergo modifications as a result of the RD and construction processes. Modifications of the remedy described in the ROD will be documented using a technical memorandum in the Administrative Record, an Explanation of Significant Differences (ESD), or a ROD amendment.

The major components of the selected remedy include:

- ISB of groundwater in an area in the vicinity of monitoring well 04WW04. Additional applications of substrate may be needed based on effectiveness of the ISB Substrates may include a wide variety of nutrients: sugars (molasses), alcohols (methanol, ethanol), volatile acids (acetate, lactate), and/or wastes (food processing, manure) Bioaugmentation will be performed if necessary to introduce the appropriate kind of microbial culture into the subsurface environment. It is estimated that perchlorate could be reduced to below its cleanup level in approximately 6 years.
- The LUC objectives include maintaining the integrity of any current or future remedial or monitoring systems, and preventing the use of groundwater contaminated above cleanup levels as a potable water source. The groundwater treatment and LTM remedial components include a groundwater monitoring system that will be used to characterize the condition of the groundwater during the period the groundwater remedy is in place until the groundwater remediation goals are achieved, and to demonstrate achievement of the groundwater remediation goals when the groundwater remedy is complete. As a part of this groundwater remedy, the Army will maintain the remedial and monitoring systems associated with the groundwater remedies until these components of the remedy are no longer needed to achieve cleanup levels, and cleanup levels have been achieved. During the period of operation of the groundwater remedy, if any of the elements of the remedial and groundwater monitoring systems are damaged, destroyed, or become ineffective, they will be repaired or replaced with suitable components to assure that the remedial and groundwater monitoring systems are able to provide data of the quality necessary to

determine the progress of and eventual completion of this component of the remedy. The actions to be taken to implement these LUC objectives and requirements will be provided through modifying the "Comprehensive Land Use Control (LUC) Management Plan, Former Longhorn Army Ammunition Plant, Karnack, Texas" and detailed in the LUC RD. The preliminary boundary for the groundwater LUC is presented on Figure 2-7.

- The LUC for prohibition of groundwater use (except for monitoring and testing) shall be implemented and shall remain in place at the Site until the levels of COCs (i.e. including all hazardous substances, pollutants and contaminants found at the Site at cleanup levels as listed in Table 2-3) in soil and groundwater allow for unlimited use and unrestricted exposure. A LUC RD will be finalized as the land use component of the Remedial Design. Within 21 days of the issuance of the ROD, the Army will propose deadlines for completion of the RD Work Plan, RD and Remedial Action Work Plan. The documents will be prepared and submitted to the EPA and the TCEQ pursuant to the FFA. The LUC RD will contain implementation and maintenance actions, including periodic inspections. The long-term monitoring groundwater plan will also be presented in the RD. The recordation notification for the Site which will be filed with Harrison County, will include a description of the LUCs.
- The LUC restricting land use to nonresidential shall be implemented until it is demonstrated that surface and subsurface soil and groundwater COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-3) are at levels that allow for unlimited use and unrestricted exposure.
- The LUC to maintain the integrity of any current or future remedial or monitoring systems will remain in place until the levels of COCs (i.e., including all hazardous substances, pollutants and contaminants found at the Site at cleanup levels as listed in Table 2-3) in groundwater are met. The LUC to prohibit groundwater use (except for environmental monitoring and testing) as a potable source will remain in place until the levels of COCs (i.e., all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-3) in soil and groundwater allow for unlimited use and unrestricted exposure.

The Army will implement, maintain, monitor, report on and enforce land use controls at Army-owned property. The Army shall perform those actions related to land use control activities described in this ROD and in the Remedial Design for the ROD. For portions of the Site subject to land use controls that are not owned by the Army, the Army will monitor and report on the implementation, maintenance, and enforcement of land use controls, and coordinate with federal, state, and local governments and owners and occupants of properties subject to land use controls. The Army will provide notice of the groundwater and soil (surface and subsurface) contamination and any land use restrictions referenced in the ROD. The Army will send these notices to the federal, state and local governments involved at this site and the owners and occupants of the properties subject to those use restrictions and land use controls. The Army shall provide the initial notice within 90 days of ROD signature. The frequency of subsequent notifications will be described in the Remedial Design for the ROD. The Army remains responsible for ensuring that the remedy remains protective of human health and the environment. The Army will fulfill its responsibility and obligations under CERCLA and the NCP as it implements, maintains, and reviews the selected remedy.

Upon transfer of Army-owned property, the Army will provide written notice of the land use controls to the transferee of the groundwater and soil (surface and subsurface) contamination and any land use restrictions referenced in the ROD. Within 15 days of transfer, the Army shall provide EPA and TCEQ with written notice of the division of implementation, maintenance, and enforcement responsibilities unless such information has already been provided in the LUC RD. The LUC RD will address the procedures to be used by the Army and the transferee to document compliance with the LUCs described in this ROD. In the event property is transferred out of Federal control, the land use controls relating to property and groundwater restrictions shall be recorded in the deed and shall be enforceable by the United States and the state of Texas.

- LUC implementation and maintenance actions would be described in the RD for LHAAP-04. The LUCs would be included in the property transfer documents and a recordation of the area of groundwater prohibition would be filed in the Harrison County Courthouse. The LUC for groundwater will prevent human exposure to groundwater contaminated with perchlorate through the prohibition of groundwater use. In addition, within 90 days of signature of this ROD, the Army shall request the Texas Department of Licensing and Regulation to notify well drillers of groundwater use prohibitions based on a preliminary LUC boundary. A LUC Remedial Design (RD) will be finalized as the land use component of the Remedial Design. Within 21 days of the issuance of the ROD, the Army will propose deadlines for completion of the RD Work Plan, RD, and Remedial Action Work Plan. The documents will be prepared and submitted to EPA and TCEQ pursuant to the FFA. The LUC RD will contain implementation and maintenance actions, including periodic inspections. The long-term groundwater and surface water monitoring and LTM performance monitoring plan will also be presented in the remedial design (RD). Consistent with the dates presented for these documents, the U.S. Army shall: 1) request the Texas Department of Licensing and Regulation to notify well drillers of groundwater use prohibitions; and 2) notify the Harrison County Courthouse of the LUC to include a map showing the areas of groundwater use prohibition at the site, in accordance with 30 TAC 335.565. Following implementation of the remedy, LTM will be conducted on a select number of wells. The number and location of the wells will be reviewed on an annual basis. LTM will be conducted to evaluate contaminant migration, ensure that the COC plume continues to degrade, and to demonstrate compliance with ARARs until groundwater cleanup levels are achieved. Performance monitoring would be performed on a quarterly basis for a period of two years and will include analysis of perchlorate and geochemical parameters (sulfate, nitrate, nitrites, alkalinity). Field parameters will include dissolved oxygen, redox potential and ferrous ion. LTM would begin in year 3 after treatment and would be conducted semiannually for 3 years (through Year 5), and annually thereafter. Annual reports will be prepared to document the effectiveness of the treatment. The first year annual report will include a review of the four quarters of data and provide an evaluation of the effectiveness of the selected remedy.
- CERCLA five-year reviews to evaluate whether the remedy remains protective of human health and the environment. The need for continued groundwater monitoring will be evaluated every 5 years during the reviews.

2.12.3 Cost Estimate for the Selected Remedy

Table 2-6 presents the present worth analysis of the cost for the selected remedy, Alternative 3. The information in the table is based on the best available information regarding the anticipated scope of the remedial alternative. The quantities used in the estimate are for estimating purposes only. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedial alternative. Modifications may be documented in the form of a memorandum in the Administrative Record, an ESD, or a ROD amendment. This is an order-of-magnitude engineering cost estimate that is expected to be within -30 to +50 percent of the actual project cost.

The total project present worth cost of this alternative is approximately $665,000, using a discount rate of 2.7%. The capital cost is estimated at $243,000. The total O&M present value cost is estimated at approximately $422,000. The O&M cost includes long term monitoring associated with the LUCs, and the assessment of in situ bioremediation performance. The LTM will support the required CERCLA five-year reviews.

2.12.4 Expected Outcomes of Selected Remedy

The purpose of this response action is to attain the RAOs stated in Section 2.8 of this ROD. The groundwater will be restored to attain groundwater cleanup level for perchlorate, to the extent practicable. In the absence of federal drinking water standards, clean-up levels will be based on TRRP Tier 1 Groundwater Residential PCL.

The expected outcome of the selected remedy is that perchlorate in the groundwater will be reduced to clean-up levels. Achievement of the groundwater cleanup level is anticipated to be completed in approximately 6 years. This approximate timeframe to achieve cleanup levels is considered reasonable for the anticipated future land use as a national wildlife refuge. The actual time frame depends on the success of the active remediation, but, for cost estimating purposes, it is assumed that five-year reviews will continue until Year 30. The LUC for the maintenance of the monitoring system will be maintained until the groundwater cleanup levels are achieved. The LUCs for soil and groundwater will be maintained until the levels of COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-3) allow for unlimited use and unrestricted exposure. The site will be made part of a national wildlife refuge operated by USFWS, and will continue in such use for the foreseeable future.

In addition, the monitoring activities will confirm the protection of human health and the environment by documenting the return of the groundwater to the cleanup level (MCL or PCL) through reduction of the contaminant mass and by preventing the perchlorate-contaminated groundwater plume from migrating into surface water. The LUC for groundwater will prohibit the use of the site's groundwater except for environmental monitoring and testing.

2.13 Statutory Determinations

Under CERCLA §121 and the NCP, the U.S. Army must select remedies that are protective of human health and the environment, comply with ARARs (unless a statutory waiver is justified), are cost effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes

a preference for remedies that employ treatment that permanently and significantly reduces the volume, toxicity, or mobility of hazardous wastes as a principal element and a bias against off-site disposal of untreated wastes. The following sections discuss how the selected remedy meets the statutory requirements

2.13.1 Protection of Human Health and the Environment

Existing groundwater perchlorate concentrations pose a hazard to the hypothetical future maintenance worker since the clean-up level is exceeded. The selected remedy, Alternative 3, will achieve the RAOs for LHAAP-04. For the protection of human health, the remedial action would eventually achieve the reduction of the perchlorate present in groundwater above the cleanup level established for LHAAP-04. LUCs would ascertain that receptors are not exposed to unacceptable levels of contaminated groundwater. Continued maintenance of the LUC for groundwater would prevent human access and exposure to groundwater that poses an unacceptable risk to human health, until COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-3) in soils and groundwater have sufficiently degraded to levels that allow for unlimited use and unrestricted exposure. The LUCs for soil and groundwater will be maintained until the levels of COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-3) in soil and groundwater allow for unlimited use and unrestricted exposure.

The installation-wide ecological risk assessment concluded that risks to ecological receptors at the Group 4 sites (inclusive of LHAAP-04) were within the acceptable risk range.

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

2.13.2 Compliance with ARARs

The selected remedy complies with all ARARs. The ARARs are presented below and in **Table 2-7**.

Chemical-Specific ARARs

There are no potential chemical-specific ARARs associated with this site. The only identified COC is perchlorate for groundwater. In the absence of a federal drinking water standard, the clean-up levels will be based on TRRP Tier 1 Groundwater Residential PCL.

The selected remedial action employs ISB to return the contaminated groundwater at LHAAP-04 to its potential beneficial use as drinking water, wherever practicable. For the purposes of this ROD, attainment of the TRRP Tier 1 Groundwater Residential PCL constitutes a return of the contaminated groundwater to it potential beneficial use as a drinking water. If a return to potential beneficial uses is not practicable based upon 40 CFR§300.430(f)(1)(ii)(C), this alternative would still meet the NCP remedy selection requirements by reducing or controlling exposure to the contaminated groundwater consistent with 40 CFR§300.430(e)(9).

Location-Specific ARARs

There are no potential location-specific ARARs associated with this site.

Action-Specific ARARs

The selected remedy has potential action-specific ARARs related to the following activities: waste and disposal activities, well construction, and water treatment.

- **Waste and Disposal Activities -** The processes of treating and monitoring contaminated groundwater may generate a variety of primary and secondary waste streams (e.g., soil, personal protective equipment, and dewatering and decontamination fluids). These waste streams are expected to be non-hazardous waste. All solid waste (defined as any solid, liquid, semisolid, or contained gaseous material intended for discard [40 CFR 261.2]) generated during remedial activities must be appropriately characterized to determine whether it contains RCRA hazardous waste (40 CFR 262.11; 30 TAC 335.62; 30 TAC 335.503[a][4]; 30 TAC 335.504). All wastes must be managed, stored, treated (if necessary), and disposed in accordance with the ARARs for waste management listed in **Table 2-7** for the particular type of waste stream or contaminants in the waste.
- **Well Construction -** The remedial action may involve the placement, use, or eventual plugging and abandonment of some type of groundwater monitoring, substrate injection or for LTM of the groundwater. Available standards for well construction and plugging/abandonment would provide ARARs for such actions and include 30 TAC 331, Subchapters A, C, and H. Texas has promulgated technical requirements in Chapter 76 of Title 16 of the TAC applicable to construction, operation, and plugging/abandonment of water wells. In particular, 16 TAC 76.1000 (*Locations and Standards of Completion for Wells*), 16 TAC 76.1002 (*Standards for Wells Producing Undesirable Water or Constituents*) (LHAAP-04 contaminated groundwater could be considered "undesirable water" defined pursuant to Section 76.10[36] as "water that is injurious to human health and the environment or water that can cause pollution to land or other waters"), 16 TAC 76.1004 (*Standards for Capping and Plugging of Wells and Plugging Wells that Penetrate Undesirable Water or Constituent Zones*), and 16 TAC 76.1008 (*Pump Installation*) may provide ARARs for the placement, construction, and eventual plugging/abandonment of groundwater injection or extraction wells or the placement and long-term operation of groundwater monitoring wells for proposed groundwater remedial strategies.
- **Water Treatment -** Contaminated groundwater and wastewaters collected during well drilling or decontamination activities will be transported to the groundwater treatment plant at LHAAP-18/24 for processing, and would subsequently be discharged in compliance with the effluent limits for that plant. Such waters would be characterized, as required, before transport and managed accordingly in compliance with requirements for the type of waste contaminating the water. To assure compliance with the groundwater treatment plant's discharge limits, the incoming water must meet the waste acceptance criteria for the facility. On-site wastewater treatment units (as defined in 40 CFR 260.10) that are part of a wastewater treatment facility that is subject to regulation under Section 402 or Section 307(b) of the CWA are not subject to RCRA Subtitle C hazardous waste management standards (40 CFR 270.1[c][2][v]; 40 CFR 264.1[g][6]; 30 TAC 335.42[d][1]). The USEPA has clarified that this exemption applies to all tanks, conveyance systems, and

ancillary equipment, including piping and transfer trucks, associated with the wastewater treatment unit (Federal Register [FR] Title 53, 34079, September 2, 1988).

2.13.3 Cost-Effectiveness

Alternative 3 has the second lowest PW and capital costs of the action alternatives that were evaluated in the FS (Shaw, 2012). The PW for Alternative 3 exceeds that of Alternative 2 which consists of a passive treatment process such as MNA. Alternative 3 utilizes active technology (ISB) which is less intrusive than Alternatives 4 and 5, thus giving Alternative 3 a relatively low PW compared to these alternatives. **Table 2-6** is the cost estimate summary table for the selected remedy.

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

The U.S. Army has determined that the selected final remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a practicable manner at the site. In-situ bioremediation will lower groundwater COC concentrations in the groundwater plume. Alternative 3 would provide almost immediate protection because the LUCs would be implemented relatively quickly. Maintenance of this control would be required until COC concentrations in groundwater allow for unlimited use and unrestricted exposure.

2.13.5 Preference for Treatment as a Principal Element

The selected remedy satisfies the statutory preference for treatment as a principal element of the remedy. The selected final remedy will reduce the toxicity, mobility, or volume of the COC in groundwater through the implementation of ISB. ISB will lower COC concentrations in the groundwater plume to meet cleanup level. The biological activity in the ISB treatment area will significantly reduce the overall mass of COC in the groundwater.

2.13.6 Five-Year Review Requirements

Section 121(c) of CERCLA and NCP §300.430(f)(5)(iii)(C) provide the statutory and legal bases for conducting five-year reviews. Because this remedy will result in contaminants that remain onsite above levels that allow unlimited use and unrestricted exposure, a review will be conducted at least every 5 years to ascertain 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 public comment period for LHAAP-04 was January 1 through January 31, 2013. The proposed plan identified Alternative 3 as the Preferred Alternative for groundwater remediation. The U.S. Army reviewed all written comments during the public comment period and verbal comments during the January 9, 2013 public meeting. After careful consideration of the comments, it was determined that no significant changes to the remedy, as originally identified in the proposed plan, were necessary or appropriate.

Figure 2-1: Site Location Map

Figure 2-2: LHAAP-04 Location Map

Figure 2-2A: LHAAP-04 Surface Water Monitoring Points

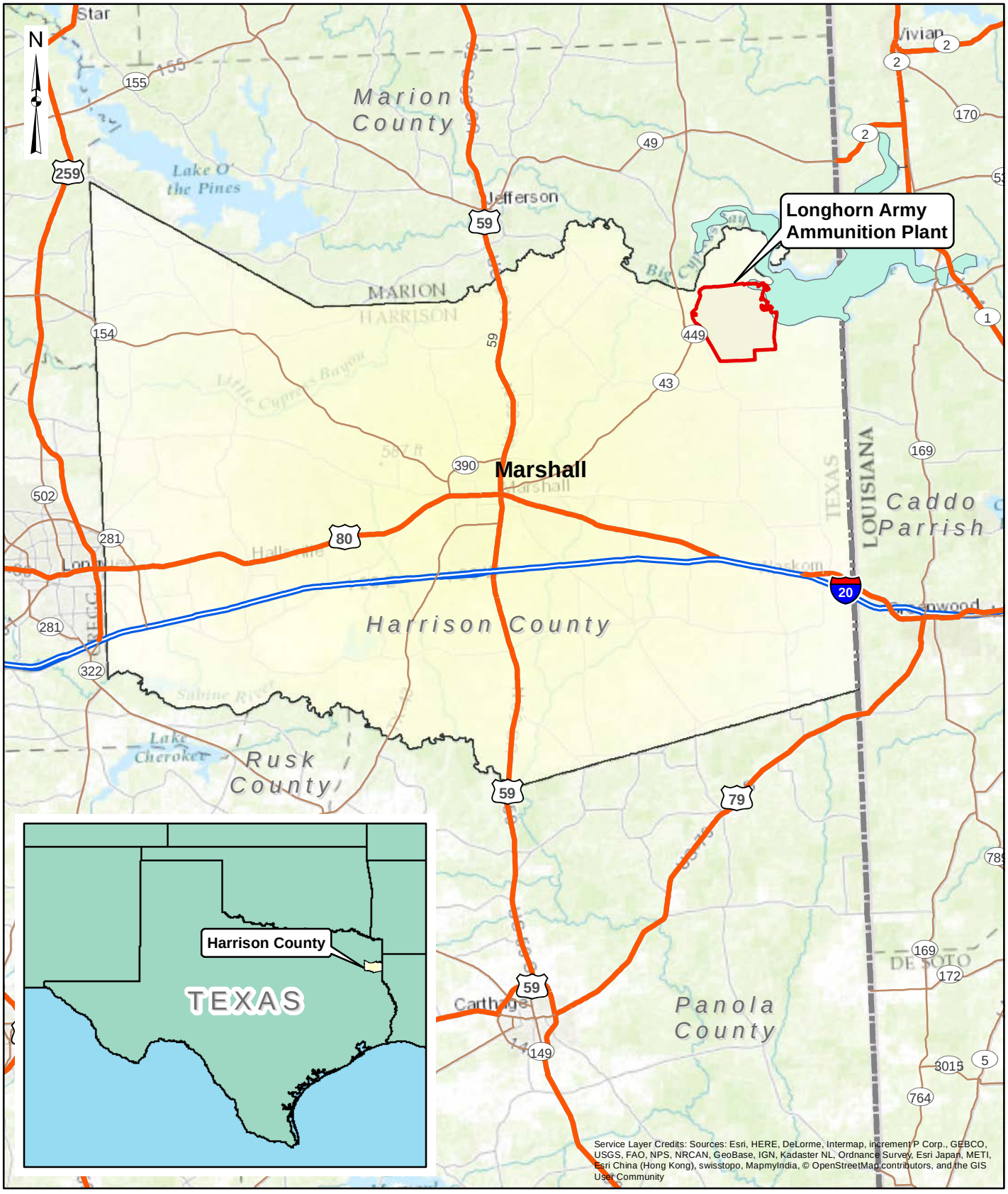
Figure 2-3: Conceptual Site Model

Figure 2-4: Groundwater Elevations 2007

Figure 2-5: Groundwater Elevations 2010

Figure 2-6: Perchlorate Concentrations in Shallow Groundwater

Figure 2-7: Preliminary Land Use Control Boundary at LHAAP-04



L:\AGE\GIS\AUS GIS\GIS_Projects\Longhorn_AAP\01_Reports\LHAAP-04\Record of Decision\Figure 2-1 LHAAP-04 Site Location Map.mxd

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Figure 2-1
Site Location Map
LHAAP-04

Longhorn Army Ammunition Plant
Karnack, Texas

60256135

October 2016

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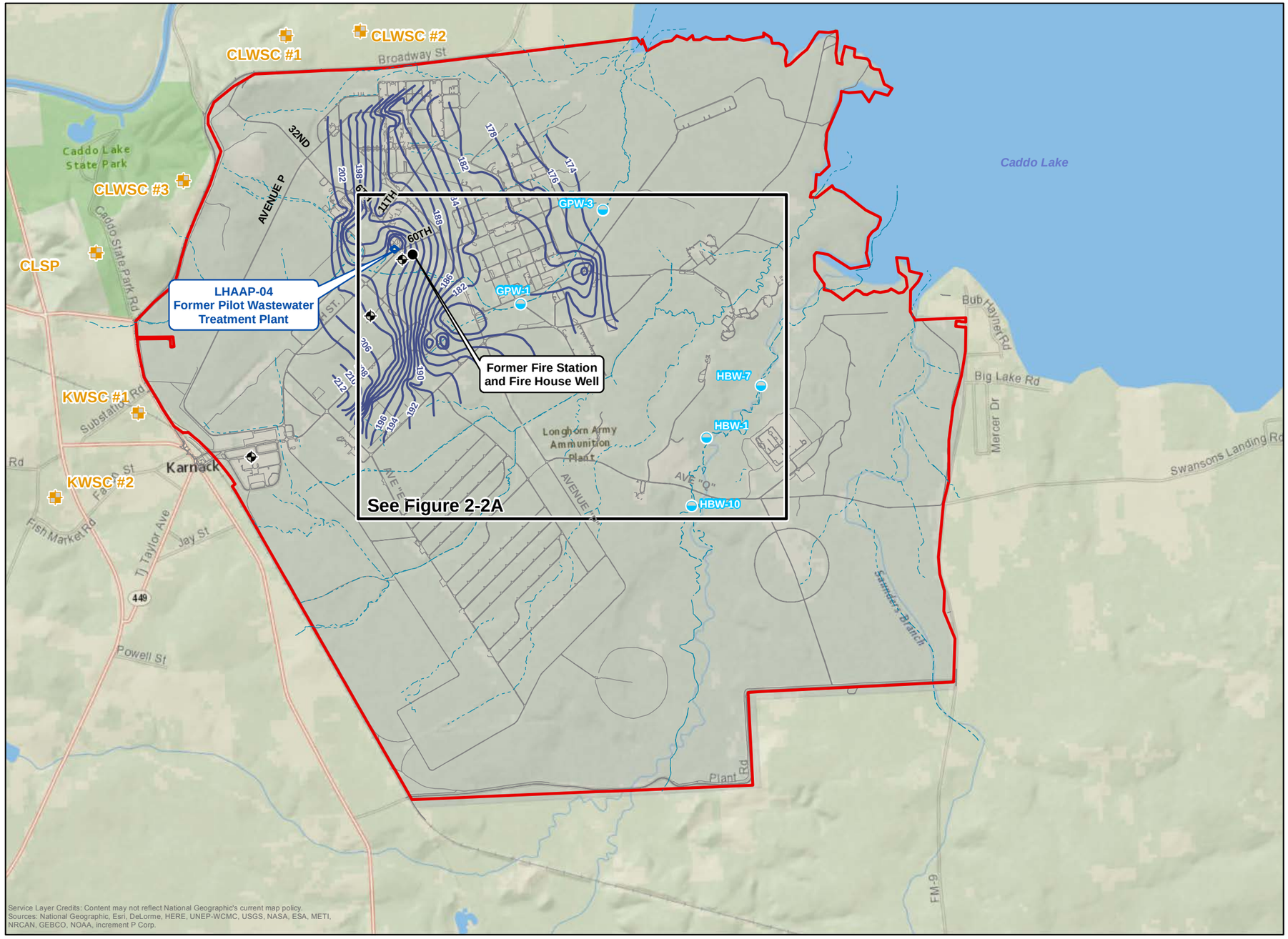

N

0 1,500 3,000 6,000
Feet

Legend

- Water Supply Well Locations
- Surface Water Sampling Locations
- Public Water Supply Well Locations
- Fire House Well
- Shallow Groundwater Contour (ca. 2007)
- Streams
- Road
- LHAAP Boundary
- LHAAP-04 Site Boundary

KWSC – Karnack Water Supply Corporation
CLWSC – Caddo Lake Water Supply Corporation
CLSP - Caddo Lake State Park

Source: Shaw 2012, LHAAP-04 Feasibility Study Report

Path: L:\AGE\GIS\AUS_GIS\GIS_Projects\Longhorn_AAP\01_Reports\LHAAP-04\Record of Decision\Figure 2-2 LHAAP-04 Location Map.mxd

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Figure 2-2
LHAAP-04 Location Map
Record of Decision
Longhorn Army Ammunition Plant
Karnack, Texas

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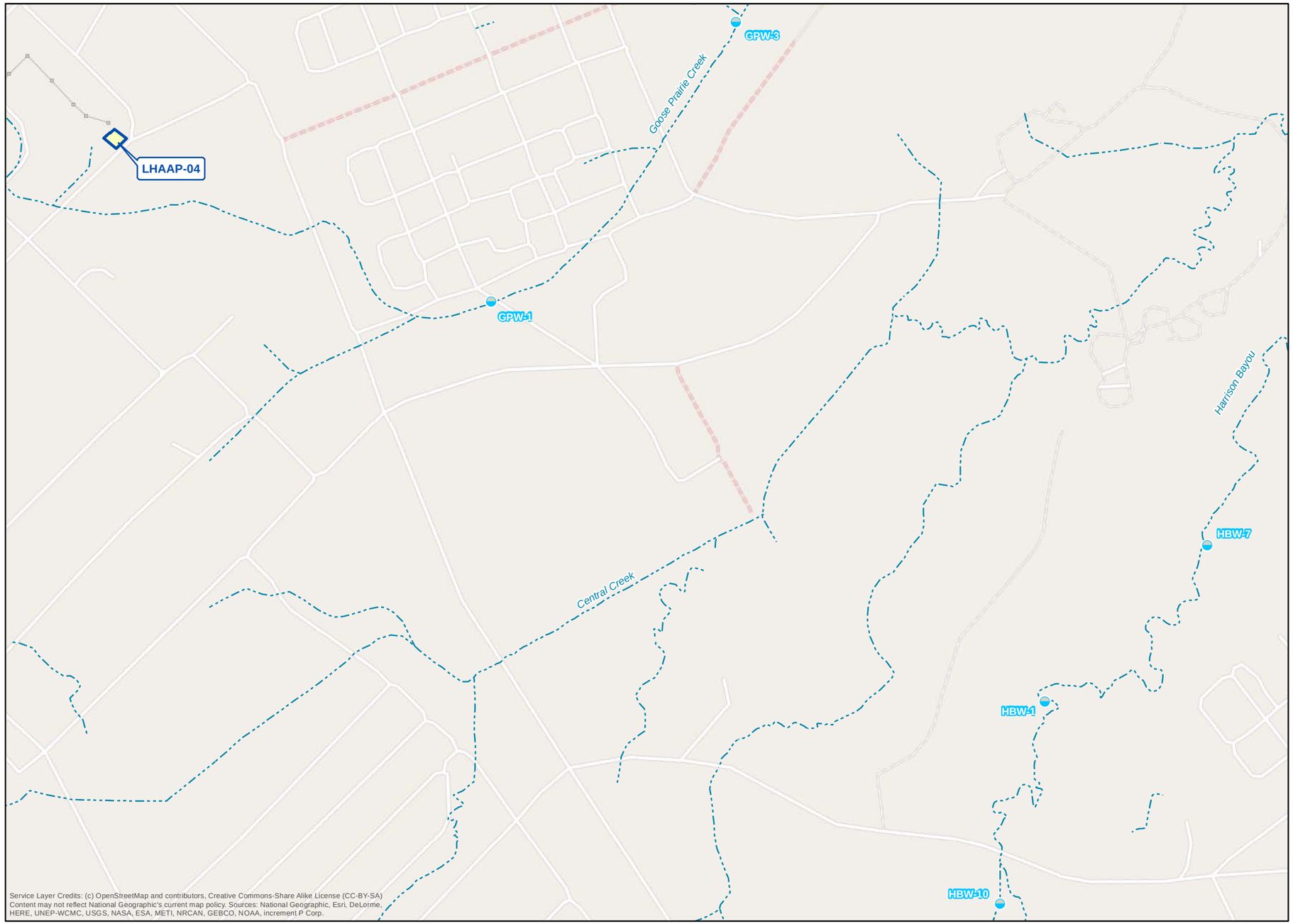

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0 500 1,000 2,000
Feet

Legend

- Surface Water Sampling Location
- Streams
- LHAAP-04 Site Boundary

Source: Shaw 2012, LHAAP-04 Feasibility Study Report

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Figure 2-2A
LHAAP-04 Surface Water Monitoring Points
Record of Decision
Longhorn Army Ammunition Plant
Karnack, Texas

60274185 October 2016

Path: L:\AGE\GIS\AUS GIS\GIS_Projects\Longhorn_AAP\01_Reports\LHAAP-04\Record of Decision\Figure 2-2a LHAAP-04 Location Map.mxd

Source	Release Mechanisms	Primary Media	Transport Pathway	Secondary Media	Exposure Pathway	Human Receptor	Human Health Risk
Industrial Area	Leaks, Spills	Soil			Ingestion, Inhalation Dermal Contact	Hypothetical Future Maintenance Worker	1.2 x 10^{-6} (HI = 0.28)
		Soil	Runoff	Drainage Ditches	Ingestion, Inhalation Dermal Contact	Hypothetical Future Maintenance Worker	1.2 x 10^{-6} (HI = 0.28)
		Soil	Infiltration, Leaching	Groundwater	Ingestion, Inhalation Dermal Contact	Hypothetical Future Maintenance Worker	4.5 x 10^{-5} (HI = 0.18)
		Soil	Infiltration, Leaching	Groundwater	Hypothetical		
		Soil	Infiltration, Leaching	Groundwater	Recharge, Seepage	Goose Prairie Creek	Surface Water and Fish Ingestion, Dermal Contact	Trespasser	No Risk Linked to LHAAP-04
		Soil	Infiltration, Leaching	Groundwater	Recharge, Seepage	Goose Prairie Creek	Caddo Lake	Surface Water and Fish Ingestion, Dermal Contact	Off-LHAAP Resident	No Risk Linked to LHAAP-04

Legend

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

Notes:
1.Human Health Risk from “Final Baseline Human Health and Screening Ecological Risk Assessment for the Group 4 Sites” (Jacobs, 2003).
2. Perchlorate concentrations detected in groundwater at LHAAP-04 exceeded the Texas Commission on Environmental Quality (TCEQ) Texas Risk Reduction Program (TRRP) Protective Concentration Level (PCL) for residentual groundwater of 17 micrograms per liter (µg/L) (cleanup level).
3. Groundwater migration to surface water pathway is not currently a complete pathway.
4. Soil to groundwater pathway is no longer a complete pathway because impacted soils have been removed.

AECOM

Figure 2-3
Conceptual Site Model
LHAAP-04 Record of Decision
Longhorn Army Ammunition Plant
Karnack, Texas

60256135 October 2016

Path: L:\AGE\GIS\AUS GIS\GIS_Projects\Longhorn_AAP\01_Reports\LHAAP-04\Record of Decision\Figure 2-3 LHAAP-04 Conceptual Site Model.mxd

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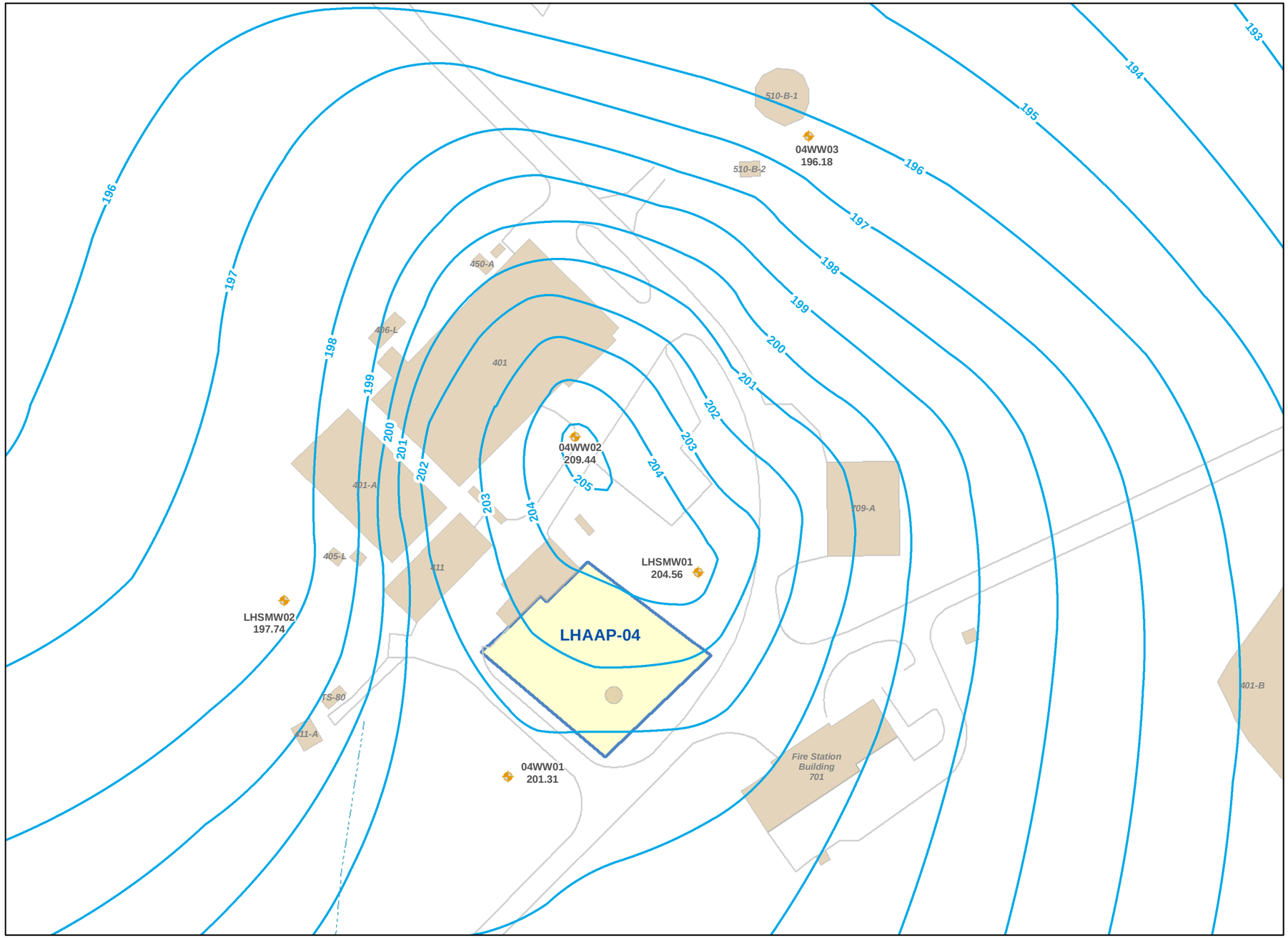

Legend

- Shallow Monitoring Well
- Groundwater Contour Interval 2007
- Stream
- Road
- Building
- LHAAP-04 Site Boundary

Source: Shaw 2012, LHAAP-04 Feasibility Study Report

Notes:
1. Groundwater contour elevations reported in feet.
2. Groundwater contour elevations are based on data collected from shallow monitoring wells at LHAAP-04 in December 2007.

AECOM

Figure 2-4
Groundwater Elevations 2007
LHAAP-04 Record of Decision
Longhorn Army Ammunition Plant
Karnack, Texas

60274185 October 2016

Path: L:\AGE\GIS\AUS GIS\GIS_Projects\Longhorn_AAP\01_Reports\LHAAP-04\Record of Decision\Figure 2-4 LHAAP-04 GW Elevations 2007.mxd

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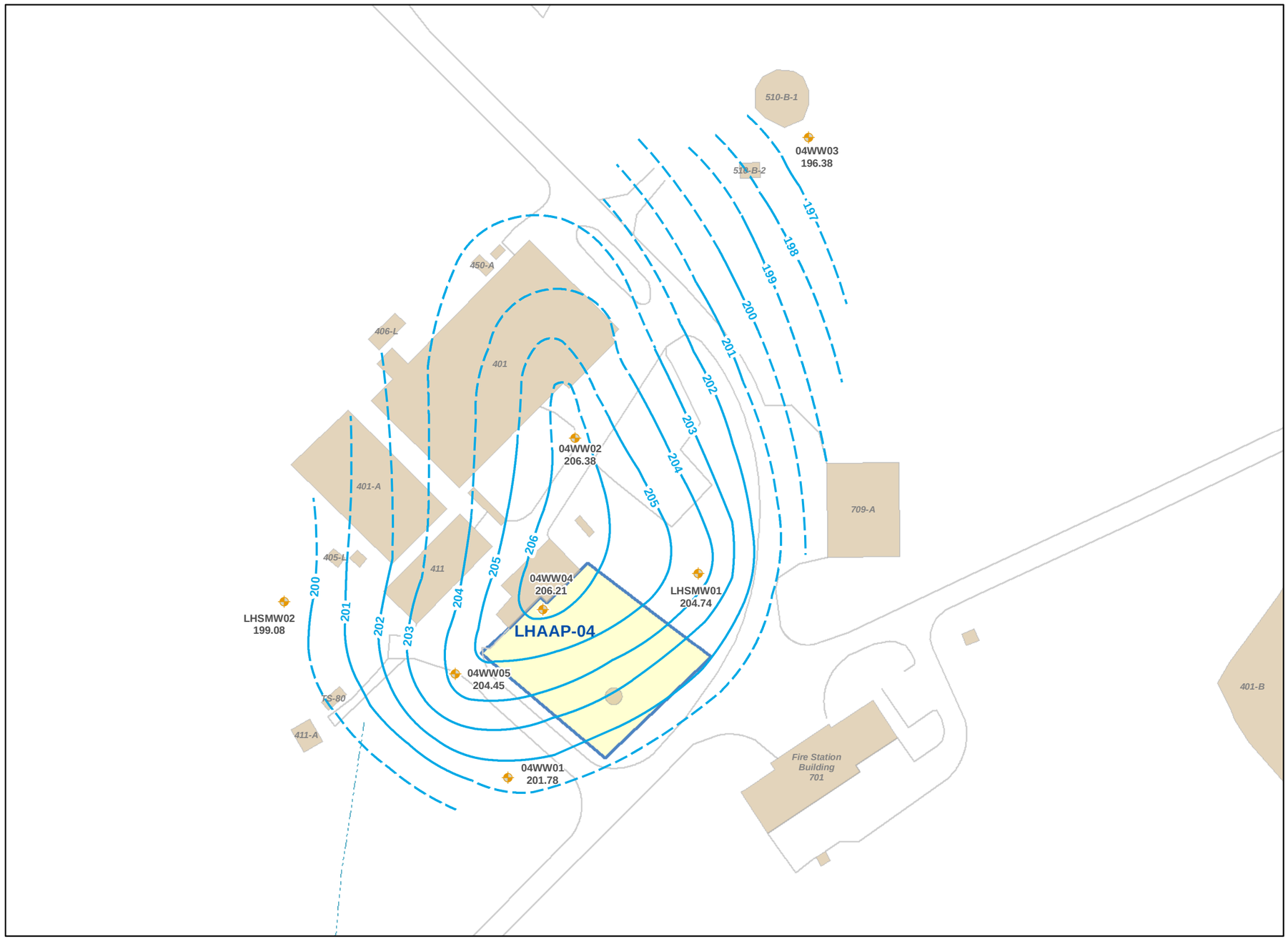

Legend

- Shallow Monitoring Well
- Groundwater Contour Interval 2010 (Dashed Where Inferred)
- Stream
- Road
- Building
- LHAAP-04 Site Boundary

Source: Shaw 2012, LHAAP-04 Feasibility Study Report

Notes:
1. Groundwater contour elevations reported in feet.
2. Groundwater contour elevations are based on data collected from shallow monitoring wells at LHAAP-04 in October 2010.

AECOM

Figure 2-5
Groundwater Elevations 2010
LHAAP-04 Record of Decision
Longhorn Army Ammunition Plant
Karnack, Texas

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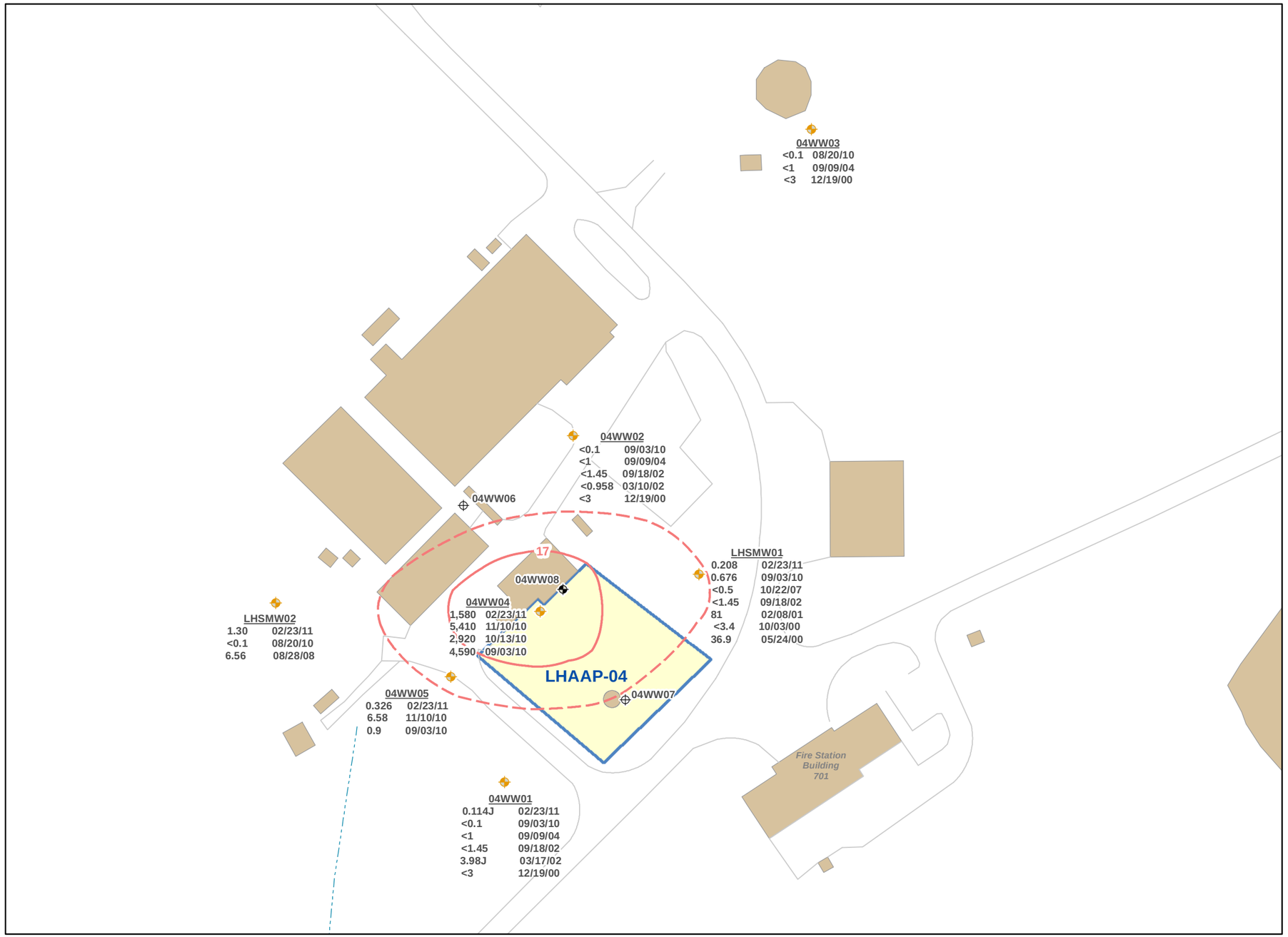
Path: L:\AGE\GIS\AUS GIS\GIS_Projects\Longhorn_AAP\01_Reports\LHAAP-04\Record of Decision\Figure 2-5 LHAAP-04 GW Elevations 2010.mxd



Legend

- Proposed Shallow Monitoring Well
- Proposed Intermediate Monitoring Well
- Shallow Monitoring Well
- Perchlorate Plume Extent (PCL - 17 µg/L)
- Possible Past Extent of Perchlorate
- Stream
- Road
- Building
- LHAAP-04 Site Boundary

Source: Modified from Shaw 2012, LHAAP-04 Feasibility Study Report

Notes:
1. Perchlorate concentrations reported in micrograms per liter (µg/L).
2. Plume boundaries based on most recent results available at each well (2011).
3. The wells 04WW06, 04WW07, and 04WW08 are proposed and will be installed as part of the Remedial Design activities. Locations shown are approximate and will be adjusted in the field based on site conditions and any additional data that may be available at that time.
4. PCL - Texas Risk Reduction Program Protective Concentration Level for Residential Groundwater.

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Figure 2-6
Perchlorate Concentrations in Groundwater
LHAAP-04 Record of Decision
Longhorn Army Ammunition Plant
Karnack, Texas

60274185 October 2016

Path: L:\AGE\GIS\AUS GIS\GIS_Projects\Longhorn_AAP\01_Reports\LHAAP-04\Record of Decision\Figure 2-6 LHAAP-04 Perchlorate Concentrations in GW.mxd

Legend

- Shallow Monitoring Well
- Proposed Shallow Monitoring Well
- Proposed Intermediate Monitoring Well
- Groundwater Contour Interval 2010 (Dashed Where Inferred)
- Perchlorate Plume Extent (PCL - 17 µg/L)
- Stream
- Road
- Building
- LHAAP-04 Site Boundary
- Preliminary Land Use Control Boundary

Source:
May 2012 Final Feasibility Study Report for LHAAP-04, Former Pilot Wastewater Treatment Plant, Karnak, Harrison County, Texas (Shaw, 2012).

Notes:
1. Groundwater contour elevations reported in feet.
2. Groundwater contour elevations are based on data collected from shallow monitoring wells at LHAAP-04 in October 2010.

0 50 100
Feet

AECOM

Figure 2-7
Preliminary Land Use Control Boundary
LHAAP-04
Longhorn Army Ammunition Plant
Karnack, Texas

60274185 October 2016

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Table 2-1: Perchlorate Results from Goose Prairie Creek Sampling

Table 2-2: Chemicals Contributing to Carcinogenic Risk in Groundwater

Table 2-3: Chemicals Contributing to Hazard Index in Groundwater

Table 2-4: Summary of Carcinogenic Risks and Non-Carcinogenic Hazard at LHAAP-04

Table 2-5: Comparative Analysis of Alternatives

Table 2-6: Present Worth Analysis

Table 2-7: Potential Action-Specific ARARs

Table 2-1: Perchlorate Results from Goose Prairie Creek Sampling

Creek Sample ID	TRRP PCL	Sep 2010	Dec 2010	Mar 2011	Jun 2011	Sep 2011	Dec 2011
GPW-1	17	dry	0.1 U	8.7	dry	dry	1.76
GPW-3	17	dry	0.199 J	0.673	dry	dry	1.31
HBW-1	17	dry	0.1 U	0.2 U	dry	dry	0.1 U
HBW-7	17	dry	0.1 U	0.2 U	dry	dry	0.171 J
HBW-10	17	dry	0.1 U	0.2 U	dry	dry	0.1 U

Notes and Abbreviations:

All units in micrograms/liter (µg/L)

dry	no surface water was available to sample
J	estimated value present below normal reporting limit
U	concentration below laboratory reporting limit
GPW	Goose Prairie Creek Surface Water
HBW	Harrison Bayou Surface Water
TRRP PCL	Texas Risk Reduction Program Protective Concentration Level (Tier 1 Groundwater Residential)

Creek Conditions for last five sampling events:

September 2010 conditions: All creek sampling locations were dry in September.

December 2010 conditions: GPW locations some water but no visible flow; HBW locations plenty of water volume but very little flow. March 2011 conditions: GPW locations slow flow; HBW locations fairly good flow.

June 2011 conditions: All creek sampling locations were dry in June.

September 2011 conditions: All creek sampling locations were dry in September.

December 2011 conditions: Small amount of flow at HBW locations and no visible flow at GPW locations.

Source: Shaw 2012, Final Feasibility Study for Groundwater, LHAAP-04, Former Pilot Wastewater Treatment Plant, Longhorn Army Ammunition Plant, Karnack, Texas.

Table 2-2: Chemicals Contributing to Carcinogenic Risk in Groundwater

Chemical	Cancer Risk Groundwater[a]	Exposure Point Concentration[b] (µg/L)	Well	Date	MCL (µg/L)	Retained as Chemical of Concern?
2,3,7,8-TCDD	4.5×10^{-5}	9.3×10^{-6}	04WW02	12-19-00	3×10^{-5}	No, 1

Notes and Abbreviations:

1 Excluded since Exposure Point Concentration is below the Safe Drinking Water Act MCL.

[a] All chemicals with cancer risks exceeding 1.0×10^{-6} are listed from Baseline Risk Assessment Table 3-73 (Jacobs, 2003).

[b] From Baseline Risk Assessment Table 3-49 (Jacobs, 2003).

MCL maximum contaminant level

µg/L micrograms per liter

Source: Shaw 2012, Final Feasibility Study for Groundwater, LHAAP-04, Former Pilot Wastewater Treatment Plant, Longhorn Army Ammunition Plant, Karnack, Texas.

Table 2-3: Chemicals Contributing to Hazard Index in Groundwater

Chemical	Hazard Quotient [a]	Exposure Point Concentration [b] (µg/L)	Well	Concentration (µg/L)	Well	Sampling Date	TRRP PCL (µg/L)	Retained as Chemical of Concern?
Perchlorate	—	ND	04WW04	5410	04WW04	11-10-10	17	Yes, 1
Manganese	0.10	493	04WW04	—	04WW04	12-19-00	1,100	No, 2

Notes and Abbreviations:

All chemicals with hazard indexes exceeding 0.1 or concentrations exceeding the TRRP PCL are listed.

1 Identified as chemical of concern (COC) since recent concentration is above value indicated in TRRP PCL column.

2 Excluded as COC since Exposure Point Concentration is less than LHAAP perimeter well background of 7,820 µg/L and HQ is less than or equal to 0.1.

[a] From Baseline Risk Assessment Table C-8 (Jacobs, 2003).

[b] From Baseline Risk Assessment Table 3-49 (Jacobs, 2003).ND not detected

TRRP PCL Texas Risk Reduction Program Protective Concentration Level (Tier 1 Groundwater Residential)

µg/L micrograms per liter

Source: Shaw 2012, Final Feasibility Study for Groundwater, LHAAP-04, Former Pilot Wastewater Treatment Plant, Longhorn Army Ammunition Plant, Karnack, Texas.

Table 2-4: Summary of Carcinogenic Risks[(1)] and Non-Carcinogenic Hazard[(1)] at LHAAP-04

Scenario	Total Hazard Index	Total Cancer Risk
Risks from Soil		
Current Trespasser (0 to 0.5 feet bgs)	0.028	9.69E-08
Future Maintenance Worker (0 to 0.5 feet bgs)	0.16	1.15E-06
Future Maintenance Worker (0 to 2 feet bgs)	0.28	1.15E-06
Risks from Groundwater		
Future Maintenance Worker	0.18	4.54E-05
Combined Risks- Soil and Groundwater		
Future Maintenance Worker (0 to 0.5 feet bgs)	0.35	4.65E-05
Future Maintenance Worker (0 to 2 feet bgs)	0.46	4.65E-05

Note: [(1)] The carcinogenic risks and non-carcinogenic hazards are based on the Baseline Human Health Risk Assessment (Jacobs, 2003). These risks have not been adjusted to account for current higher perchlorate concentrations in groundwater or lower perchlorate and mercury contaminated soils that have been removed.

Table 2-5: Comparative Analysis of Alternatives

Comparative Analysis of Alternatives Criteria	Alternative 1 No Action	Alternative 2 Monitored Natural Attenuation, Land Use Controls	Alternative 3 In-Situ Bioremediation, Land Use Controls	Alternative 4 Extraction and Treatment, Land Use Controls	Alternative 5 ICTs, Extraction and Treatment, Land Use Controls
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. MNA activities would demonstrate that degradation of plume is occurring. Land use controls in place until cleanup level is met.	Achieves RAOs. Protection of human health and environment provided by remediation of perchlorate in groundwater in a target area. Land use controls in place until cleanup level is met.	Achieves RAOs. Protection of human health and environment provided by extraction and treatment of perchlorate in groundwater in a target area. Land use controls in place until cleanup level is met.	Achieves RAOs. Protection of human health and environment provided by extraction and treatment of perchlorate in groundwater in a target area. Land use controls in place until cleanup level is met.
Compliance with ARARs	Does not comply with chemical-specific ARARs guidance for perchlorate.	Complies with ARARs.	Complies with ARARs.	Complies with ARARs.	Complies with ARARs.
Long-term effectiveness and permanence	Not effective.	Contaminants may be degrading naturally. To be confirmed by MNA sampling following remedy selection. Land use controls would be effective and reliable so long as they are maintained.	Should be effective and permanent; however, uncertainty exists concerning the degree to which the alternative will be effective in enhancing the natural biological processing occurring at the site. Pilot testing may be required prior to implementation. May require a second treatment. Land use controls would be effective and reliable so long as they are maintained.	Should be effective and permanent; use of resin filters for perchlorate treatment has been successful at other military sites, which indicates treatment is practical and effective for perchlorate at LHAAP. Land use controls would be effective and reliable so long as they are maintained.	Should be effective and permanent; use of resin filters for perchlorate treatment has been successful at other military sites, which indicates treatment is practical and effective for perchlorate at LHAAP. Land use controls would be effective and reliable so long as they are maintained.

Comparative Analysis of Alternatives Criteria	Alternative 1 No Action	Alternative 2 Monitored Natural Attenuation, Land Use Controls	Alternative 3 In-Situ Bioremediation, Land Use Controls	Alternative 4 Extraction and Treatment, Land Use Controls	Alternative 5 ICTs, Extraction and Treatment, Land Use Controls
Reduction of TMV through treatment	No reduction.	No active remediation would be performed for groundwater. However, a reduction in TMV would be provided through natural biodegradation processes that are occurring in the aquifer.	Provides permanent reduction in TMV in the target area provided conditions are favorable.	Provides permanent reduction in TMV in the target area through removal and ex-situ treatment. Treated groundwater is expected to be reinjected to LHAAP-04.	Provides permanent reduction in TMV in the target area through removal and ex-situ treatment. Treated groundwater is expected to be reinjected to LHAAP-04.
Short-term effectiveness	No short-term impacts.	Minimal impacts to the community, workers, or the environment from short- term activities. Provides almost immediate protection.	Minimal impacts to the community, workers, or the environment from short-term activities. Provides almost immediate protection.	Minimal impacts to the community, workers, or the environment from short-term activities. Provides almost immediate protection.	Minimal impacts to the community, workers, or the environment from short-term activities. Provides almost immediate protection.
Implementability	Inherently implementable.	Readily implemented.	Readily implemented. Specialized knowledge required for implementation.	Readily implemented. Specialized knowledge required for implementation of treatment system.	Readily implemented. Specialized knowledge required for installation of ICTs and implementation of treatment system.
Duration	None	12 years to cleanup level 30 years LUC	6 years to cleanup level 30 years LUC	15 months to cleanup level 30 years LUC	6 months to cleanup level 30 years LUC
• Capital	$0	$126,000	$243,000	$325,000	$405,000
• O&M	$0	$463,000	$422,000	$436,000	$411,000
• Present worth	$0	$589,000	$665,000	$761,000	$816,000

Notes and Acronyms:

Costs rounded to nearest thousand dollars

Costs have been escalated to bring FY13 dollars to FY16 dollars using escalation rate of 1.0421

ARARs	applicable or relevant and appropriate requirements	LUC	Land Use Control
ICT	interceptor collection trench	MNA	monitored natural attenuation
LHAAP	Longhorn Army Ammunition Plant	RAO	remedial action objective
		TMV	toxicity, mobility, or volume

Source: Shaw 2012, Final Feasibility Study for Groundwater, LHAAP-04, Former Pilot Wastewater Treatment Plant, Longhorn Army Ammunition Plant, Karnack, Texas.

Table 2-6: Present Worth Analysis
(Alternative 3 – In-Situ Bioremediation, LUC)

PROJECT LOCATION: KARNACK, TEXAS **DATE: October 2016**

Year	FY	Capital Costs		O & M Costs				Present Value (NPV)		
		Bioremediation	Plans and Wells	Monitoring	LTM	Five-Year Review	Total	Discount Rate	Capital	O & M
1	2012	142,593	88,956	60,463			60,463	2.7%		
2	2013			60,463			60,463	**NPV**	**243,000**	**422,000**
3	2014	12,075			29,080		29,080			
4	2015				29,080		29,080			
5	2016				29,080	44,315	73,395	**Total Capital and O&M**		**$665,000**
6	2017				17,947		17,947			
7	2018				17,947		17,947			
8	2019				17,947		17,947			
9	2020						0			
10	2021					44,315	44,315			
11	2022						0			
12	2023						0			
13	2024						0			
14	2025						0			
15	2026					44,315	44,315			
16	2027						0			
17	2028						0			
18	2029						0			
19	2030						0			
20	2031					44,315	44,315			
21	2032						0			
22	2033						0			
23	2034						0			
24	2035						0			
25	2036					44,315	44,315			
26	2037						0			
27	2038						0			
28	2039						0			
29	2040						0			
30	2041					44,315	44,315			
		154,668	88,956	120,926	141,081	265,890	527,897			

Note:

Discount rate of 2.7% is based on the Office of Management and Budget Circular No. A-94, December 2009.

Costs have been escalated to bring FY13 dollars to FY16 dollars using escalation rate of 1.0421

Table 2-6: Present Worth Analysis
(Alternative 3 – In-Situ Bioremediation, LUC)

PROJECT LOCATION: KARNACK, TEXAS **DATE: May 2013**

Item NO	DESCRIPTION	QTY	UNIT	LABOR UNIT MH	LABOR TOTAL MH	LABOR CRAFT	LABOR $/MH	LABOR $ VALUE	MATERIAL $/UNIT	MATERIAL $ VALUE	EQUIPMENT $/UNIT	EQUIPMENT $ VALUE	SUBCONTRACT $/UNIT	SUBCONTRACT $ VALUE	TOTAL ($)
	Perform Direct Injection Bioremediation in Year 1 - near 04WW04														
	Treatability Study														
1	Work plans, safety plans	1	ea	240	240	eng	81.60	19,584	200	200					19,784
2	UIC Permit and Design	1	ea	160	160	geol	71.20	11,392	200	200					11,592
3	Additional Characterization for RD	1	ea	40	40	geol	71.20	2,848	200	200			5000	5,000	8,048
	Additional Characterization Samples	8	ea	10	80	tech	34.30	2,744					275	2,200	4,944
	Per Diem and Travel Costs	4	days						159	636	80.00	320			956
	Mob / Demob	1	ea	40	40	eng	81.60	3,264	1,200	1,200	1,000	1,000			5,464
4	Treatability/Pilot Study	1	ea	120	120	eng	81.60	9,792	200	200			1650	1,650	11,642
5	Treatability/Pilot Sample Collection	1	hr	50	50	geol	71.20	3,560							3,560
6	Driller for Treatability/Pilot Sampling	3	borings										3150	9,450	9,450
7	Per Diem and Travel Costs	4	days						159	636	80.00	320			956
8	Mob / Demob	1	ea	40	40	eng	81.60	3,264	1,200	1,200	1,000	1,000			5,464
	Site Clearing for Injection Access														
9	Superintendent	2	dy	10	20	super	72.30	1,446							1,446
10	Geologist	2	dy	10	20	geol	71.20	1,424							1,424
11	Technician	2	dy	10	20	tech	34.30	686							686
12	Equipment Rental	1	wk								1000	1,000			1,000
	Injection Activities														
13	Superintendent	3	dy	10	30	super	72.30	2,169							2,169
14	Geologist	3	dy	10	30	geol	71.20	2,136							2,136
15	Technician	3	dy	10	30	tech	34.30	1,029							1,029
16	Bioaugmentation Materials, Lactate and	4	pts	60% Sodium Lactate					36.00	144					144
	Bacterial Culture specific for perchlorate	1	ea	Shipping Lactate, Trailer, Mob/Demob					1,000	1,000	5,000	5,000	3,000	3,000	9,000
		4	pts	Bacterial Culture (perchlorate specific)					150	600	cost	150	shipping		750
17	Injection System - Equipment, materials	3	days						400	1,200	400	1,200			2,400
	and flush water	4	pts	Injection Chase Water					4	16					16
18	DPT Injections	4	ea										500	2,000	2,000
19	Airfare	2	ea										500	1,000	1,000
20	Per Diem and PPE, Crew Truck, Lodging	15	m-day						175	2,625	75	1,125	77	1,155	4,905
	Subtotal							**65,338**		**10,057**		**11,115**		**25,455**	**111,965**
	Taxes @ 6.5 %									654					654
	Subtotal														**112,619**
	Indirects @ 21.5%														24,213
	Year 1 Total Capital Costs														**$ 136,832**

Source: Shaw 2012, Feasibility Study for Groundwater, LHAAP-04

Table 2-6: Present Worth Analysis
(Alternative 3 – Groundwater Monitoring, LUC)

PROJECT LOCATION: KARNACK, TEXAS **DATE: May 2013**

Item NO	DESCRIPTION	QTY	UNIT	LABOR UNIT MH	LABOR TOTAL MH	LABOR CRAFT	LABOR $/MH	LABOR $ VALUE	MATERIAL $/UNIT	MATERIAL $ VALUE	EQUIPMENT $/UNIT	EQUIPMENT $ VALUE	SUBCONTRACT $/UNIT	SUBCONTRACT $ VALUE	TOTAL ($)
	Year 1									0					
	Capital costs														
1	Allowance for Legal Fees, Administration Controls, and Documentation	1	lot										15,000	15,000	15,000
2	Install 2 new Shallow Monitoring wells	2	ea	8	16	tech	34.30	549	400	800			5,000	10,000	11,349
3	Install 1 new Intermediate Monitoring well	1	ea	16	16	eng	81.60	1,306	700	700			7,000	7,000	9,006
4	Establish initial database, licenses, work plans	1	ea	300	300	eng	81.60	24,480	5,000	5,000			5000	5,000	34,480
	Capital Costs Subtotal							**26,334**		**6,500**		**0**		**37,000**	**69,834**
	Taxes @ 6.5 %									423					423
	Subtotal														**70,257**
	Indirects @ 21.5%														15,105
	Year 1 total Capital costs														**$ 85,362**
	Year 1 - Quarterly Monitoring (O&M) - 8 wells to be monitored + 1 QC sample set														
1	Collect and prepare samples quarterly (GW)	36	ea	16	576	tech	34.30	19,760	110	3,960	36	1,296			25,016
2	Sample analysis (perchlorate)	36	ea										475	17,100	17,100
3	Annual report	1	ea	64	64	eng	81.60	5,220	150	150					5,370
	Subtotal							**24,980**		**4,110**		**1,296**		**17,100**	**47,486**
	Taxes @ 6.5 %									267					267
	Subtotal														**47,753**
	Indirects @ 21.5%														10,267
	Year 1 Annual Cost (O&M), Year 2 the same														**$ 58,020**
	Year 3														
	Capital costs for ISB Evaluation														
1	Prepare ISB Evaluation	1	ea	60	60	eng	81.60	4,900							4,900
2	Produce ISB Evaluation Report	1	ea	60	60	geol	71.20	4,270	250	250	100	100			4,620
	Capital Costs Subtotal							**9,170**		**250**		**100**		**0**	**9,520**
	Taxes @ 6.5 %									16					16
	Subtotal														**9,536**
	Indirects @ 21.5%														2,050
	Year 3 total Capital costs														**$ 11,587**

Table 2-6: Present Worth Analysis
(Alternative 3 – Groundwater Monitoring, LUC)

PROJECT LOCATION: KARNACK, TEXAS **DATE: May 2013**

Item NO	DESCRIPTION	QTY	UNIT	LABOR UNIT MH	LABOR TOTAL MH	LABOR CRAFT	LABOR $/MH	LABOR $ VALUE	MATERIAL $/UNIT	MATERIAL $ VALUE	EQUIPMENT $/UNIT	EQUIPMENT $ VALUE	SUBCONTRACT $/UNIT	SUBCONTRACT $ VALUE	TOTAL ($)
	Year 3 LTM - Semiannual Monitoring - 8 wells to be monitored + 1 QC set														
1	Collect and prepare samples semiannually	18	ea	16	288	tech	34.30	9,878	110	1,980	36	648			12,506
2	Sample analysis (perchlorate)	18	ea										275	4,950	4,950
3	Annual report	1	ea	64	64	eng	81.60	5,222	150	150					5,372
	Subtotal							**15,101**		**2,130**		**648**		**4,950**	**22,829**
	Taxes @ 6.5 %									138					138
	Subtotal														**22,967**
	Indirects @ 21.5%														4,938
	Year 3 Annual Cost (O&M), Years 4 and 5 the same														**$ 27,905**
	Five-Year Review Report/Inspection														
1	Five-Year Inspection and Review	1	ea										35,000	35,000	35,000
	Subtotal							**0**		**0**		**0**		**35,000**	**35,000**
	Taxes @ 6.5 %									0					0
	Subtotal														**35,000**
	Indirects @ 21.5%														7,525
	Year 5 Total Cost (O&M)														**$ 42,525**
	Total Cost for Years 10, 15, 20, 25, 30 (Same as Year 5)														
	Year 6 LTM - Annual Monitoring														
1	Collect and prepare samples Annually	9	ea	16	144	tech	34.30	4,939	110	990	36	324			6,253
2	Sample analysis (perchlorate)	9	ea										275	2,475	2,475
3	Annual report	1	ea	64	64	eng	81.60	5,222	150	150					5,372
	Subtotal							**10,162**		**1,140**		**324**		**2,475**	**14,101**
	Taxes @ 6.5 %									74					74
	Subtotal														**14,175**
	Indirects @ 21.5%														3,048
	Year 6 Annual Cost (O&M)														**$ 17,222**
	Total Cost for Years 7 and 8 (Same as Year 6)														
	Expected Duration is 6 years, no further sampling after Year 8.														

Source: Shaw 2012, Feasibility Study for Groundwater, LHAAP-04

Table 2-7: Potential Action-Specific ARARs

Citation	Activity or Prerequisite/Status	Requirement
Waste Generation, Management, and Storage		
Characterization of Solid Waste 40 CFR 262.11 30 TAC 335.62 30 TAC 335.504 30 TAC 335.503(a)(4)	Generation of solid waste, as defined in 30 TAC 335.1**—applicable**. (The material removed during excavation was tested for reactivity, corrosivity, and ignitability and did not display those RCRA hazard characteristics).	Must determine whether the generated solid waste is RCRA hazardous waste by using prescribed testing methods or applying generator knowledge based on information regarding material or process used. If the waste is determined to be hazardous, it must be managed in accordance with 40 CFR 262–268. After making the hazardous waste determination as required, if the waste is determined to be nonhazardous, the generator shall then classify the waste as Class 1, Class 2, or Class 3 (as defined in Section 335.505 through Section 335.507) using one or more of the methods listed in Section 335.503(a)(4) and Section 335.508 and manage the waste in accordance with the requirements of Chapter 335 of the TAC for industrial solid waste.
Characterization of Hazardous Waste 40 CFR 264.13(a)(1); 40 CFR 268.7 30 TAC 335.504(3) 30 TAC 335.509 30 TAC 335.511	Generation of a RCRA hazardous waste for treatment, storage, or disposal**—applicable** if hazardous waste is generated (e.g., PPE).	Must obtain a detailed chemical and physical analysis of a representative sample of the waste(s) that at a minimum contains all the information that must be known to treat, store, or dispose of the waste in accordance with 40 CFR 264 and 268. Must also determine whether the waste is restricted from land disposal under 40 CFR 268 et seq. by testing in accordance with prescribed methods or use of generator knowledge of waste.
Requirements for Temporary Storage of Hazardous Waste in Accumulation Areas 40 CFR 262.34(a) and (c)(1) 30 TAC 335.69(a) and (d)	On-site accumulation of 55 gallons or less of RCRA hazardous waste for 90 days or less at or near the point of generation**—applicable** if hazardous waste is generated (e.g., PPE) and stored in an accumulation area.	A generator may accumulate hazardous waste at the facility provided that • Waste is placed in containers that comply with 40 CFR 264.171 to 264.173 (Subpart I); and • Container is marked with the words “hazardous waste”; or • Container may be marked with other words that identify the contents.
Wells		
Well Construction Standards—Monitoring or Injection Wells 16 TAC 76.1000	Construction of water wells—**applicable** to construction of new monitoring or injection wells, if needed.	Wells shall be completed in accordance with the technical requirements of Section 76.1000, as appropriate.
Class V Injection Wells 30 TAC 331, Subchapter A, C and H	Installation, operation, and closure of injection wells for in situ bioremediation fall in the category of Class V Injection Wells—**relevant and appropriate**	Injection wells shall be constructed to the required specifications for isolation casing, surface completion, prevention of commingling, and confinement of undesirable groundwater to its zone of origin. Closure shall be accomplished by removing all of the removable casing and the entire well shall be pressure filled via a tremie pipe with cement from bottom to the land surface, or closure shall be performed by the alternative method for Class V Wells completed in zones of undesirable groundwater. Groundwater concentrations at time of well closure will determine the appropriate method of abandonment.

Table 2-7: Potential Action-Specific ARARs

Citation	Activity or Prerequisite/Status	Requirement
Well Construction Standards—Extraction Wells 16 TAC 76.1000(a) and (c) through (h) 16 TAC 76.1002(a) through (c) 16 TAC 76.1008(a) through (c)	Construction of water wells—applicable to construction of extraction (recovery) wells.	Wells shall be completed in accordance with the technical requirements of Section 76.1000, as appropriate. Water wells completed to produce undesirable water shall be cased to prevent the mixing of water or constituent zones. The annular space between the casing and the wall of the borehole shall be pressure grouted with cement or bentonite grout to the land surface. Bentonite grout may not be used if a water zone contains chloride water above 1500 ppm or if hydrocarbons are present. Wells producing undesirable water or constituents shall be completed in such a manner that will not allow undesirable fluids to flow onto the land surface. During installation of a water well pump, installer shall make a reasonable effort to maintain integrity of groundwater and to prevent contamination by elevating the pump column and fittings, or by other means suitable under the circumstances. Pump shall be constructed so that no unprotected openings into the interior of the pump or well casing exist.
Treatment/Disposal		
Disposal of Wastewater (e.g., contaminated groundwater, dewatering fluids, decontamination liquids) 40 CFR 268.1(c)(4)(i) 30 TAC 335.431(c)	RCRA-restricted characteristically hazardous waste intended for disposal—**applicable** if extracted groundwater is determined to be RCRA characteristically hazardous.	Disposal is not prohibited if such wastes are managed in a treatment system subject to regulation under Section 402 of the CWA that subsequently discharges to waters of the United States.
Closure		
Standards for Plugging Wells that Penetrate Undesirable Water or Constituent Zones 16 TAC 76.1004(a) through (c)	Plugging and abandonment of wells—**applicable** to plugging and closure of monitoring and/or extraction wells.	If a well is abandoned, all removable casing shall be removed and the entire well pressure filled via a tremie pipe with cement from bottom up to the land surface. In lieu of this procedure, the well shall be pressure-filled via a tremie tube with bentonite grout of a minimum 9.1 lb/gal weight followed by a cement plug extending from land surface to a depth of not less than 2 feet. Undesirable water or constituents or the freshwater zone(s) shall be isolated with cement plugs.

Abbreviations:

ARAR	applicable or relevant and appropriate requirement	PPE	personal protective equipment
CFR	Code of Federal Regulations	ppm	part per million
CWA	Clean Water Act of 1972	RCRA	Resource Conservation and Recovery Act of 1976
lb/gal	pound per gallon	TAC	Texas Administrative Code

Source: Shaw 2012, Final Feasibility Study for Groundwater, LHAAP-04, Former Pilot Wastewater Treatment Plant, Longhorn Army Ammunition Plant, Karnack, Texas.

3 RESPONSIVENESS SUMMARY

The Responsiveness Summary serves three purposes. First, it provides the U. S. Army, USEPA, and the TCEQ with information about community concerns with the Preferred Alternative at LHAAP-04 as presented in the Proposed Plan. Second, it shows how the public's comments were considered in the decision-making process for selection of the remedy. Third, it provides a formal mechanism for the U.S. Army to respond to public comments

The U.S. Army, the USEPA, and the TCEQ provide information regarding LHAAP-04 through public meetings, the Administrative Record for the facility, and announcements published in the Marshall News Messenger newspapers. **Section 2.3** discusses community participation on LHAAP-04, 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 January 9, 2013
- Presentation slides from the January 9, 2013 public meeting
- Written questions and comments from the public during the public comment period, and the U.S. Army response to those comments.

3.1 Stakeholder Issues and Lead Agency Responses

This section responds to significant issues raised by stakeholders including the public and community groups that were received in written or verbal form.

3.1.1 Question/Recommendation No. 1

Extent of groundwater contamination: The only monitor well at the site, well 04WW04, contains high concentrations of perchlorate. This well is only 18 feet deep. A single well is insufficient. Both the lateral and vertical extent of groundwater contamination are unknown.

Recommendation: The three additional monitor wells the U.S. Army plans to install will better define the extent of contamination.

Response – The LHAAP-04 site is currently monitored by a total of seven wells, although only one well is technically within the very small area of the site (approximately 150 feet by 150 feet). The site is well-monitored as the remainder of the wells are within 250 feet of the impacted well, Three additional wells planned for installation as part of the RD will help further refine the perchlorate plume footprint and depth of contamination..

3.1.2 Question/Recommendation No. 2

Groundwater Contaminants: Samples from well 04WW04 do not appear to have been analyzed for contaminants other than perchlorate. Other groundwater contaminants may be present.

Recommendation: The U.S. Army should sample all monitor wells and the fire station well for all contaminants that might reasonably be expected to occur at the site. In addition to perchlorate, this would include volatile organic compounds (VOCs) (e.g., methylene chloride, trichloroethylene, explosives (e.g., TNT, DNT), and metals (e.g., arsenic, thallium). If

contaminants are found that are not amenable to restoration under the Proposed Plan (e.g., metals), the U.S. Army should modify the plan to ensure that all the contaminants will be cleaned up.

Response – Groundwater samples from three shallow monitoring wells (04WW01, 04WW02, and 04WW03) were analyzed for VOCs, SVOCs, metals, pesticides, PCBs, explosives, perchlorate, and dioxins/furans during the RI (Jacobs, 2003). No VOCs, SVOCs, perchlorate, pesticides, explosives, and PCBs were detected in the samples. Inorganic constituent concentrations were detected at or lower than the protective concentration level (PCL) or background comparison levels. Eight dioxin/furan compounds (with no established MCL or PCL) were detected in groundwater samples (Jacobs, 2003). Subsequently, perchlorate was identified as the only groundwater COC at the site with its source being historical perchlorate impacts in soil. Parameters, other than those discussed in the Proposed Plan and the ROD, will not be added to the monitoring program.

3.1.3 Question/Recommendation No. 3

Residual soil contamination: The U.S. Army has stated that contaminated soil probably remains beneath some portions of the site.

Recommendation: The U.S. Army should either perform an assessment to determine whether the contaminated soil is likely to be a source of groundwater contamination, or explain why such an assessment is not necessary.

Response – Residual contaminated soil, if any, is likely to be restricted to the two grid areas FL09 and FL11 (where confirmation samples could not be collected due to groundwater infiltration). Contaminated soil was removed from these two areas up to depths of 14 ft bgs. However, samples collected from the remaining north side wall just above the groundwater interface indicated perchlorate concentrations less than cleanup levels. Residual soil contamination, if any, is likely to be in the saturated zone and will be addressed as part of groundwater remedy.

3.1.4 Question/Recommendation No. 4

Concrete slab: The U.S. Army does not appear to have investigated the soil or groundwater beneath the concrete slab.

Recommendation: The U.S. Army should either perform an investigation, or explain why it is not necessary.

Response –The concrete slab was penetrated in six locations near the tank pad/foundations. See **Figure 2-2** of the Final Removal Action Work Plan (Shaw, 2009c). Based on perchlorate results from soil samples taken from under the slab, a section of the concrete was removed. See **Figure 2-1** and **Figure 2-8** of the Final Completion Report (Shaw, 2011). Soil was excavated to a depth of five feet below top of concrete in section FL08 and to a depth of twelve feet below top of concrete in section FL07. Perchlorate concentrations in final floor confirmation samples from FL07 and FL08 were less than the GWP-Ind MSC. Monitoring well 04WW04 is located adjacent to the concrete slab and soil removal at section FL07. Therefore, further investigation beneath the concrete slab is not warranted.

3.1.5 Question/Recommendation No. 5

Perchlorate cleanup standard: The U.S. Army's cleanup standard for perchlorate in groundwater is the same as the State of Texas' standard for industrial use (GWP-Ind): 72 µg/L. However, the USEPA has decided to regulate perchlorate under the SDWA and has established an Interim Drinking Water Health Advisory of 15 µg/L. The USEPA and the Army are currently discussing this issue.

Recommendation: Pending the outcome of discussions with the USEPA, the Army should assume that the perchlorate cleanup will be 15 µg/L, and plan accordingly.

Note – The purpose of excavating the perchlorate contaminated soils was to protect the underlying groundwater. A more stringent perchlorate groundwater standard may mean that the cleanup standards for soils will also have to be more stringent.

Response – The cleanup level for perchlorate is 17 µg/L, which is the TRRP Tier 1 Groundwater Residential PCL. The cleanup level for perchlorate was revised as a result of dispute resolution between the Army and the EPA.

3.1.6 Question/Recommendation No. 6

Surface water modeling: The U.S. Army has concluded that contaminated groundwater will not adversely affect surface water in Goose Prairie Creek. This conclusion is based on modeling performed in 2007. However, in its Proposed Plan for LHAAP-47, the U.S. Army stated that the uncertainties associated with the model were unacceptable, and it would not be used to assess the effect of groundwater contaminants on Goose Prairie Creek.

Recommendation: The U.S. Army should explain why it is using the model at LHAAP-04 but not at LHAAP-47.

Response – References to use of surface water modeling for LHAAP-04 will be removed from this and the future documents. Surface water directly overlies the LHAAP-47 plume and surface water monitoring is planned in conjunction with the final remedy for that site. At LHAAP-04 surface water is not located on the site directly on top of the groundwater plume. It is located ~700 feet from the site and based upon the localized, small nature of the plume, no impact to surface water is anticipated. Surface water data from 2010 and 2011 indicates perchlorate concentrations below TRRP Tier 1 Groundwater Residential PCL.

3.1.7 Question No. 7

Public Comment Period: What is the duration of the public comment period? When does the public comment period end?

Response – The duration of the public comment period is 30 days. The period began on January 1, 2013, and was extended through January 31, 2013.

3.1.8 Question No. 8

Cleanup Level for Perchlorate in Groundwater: The U.S. Army proposes that the cleanup level for perchlorate in groundwater be 72 µg/L whereas the USEPA states that the cleanup level for perchlorate shall be 15 µg/L. The U.S. Army may have to switch over and use 15 µg/L as the cleanup level.

Response – The cleanup level for perchlorate is 17 µg/L, which is the TRRP Tier 1 Groundwater Residential PCL. The cleanup level for perchlorate was revised as a result of dispute resolution between the Army and the EPA.

3.1.9 Question No. 9

Growth of Microorganisms during ISB: How do you encourage the growth of microorganisms? What is the relationship between microorganisms' growth and reduction in contaminants?

Response – The material (substrate) that is injected into the aquifer during ISB provides the food source for the growth of native microorganisms in the aquifer. These microorganisms increase in population (via reproduction) and during the corresponding metabolism, they break down the contaminants in groundwater.

Perchlorate, the COC in groundwater at LHAAP-04 site is more amenable to ISB than some other contaminants found at the LHAAP. Evaluation of data collected quarterly in the first two years of the ISB implementation will help determine need for additional injections (additional substrate into the aquifer), or bioaugmentation culture (to add/enhance the right type of microbes into the aquifer). Providing the substrate (food source) to the microbes helps sustain and grow their population with corresponding decrease in the COC levels until the cleanup level is attained.

3.1.10 Question No. 10

Submittal of Questions and Appropriate Response: If someone sends in written comments to the U.S. Army, who does it go to, who actually reads them, who responds, do they respond to all comments?

Response – Dr. Rose Zeiler, with the U.S. Army is the point of contact for correspondence associated with comments/responses. Dr. Zeiler's official contact information (mail, email, and telephone no.) is provided in the Proposed Plan. Formal comments are accepted verbally at the public meeting or via email or mail sent to the attention of Dr. Zeiler. All written comments on the Proposed Plan should be submitted to her. Verbal comments asked during the public meeting are captured by the court reporter. A concerted response from the team is provided to the comments and included in the Responsiveness Summary of the ROD. Similar questions are grouped together and a comprehensive answer is provided to that group of questions.

3.2 Technical and Legal Issues

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

4 REFERENCES

AECOM, 2012, *Final Proposed Plan for LHAAP-04, Former Pilot Wastewater Treatment Plant, Longhorn Army Ammunition Plant, Karnack, Texas*, December.

AGEISS, Inc., 2014, *Final Baseline Ecological Risk Assessment Addendum, Longhorn Army Ammunition Plant, Karnack, Texas*, July.

Anderson Columbia Environmental, 1997, *Closure Report, Pilot Wastewater Treatment Plant, Longhorn Army Ammunition Plant, Karnack, Texas, EPA Identification No. TX6213820583, Solid Waste Registration No. 30990*, September.

Jacobs Engineering Group, Inc. (Jacobs), 2002, *Remedial Investigation Report Addendum for the Group 4 Sites, Remedial Investigation Report, Sites 04, 08, 67, and Hydrocarbon Study, Longhorn Army Ammunition Plant, Karnack, Texas*, Oak Ridge, Tennessee, 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, Saunders Branch, Central Creek, and Caddo Lake), Longhorn Army Ammunition Plant, Karnack, Texas*, Final, Oak Ridge, Tennessee, June.

Plexus Scientific Corporation, 2005, *Environmental Site Assessment, Phase I and II Report, Final, Production Areas, Longhorn Army Ammunition Plant, Karnack, Texas*, February.

Shaw Environmental, Inc. (Shaw), 2006. *Final Addendum 1, Soil Sampling at LHAAP-04, Former Pilot Wastewater Treatment Plant, Installation-Wide Work Plan, Longhorn Army Ammunition Plant, Karnack, Texas,* June.

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

Shaw, 2007b. *Final Modeling Report, Derivation of Soil and Groundwater Concentrations Protective of Surface Water and Sediment, Revision 1, Longhorn Army Ammunition Plant, Karnack, Texas*, February.

Shaw, 2007c. *Final Installation-Wide Baseline Ecological Risk Assessment, Longhorn Army Ammunition Plant, Karnack, Texas*, Houston, Texas, November.

Shaw, 2009a. *Final Engineering Evaluation/Cost Analysis for LHAAP-04 Former Pilot Wastewater Treatment Plant, Group 4, LHAAP, Karnack, TX, March*.

Shaw, 2009b. *Final Action Memorandum for Former Pistol Range and LHAAP-04, Former Pilot Wastewater Treatment Plant, Karnack, Harrison County, Texas*, July.

Shaw, 2009c. *Final Removal Action Work Plan for the Former Pistol Range and LHAAP-04, Former Pilot Wastewater Treatment Plant, Group 4, Longhorn Army Ammunition Plant, Karnack, Texas*, August.

Shaw, 2011, *Final Completion Report Non-Time-Critical Removal Action, Longhorn Army Ammunition Plant, Karnack, Texas*, Houston, Texas, August.

Shaw, 2012, *Final Feasibility Study Report for LHAAP-04, Former Pilot Wastewater Treatment Plant, Karnack, Harrison County, Texas*, May. Solutions to Environmental Problems

(STEP), 2005, *Plant-Wide Perchlorate Investigation, Longhorn Army Ammunition Plant, Karnack, Texas*, Final, Oak Ridge, Tennessee, April.

Texas Commission on Environmental Quality (TCEQ), 2006. Updated Examples of Standard No. 2, Appendix II, Medium-Specific Concentrations, March 31.

Texas Natural Resource Conservation Commission, 1998. Conditional Approval Letter for Closure of Former Pilot Wastewater Treatment Plant.

Texas Water Commission, 1988. *RCRA Facility Assessment, Longhorn Army Ammunition Plant*, April.

U.S. Department of the Army (U.S. Army), 1993. *Phase I Investigations of 125 Waste Process Sumps and 20 Waste Rack Sumps for Remedial Investigation*, 1993.

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 U.S. Army on April 29, 2004.

APPENDIX A: Public Notice

PUBLIC NOTICE

The United States Army invites public comment on the Proposed Plan for environmental site LHAAP-04 (Former Pilot Wastewater Treatment Plant) Longhorn Army Ammunition Plant, Texas

The U.S. Army is the lead agency for environmental response actions at the former Longhorn Army Ammunition Plant (LHAAP). In partnership with Texas Commission on Environmental Quality and the U.S. Environmental Protection Agency Region 6, the U.S. Army has developed a Proposed Plan for site LHAAP-04. Although the Proposed Plan identifies the preferred remedy for the site, the U.S. Army welcomes the public's review and comments. **The public comment period begins January 1, 2013 and ends January 31, 2013. On Wednesday, January 9, 2013, from 6:00 to 7:00 p.m., the U.S. Army is inviting all interested parties to attend an open house forum to review the Proposed Plan and ask questions. The open house forum will be held at the Karnack Community Center, Highway 134 and Spur 449, Karnack, Texas.** Copies of the Proposed Plan and supporting documentation are available for public review at the Marshall Public Library, 300 S. Alamo Blvd, Marshall, Texas 75670. A summary of LHAAP-04, including a short discussion of the planned Remedial Action, is provided below.

LHAAP-04, known as Site 04 or the former pilot wastewater treatment plant, is approximately 0.5 acres and is located at the northwest corner of 6th and 60th Streets near the former Fire Station. Industrial wastewater treatment operations began at LHAAP-04 in 1984 continuing until the demolition of the former pilot wastewater treatment facility structures, tanks, piping, and the disposal of associated wastes completed in the summer of 1997. This is the second and final planned Remedial Action for the LHAAP-04 site to clean-up underlying groundwater. An action to complete soil remediation was completed historically. The groundwater contaminant of concern (COC) is perchlorate. The Preferred Alternative to clean-up the groundwater is to perform In-situ Bioremediation with land use controls (LUCs) to reduce the level of perchlorate to the Remedial Action Objectives, prevent migration of the plume, and reduce or eliminate exposure to contaminated groundwater. LUCs may be terminated when the groundwater COC concentrations are reduced to levels to that allow for unlimited use and unrestricted exposure.

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