Final

Remedial Design
LHAAP-35A(58), Shops Area, Group 4
Longhorn Army Ammunition Plant
Karnack, Texas

Prepared for U.S. Army Corps of Engineers – Tulsa District
1645 South 101st East Avenue
Tulsa, Oklahoma 74128

Prepared by Shaw Environmental, Inc.
1401 Enclave Parkway, Suite 250
Houston, Texas 77077

Contract No. W912QR-04-D-0027, Task Order No. DS02
Project No. 117591
Rev 0
September 2011

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Shaw® Shaw Environmental, Inc.

Date: ***September 30, 2011***

Project No.: ***117591***

TRANSMITTAL LETTER:

To: Mr. Aaron Williams

Address: U.S. Army Corps of Engineers – Tulsa
CESWT-PP-M
1645 South 101st East Ave
Tulsa, Oklahoma 74128

Re: ***Final Remedial Design LHAAP-35A(58)***

Contract No. W912QR-04-D-0027/DS02

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

Item No:	*No. of Copies*	*Date:*	*Document Title*
1	2	September 2011	**Final Remedial Design** **LHAAP-35A(58), Shops Area, Group 4** **Longhorn Army Ammunition Plant, Karnack, Texas**

Aaron– Enclosed are two copies of Shaw's final version of the above-named document.

Please call with any questions or comments.

Sincerely:

for Praveen Srivastav
Project Manager

Distribution:
M. Plitnik, USAEC (1)
R. Zeiler, BRAC (1)
S. Tzhone, EPA (2)
F. Duke (2)/ D. Vodak, TCEQ (1)
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1401 Enclave Parkway, Suite 250, Houston, Texas 77077 ***Phone: (281) 531-3100/Fax: (281) 531-3136***

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

September 30, 2011

DAIM-ODB-LO

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

Re: Final Remedial Design, LHAAP-35A(58), Shops Area, Group 4, Longhorn Army Ammunition Plant, Karnack, Texas, September 2011

Dear Mr. Tzhone,

The above-referenced document is being transmitted to you in hard copy as follow-up to the electronic version sent earlier today. The document has been prepared by Shaw Environmental, Inc. (Shaw) on behalf of the Army as part of Shaw's performance based contract for the facility.

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

Sincerely,

Rose M. Zeiler

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

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

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

September 30, 2011

DAIM-ODB-LO

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

Re: Final Remedial Design, LHAAP-35A(58), Shops Area, Group 4,
Longhorn Army Ammunition Plant, Karnack, Texas, September 2011

Dear Ms. Duke,

The above-referenced document is being transmitted to you in hard copy as follow-up to the electronic version sent earlier today. The document has been prepared by Shaw Environmental, Inc. (Shaw) on behalf of the Army as part of Shaw's performance based contract for the facility.

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

Sincerely,

Rose M. Zeiler

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

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

From: Tzhone.Stephen@epamail.epa.gov
Sent: Friday, September 30, 2011 5:06 PM
To: Zeiler, Rose Ms CIV USA OSA; Lambert, John R SWT; Williams, Aaron K SWT
Cc: Fay Duke; Srivastav, Praveen; Everett, Kay; Duffield, Robert; Watson, Susan; Sanchez.Carlos@epamail.epa.gov
Subject: Longhorn: EPA Approval of DF LHAAP-58 RD
Attachments: (Main Text) 09 2011 DRAFT FINAL LHAAP-35A(58) RD.pdf

Hi Rose,

The EPA has reviewed the Draft Final Remedial Design for LHAAP-58 and has no further comments. Please proceed with finalization.

Thanks,

Stephen L. Tzhone
Superfund Remedial Project Manager
USEPA Region 6 (6SF-RA)
214.665.8409
tzhone.stephen@epa.gov

From: "Srivastav, Praveen" <Praveen.Srivastav@shawgrp.com>
To: Stephen Tzhone/R6/USEPA/US@EPA, Fay Duke <Fay.Duke@tceq.texas.gov>
Cc: "Williams, Aaron K SWT" <Aaron.K.Williams@usace.army.mil>, "Lambert, John R SWT" <John.R.Lambert@SWT03.usace.army.mil>, "Zeiler, Rose Ms CIV USA OSA" <rose.zeiler@us.army.mil>, "Watson, Susan" <Susan.Watson@shawgrp.com>, "Chan, Vincent" <vincent.chan@shawgrp.com>
Date: 09/30/2011 04:57 PM
Subject: D-F RD, LHAAP-35A(58)

Steve/Fay:

The Draft Final Remedial Design for LHAAP-58 is attached. The file contains the main text and figures to keep the size of the file within manageable limits for e-mail. The files for the entire document are being uploaded to the Longhorn Stakeholder portal. We are also shipping out hard copies today.

Thank you,

Praveen Srivastav, PhD, PG, PMP
Project Manager
Federal Division/Project Management
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From: Fay Duke [Fay.Duke@tceq.texas.gov]
Sent: Friday, September 30, 2011 5:02 PM
To: Tzhone.Stephen@epa.gov; Srivastav, Praveen
Cc: Watson, Susan; Chan, Vincent; JohnR SWT Lambert; Rose Ms CIV USA OSA Zeiler; Aaron K SWT Williams
Subject: TCEQ Approval: D-F RD, LHAAP-35A(58)

Rose,

The TCEQ has completed its review of the Draft Final RD for LHAAP-35A(58) and has no further comments.

Thank you.

Fay Duke (MC-136)
Remediation Division, TCEQ
PO Box 13087
Austin, Texas 78711-3087
512-239-2443
512-239-2450 (Fax)

Final

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LHAAP-35A(58), Shops Area, Group 4
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Acronyms and Abbreviations

µg/L	micrograms per liter
bgs	below ground surface
CDAP	Chemical Data Acquisition Plan
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cm/sec	centimeters per second
COC	chemical of concern
CQCP	Contractor Quality Control Plan
DCE	dichloroethene
DHC	*dehalococcoides* sp.
DNAPL	dense non-aqueous phase liquid
DO	dissolved oxygen
DPT	direct-push technology
ECP	environmental condition of property
FS	Feasibility Study
GPS	global positioning system
GW-Res	groundwater MSC for residential use
GWTP	groundwater treatment plant
HASP	Health and Safety Plan
Jacobs	Jacobs Engineering Group, Inc.
LHAAP	Longhorn Army Ammunition Plant
LTM	long-term monitoring
LUC	land use control
MARC	Multiple Award Remediation Contract
MCL	maximum contaminant level
MNA	monitored natural attenuation
NCP	National Oil and Hazardous Substances Contingency Plan
O&M	operation and maintenance
ORP	oxidation reduction potential
PCE	tetrachloroethene
QA/QC	quality assurance/quality control
RAO	remedial action objective
RD	Remedial Design
ROD	Record of Decision

Acronyms and Abbreviations *(continued)*

Shaw	Shaw Environmental, Inc.
SOP	standard operating procedures
STEP	Solutions to Environmental Problems, Inc.
TAC	Texas Administrative Code
TCA	trichloroethane
TCE	trichloroethene
TCEQ	Texas Commission on Environmental Quality
TOC	total organic carbon
U.S. Army	U.S. Department of the Army
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
VC	vinyl chloride
VOC	volatile organic compound

1.0 INTRODUCTION

Shaw Environmental, Inc. (Shaw) has been contracted by the U.S. Army Corps of Engineers (USACE) Tulsa District to complete the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) response at LHAAP-35A(58), Shops Area at the former Longhorn Army Ammunition Plant (LHAAP) near Karnack, Texas. This Remedial Design (RD) for LHAAP-35A(58) is a part of the response. Subsequent work plans will be prepared to provide more details of the implementation of this RD. This work is being performed under the Louisville District's Multiple Award Remediation Contract (MARC) No. W912QR-04-D-0027, Task Order DS02, with oversight by the USACE, Tulsa District.

1.1 Longhorn Army Ammunition Plant Background

Longhorn Army Ammunition Plant (LHAAP) is located in central-east Texas in the northeastern corner of Harrison County, approximately 14 miles northeast of Marshall, Texas (**Figure 1-1**). The facility occupies approximately 8,416 acres between State Highway 43 in Karnack, Texas, and the western shore of Caddo Lake. Caddo Lake is a large freshwater lake that bounds LHAAP to the north and east. The eastern fence of LHAAP is 3.5 miles from the Texas-Louisiana state border.

1.1.1 LHAAP-35A(58) Description

LHAAP-35A(58), also known as the Shops Area, is located in the north-central portion of LHAAP. LHAAP-35A(58) was established in 1942 as part of the installation's initial construction. The facility was used to provide plant-operated laundry, automotive, woodworking, metalworking, painting, refrigeration, and electrical services. The site was active throughout LHAAP's mission and became inactive in 1996-1997, along with the entire installation. The LHAAP-35A(58) site boundary has been defined differently in the past. **Figure 1-2** shows the historic site boundary and the current site boundary defined by USACE in November 2006 (USACE, 2006). Earlier investigations for LHAAP-35A(58) covered additional areas to the south, however the current boundary only covers approximately 11 acres. Located within the boundaries of LHAAP-35A(58) are additional sites including LHAAP-02, vacuum truck overnight parking; LHAAP-03, the Paint Shop Building 722 (waste collection); LHAAP-60, pesticide storage buildings; LHAAP-68, a mobile storage tank parking area; and LHAAP-69, a service station that includes underground storage tanks.

The surface features are a mixture of asphalt-paved roads, a parking area, and areas of wooded and grassy vegetation. The topography is relatively flat with the surface drainage flowing into the tributaries of Goose Prairie Creek. Runoff from the site enters Caddo Lake via Goose Prairie Creek.

Investigations of the soil, groundwater, surface water, and sediments at LHAAP-35A(58) include the following: From 1992 to 2001, investigations were conducted and the results were published in 2002 as the *Remedial Investigation* for Group 4 sites (Jacobs, 2002). From 2000 to 2002, a plant-wide perchlorate investigation was conducted that included LHAAP-35A(58) (STEP, 2005). In 2003, an environmental site assessment was conducted (Plexus Scientific Corporation, 2005), and the *Baseline Human Health Risk Assessment* was completed (Jacobs, 2003). In 2004, a data gaps investigation was conducted (Shaw, 2007a). In 2007, the *Baseline Ecological Risk Assessment* was published (Shaw, 2007b). In 2008, a sumps/waste rack sumps report was completed (Shaw, 2008). In 2009, the *Feasibility Study* (FS) was completed, which included the natural attenuation evaluation (Shaw, 2009). The findings from these investigations was that the shallow zone groundwater was impacted with volatile organic compounds (VOCs), while the soil and former sump/waste rack sump areas posed no unacceptable threat to human health or the environment (Shaw, 2009). There have been no previous remedial actions at LHAAP-35A(58).

The remedial action alternative to be implemented at LHAAP-35A(58) was developed and selected in accordance with CERCLA, as amended by the Superfund Amendments and Reauthorization Act of 1986, and the National Oil and Hazardous Substances Contingency Plan (NCP) (40 Code of Federal Regulations Part 300). The selected remedy finalized in the Record of Decision (ROD) (U.S. Army, 2010) was developed based on the assumption that future land use will be industrial/recreational (e.g., national wildlife refuge). The land use control (LUC) to restrict groundwater to environmental monitoring and testing will be recorded at the Harrison County courthouse. Additionally, the notification will indicate that the property is suitable for nonresidential use. It is also assumed that this remedial action will be the final action at the site.

1.2 Remedial Action Objectives

A remedial action at LHAAP-35A(58) must protect human health and meet applicable or relevant and appropriate requirements. As noted in the FS, there are no ecological risks at LHAAP-35A(58); and therefore, the proposed remedial action will address human health risks. At LHAAP-35A(58), the only risk that needs be addressed is the groundwater contamination that may adversely affect human health via ingestion, inhalation, and direct contact (Shaw, 2009).

The remedial action objectives (RAOs) for LHAAP-35A(58), consistent with the anticipated future use as a national wildlife refuge, are:

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

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

1.3 Planned Remedial Action

The RAOs were the basis for formulating and evaluating remedial alternatives and selecting a remedial action. The U.S. Army will implement the selected remedy described in the ROD (U.S. Army, 2010). The description of the remedy is organized as two geographic areas: 1) eastern plume and 2) western plume. **Figure 1-3** identifies these areas on a map of LHAAP-35A(58).

- **Eastern plume area.** The eastern plume remedy will include LUC; in situ bioremediation in the area of highest levels of contamination followed by monitored natural attenuation (MNA) near wells LHSMW05, 35AWW08, and 03WW01; MNA for the balance of the plume; and long-term monitoring (LTM)/Five-Year Reviews.
- **Western plume area.** The western plume remedy will consist of LUC, MNA, and LTM/Five-Year Reviews.

1.3.1 In Situ Bioremediation (eastern plume target area only)

In situ bioremediation is the process of removing contaminant mass by utilizing contaminants in the groundwater during respiratory or metabolic activities. The treatment involves injecting amendments which may include microbial cultures, electron donor sources, nutrients, and carbon sources into the subsurface. This is further discussed in **Section 5.0**.

At LHAAP-35A(58), the highest concentrations of contaminants have been observed in the shallow groundwater zone and will be the target area for active treatment. This area is designated as the eastern plume target area. The target area is located roughly in the center of the eastern plume near wells LHSMW05, 35AWW08, and 03WW01. The major components of the remedy are:

- **In Situ Bioremediation.** First, a treatability study will be conducted to evaluate the effectiveness of bioremediation using site groundwater, to determine amendment requirements, and to provide specific design parameters for field implementation. After the treatability study has been completed, a Remedial Action Work Plan incorporating the results of the treatability study and specifying the design parameters of the in situ bioremediation system will be prepared and submitted prior to the implementation in the target area. The Remedial Action Work Plan will include performance monitoring criteria used to evaluate the effectiveness of the bioremediation treatment. At a minimum, six quarterly post-injection sampling events will be used to evaluate the effectiveness of the remedy and to determine if a second round of injections will be necessary. If the in situ bioremediation treatment is effective, MNA will begin. If ineffective, a second round of injections may be followed by additional performance monitoring.

- **Monitored Natural Attenuation and Long-Term Monitoring/Five-Year Reviews**. After in situ bioremediation is used to reduce the highest contaminate concentrations, MNA will be utilized to address the lower levels observed at LHAAP-35A(58) (see **Section 1.3.2**). MNA will begin after the completion of the six quarterly performance sampling events. At that point, monitoring of the target area will be aligned with the schedule for the eastern plume. If well 03WW01 is abandoned as a consequence of excavation activities at LHAAP-03, a replacement well will be installed and added to the MNA program. Five-year reviews as described in **Section 1.3.4** will also cover the eastern plume target area.

- **Land Use Control**. The LUC that will be implemented for the site as described in **Section 1.3.3** will also cover the eastern plume target area.

1.3.2 Monitored Natural Attenuation (eastern and western plumes)

MNA is a passive treatment where contaminant concentrations decrease through natural attenuation processes such as biodegradation, dispersion, dilution, sorption, and volatilization (USEPA, 1998). Data from performance monitoring is used to evaluate whether natural attenuation is occurring and reducing chemicals of concern (COCs).

The portion of the eastern plume outside of the target area described in **Section 1.3.1** is designated as the eastern plume MNA area. MNA will be implemented in the entire western plume. Thus, the eastern plume MNA area and the western plume have the same remedial action, MNA. For both the eastern and western plumes, monitoring will be conducted in both the shallow and intermediate zones to ensure that the plumes do not migrate vertically. In the eastern plume, the intermediate well 35AWW01 will be grouped with the wells of the eastern plume MNA area.

MNA will be implemented to verify that the VOC levels are decreasing, plumes are stable, and the plume will not migrate to nearby surface water. MNA is expected to return groundwater to its potential beneficial use.

During the first two years, groundwater monitoring will be performed quarterly. At the end of the quarterly sampling events, performance objectives will be evaluated. If MNA is found to be ineffective, a contingency remedy to enhance MNA will be implemented.

1.3.3 Land Use Control (eastern and western plumes)

LUC in the impacted area will ensure the protection of human health by restricting the use of groundwater to environmental monitoring and testing. The LUC will be implemented after the design is approved. The LUC will remain in place until the cleanup levels are met.

1.3.4 Long-Term Monitoring/Five-Year Reviews (eastern and western plumes)

After MNA is evaluated for two years and verified to be effective, LTM will begin at a semiannual frequency for the following three years. In subsequent years, LTM events will be annual until the next five-year review. The LTM and reporting associated with this remedy will be used to track the effectiveness of the MNA remedy and will continue at least once every five years until cleanup levels are achieved. Based on preliminary calculated attenuation rates for LHAAP-35A(58), groundwater cleanup levels are expected to be met through natural attenuation in 200 years in the western plume. This time-frame will be re-evaluated as part of the MNA evaluation and periodic reviews. The cleanup times for natural attenuation for the eastern plume will be evaluated after in situ bioremediation, but the cleanup times are anticipated to be similar to the western plume.

1.4 Cleanup Levels

Cleanup levels were established to meet the RAOs as included in the ROD (U.S. Army, 2010). **Table 1-1** presents the groundwater cleanup levels for LHAAP-35A(58).

1.5 Areas of Contamination

Based on the risk assessment and subsequent evaluations, it was determined that the COCs for the shallow groundwater at this site are tetrachloroethene (PCE), trichloroethene (TCE), 1,1-dichloroethene (DCE), cis-1,2-DCE, trans-1,2-DCE, and vinyl chloride (VC). In addition, cleanup levels are provided for 1,1,2-trichloroethane (TCA) and its daughter products 1,1-dichloroethane and chloroethane, even though they are not currently classified as COCs due to their low detections during recent sampling. 1,1,2-TCA and its daughter products will be included as COCs for LTM as discussed in the ROD Section 2.12.2 (U.S. Army, 2010) because the historical level of 1,1,2-TCA was a concern in the past. **Figure 1-4** shows the plume boundaries for PCE, TCE, and 1,1-DCE, as determined by their respective maximum contaminant levels (MCLs), and VOC results from 2003 through 2008. The COCs are carcinogenic. No principal threat source material (such as dense non-aqueous phase liquid [DNAPL]) was identified or suspected to exist at LHAAP-35A(58).

Table 1-1
Cleanup Levels

Chemical of Concern	Concentration (µg/L)	Basis
1,1,2-Trichloroethane (TCA) [a]	5	MCL
1,1-Dichloroethane (TCA daughter product) [a]	10,000	GW-Ind [b]
1,1-Dichloroethene (DCE)	7	MCL
Chloroethane (TCA daughter product) [a]	41,000	GW-Ind [b]
cis-1,2-DCE	70	MCL
Tetrachloroethene (PCE)	5	MCL
trans-1,2-DCE	100	MCL
Trichloroethene (TCE)	5	MCL
Vinyl Chloride (VC)	2	MCL

Notes and Abbreviations:

a *Not currently classified as a chemical of concern, but will be included in the list of chemicals of concern for long-term monitoring (see Record of Decision Section 2.12.2)*

b *Groundwater medium-specific concentration for industrial use since no MCL exists*

µg/L *micrograms per liter*

GW-Ind *Texas Commission on Environmental Quality groundwater medium-specific concentration for industrial use using updated toxicity information through March 31, 2010*

MCL *Safe Drinking Water Act maximum contaminant level*

The eastern plume has an area of approximately 270,000 square feet, and a vertical extent of approximately 5 feet. Assuming a groundwater-filled porosity of 0.3, the calculated volume of contaminated groundwater is 3.03 million gallons. The highest concentrations detected are as follows: PCE was 9,590 micrograms per liter (µg/L) from well 35AWW08 in November 2008. TCE was 1,150 µg/L from 35AWW08 in May 2011. 1,1-DCE and VC were 24 µg/L and 4.1 µg/L, respectively, from well 1004TW001 in December 2003. Five shallow zone wells are within the eastern plume boundaries (35AWW08, 1004TW001, LHSMW04, LHSMW05, 03WW01), as well as one direct push data point (58DPT04).

The western plume has an area of approximately 180,000 square feet, and a vertical extent of approximately 5 feet. Assuming a total porosity of 0.3, the calculated volume of contaminated groundwater is 2.02 million gallons. The highest concentrations detected are as follows: PCE was 7.19 µg/L from well 35AWW06 in November 2008. 1,1-DCE and TCE were 669 µg/L and 41.3 µg/L, respectively, from well LHSMW07 in May 2011. VC was 14.4 from well LHSMW07 in November 2008. Three shallow zone wells, LHSMW07, 35AWW06, and 1004TW006, are within the western plume boundary.

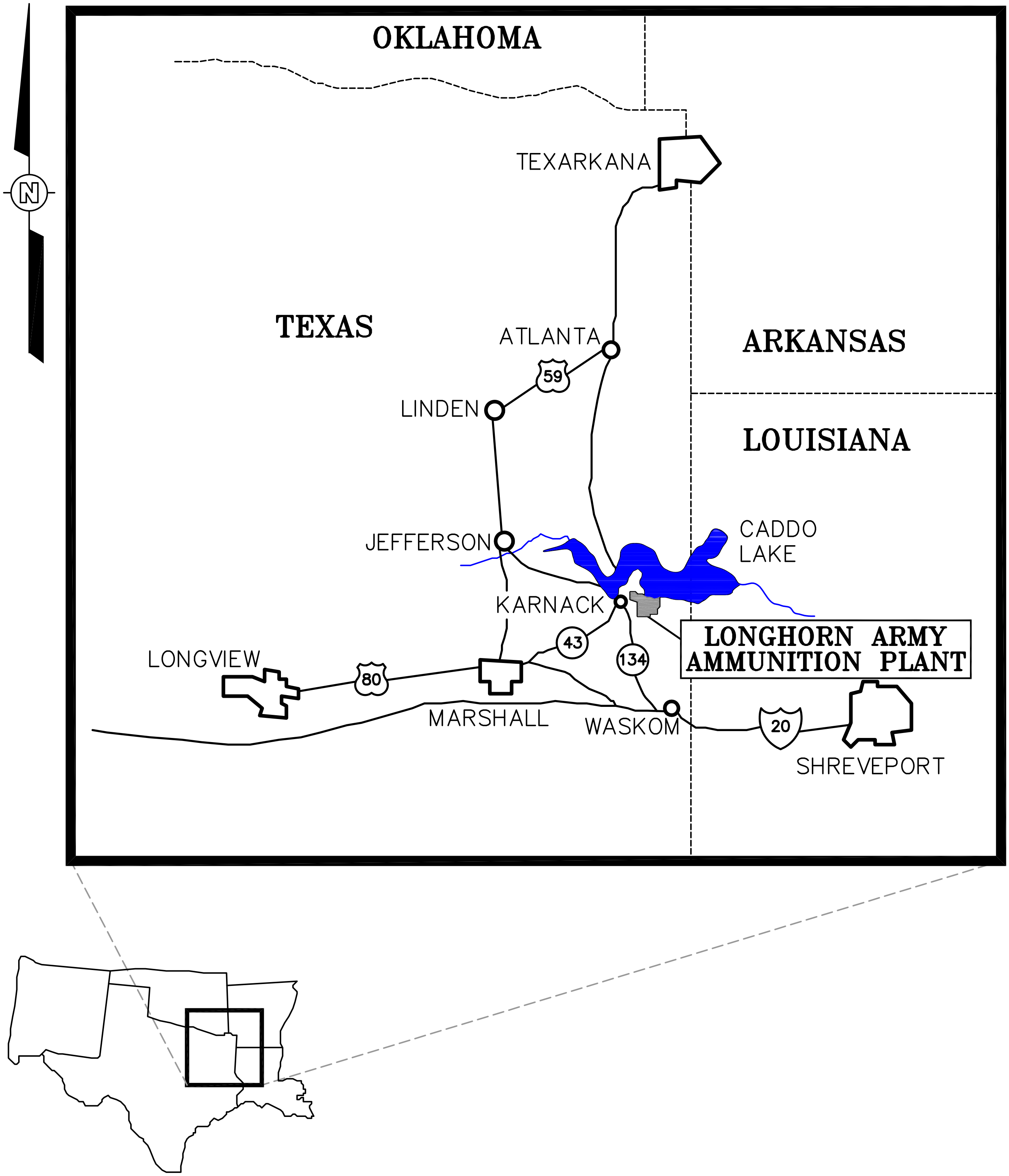
For both the eastern and western plumes, the intermediate zone wells did not have contaminants above cleanup levels.

1.6 Hydrogeology

Groundwater is present in shallow, intermediate, and deep zones at LHAAP-35A(58). The shallow, intermediate, and deep zones are encountered at 10 to 25 feet below ground surface (bgs), 60 to 71 feet bgs, and 126 to 140 bgs, respectively. Data gathered from the monitoring wells installed at the site indicated that the groundwater flows radially from near the central southwestern part of the site with an east flow on the eastern side of the site and a south/southeast flow on the western side of the site, as shown in **Figure 1-5**.

For the shallow groundwater zone, hydraulic conductivity values ranged from a minimum value of 3.5×10^{-5} centimeters per second (cm/sec) in the southeast portion of the site to a maximum value of 1.4×10^{-3} cm/sec northwest of the site (Jacobs, 2002).

The soil at LHAAP-35A(58) consists of clays and silty clays with thin lenses of sand. The sand lenses are approximately 3 to 5 feet thick. The depth to the sand lenses varies across the site. A cross-section of the site is shown in **Figure 1-6**.



"DRAWING NOT TO SCALE"

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

FIGURE 1–1
LHAAP LOCATION MAP
LHAAP–35A(58), GROUP 4
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

IMAGE	X–REF	OFFICE	DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
---	---	Houston, Texas	S. MCCAWLEY 7/27/11	K. EVERETT 7/27/11	S. WATSON 7/27/11	117591–A55

PLOT DATE: 07/27/11
FORMAT REVISION 3/25/99

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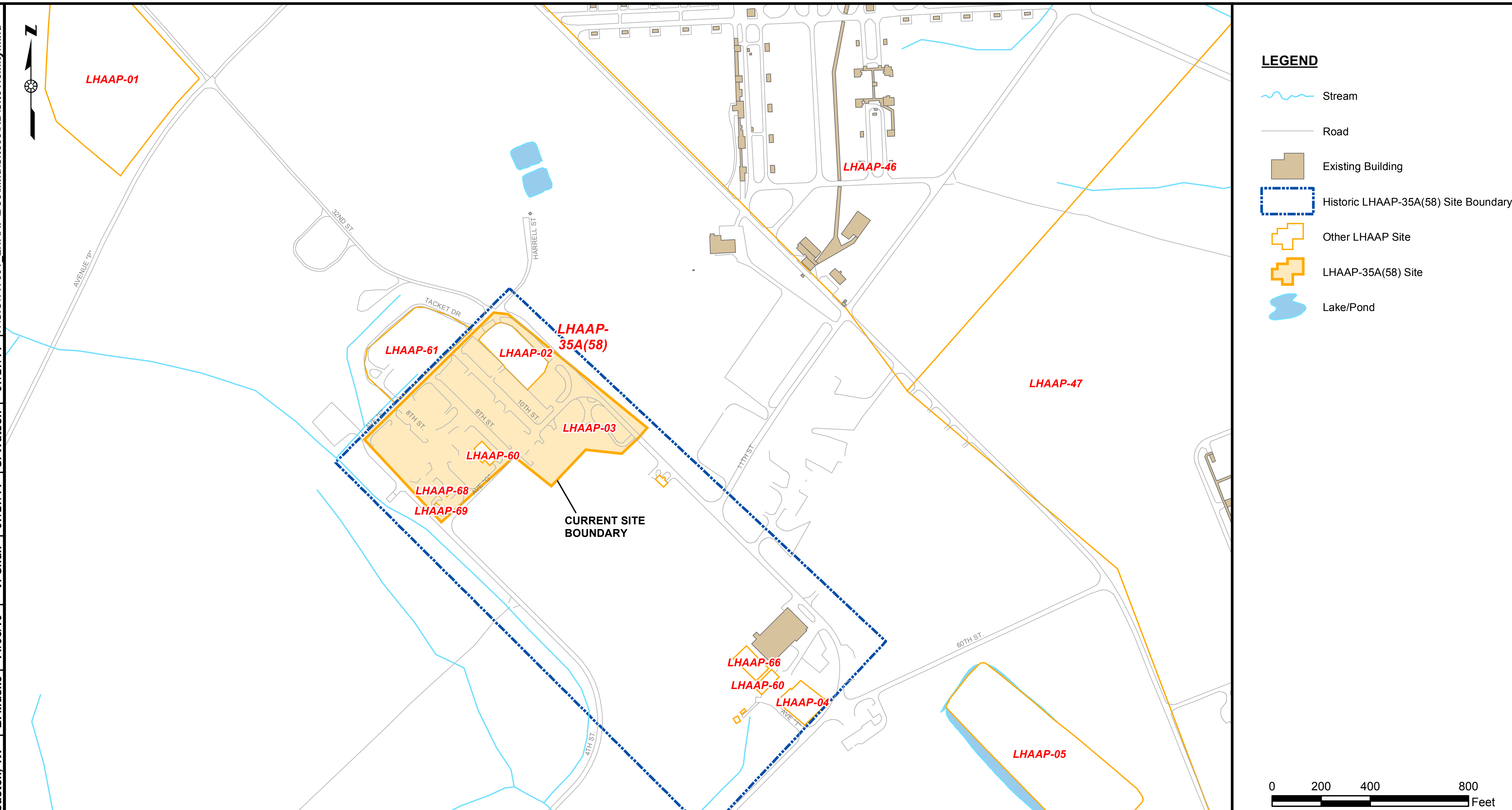

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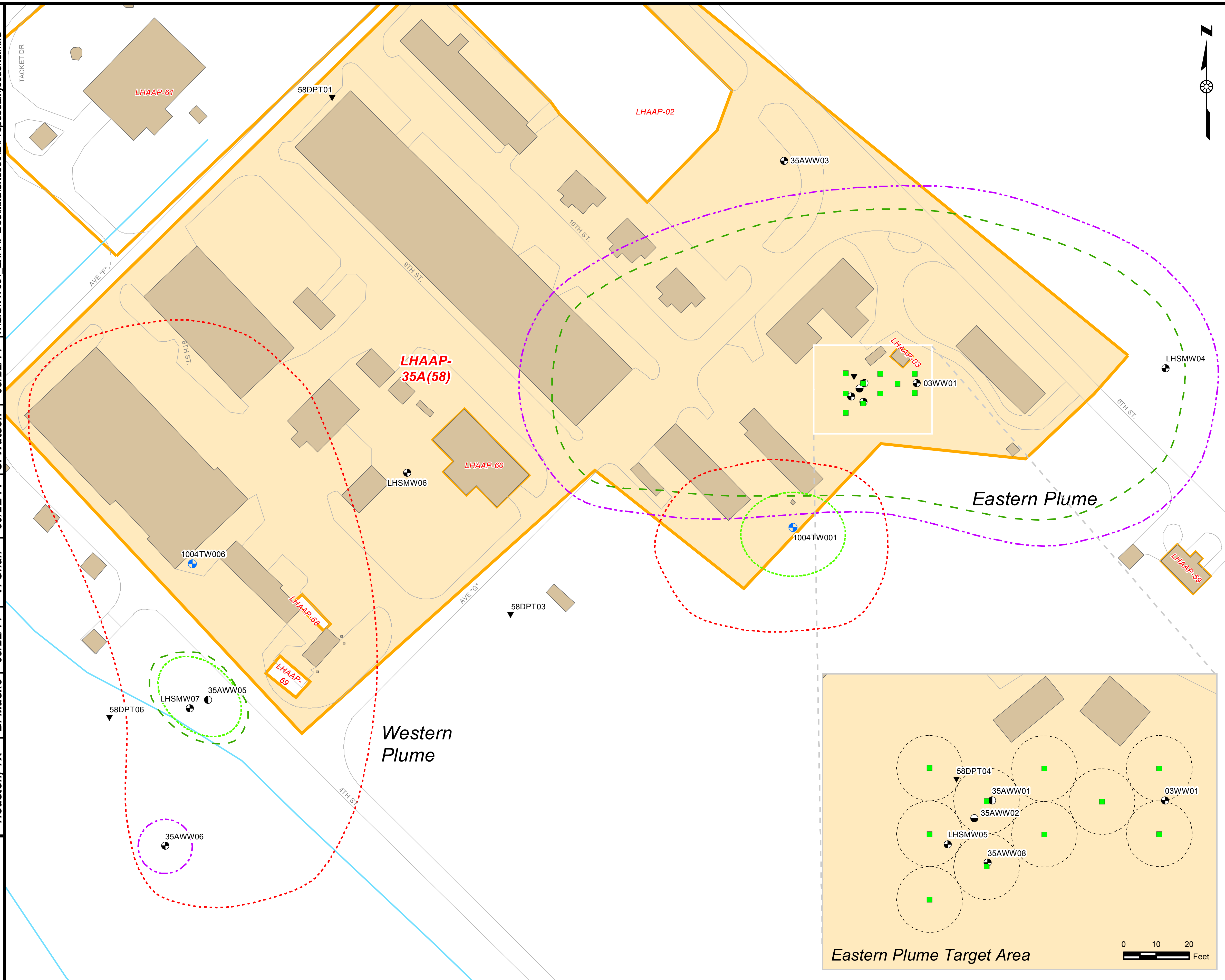
U.S. ARMY CORPS OF ENGINEERS
TULSA DISTRICT
TULSA, OKLAHOMA

FIGURE 1-2

SITE VICINITY MAP
LHAAP-35A(58), GROUP 4

LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS



LEGEND

- Proposed Injection Locations
- Plexus Temporary Monitoring Well
- Shallow Monitoring Well
- Shallow/Intermediate Monitoring Well
- Intermediate Monitoring Well
- Deep Monitoring Well
- DPT Location
- Estimated 1,1-DCE Concentration Contour (7 µg/L)
- Estimated TCE Concentration Contour (5 µg/L)
- Estimated PCE Concentration Contour (5 µg/L)
- Estimated Vinyl Chloride Concentration Contour (2 µg/L)
- Stream
- Road
- Former Building or Tank
- Other LHAAP Site
- LHAAP-35A(58) Site

Notes:

1. Circles illustrate a radius of influence of 10 ft.
2. Concentration contours are based on data from 2003 through 2008.

1,1-DCE: 1,1-dichloroethene
PCE: tetrachloroethene
TCE: trichloroethene
µg/L: micrograms per liter

0 50 100 200 Feet

Shaw

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

FIGURE 1-3

PROPOSED INJECTION LOCATIONS
LHAAP-35A(58), GROUP 4

LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

OFFICE	DRAWN BY	CHECKED BY	APPROVED BY	FILE PATH
Houston, TX	B. Muske 09/22/11	V. Chan 09/22/11	S. Watson 09/22/11	T:\GIS\117591 LHAAP\Doc\Mxd\Site58\RD\ProposedInjections.mxd

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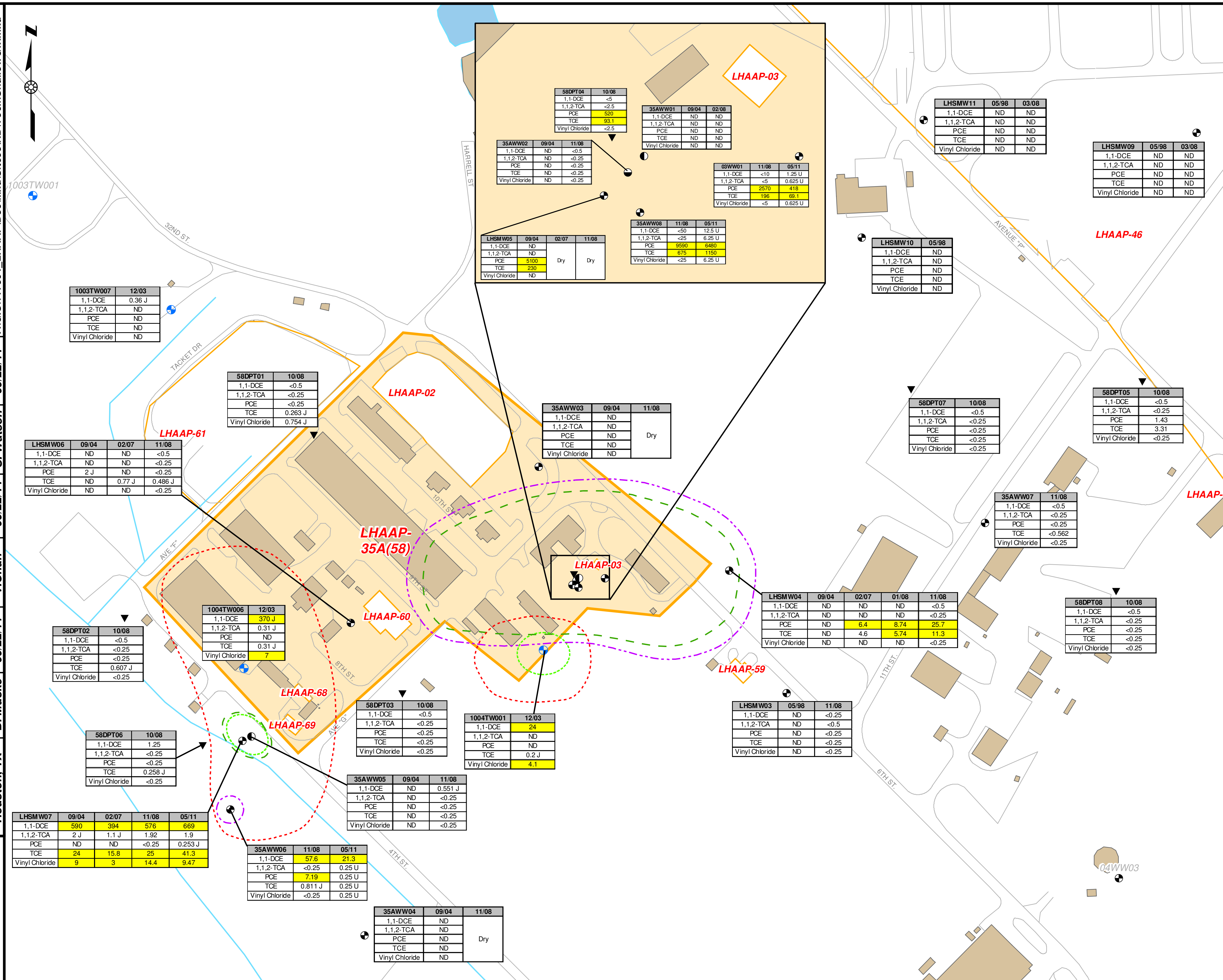

1003TW007	12/03
1,1-DCE	0.36 J
1,1,2-TCA	ND
PCE	ND
TCE	ND
Vinyl Chloride	ND

58DPT01	10/08
1,1-DCE	<0.5
1,1,2-TCA	<0.25
PCE	<0.25
TCE	0.263 J
Vinyl Chloride	0.754 J

LHSMW06	09/04	02/07	11/08
1,1-DCE	ND	ND	<0.5
1,1,2-TCA	ND	ND	<0.25
PCE	2 J	ND	<0.25
TCE	ND	0.77 J	0.486 J
Vinyl Chloride	ND	ND	<0.25

58DPT02	10/08
1,1-DCE	<0.5
1,1,2-TCA	<0.25
PCE	<0.25
TCE	0.607 J
Vinyl Chloride	<0.25

1004TW006	12/03
1,1-DCE	370 J
1,1,2-TCA	0.31 J
PCE	ND
TCE	0.31 J
Vinyl Chloride	7

58DPT06	10/08
1,1-DCE	1.25
1,1,2-TCA	<0.25
PCE	<0.25
TCE	0.258 J
Vinyl Chloride	<0.25

LHSMW07	09/04	02/07	11/08	05/11
1,1-DCE	590	394	576	669
1,1,2-TCA	2 J	1.1 J	1.92	1.9
PCE	ND	ND	<0.25	0.253 J
TCE	24	15.8	25	41.3
Vinyl Chloride	9	3	14.4	9.47

35AWW06	11/08	05/11
1,1-DCE	57.6	21.3
1,1,2-TCA	<0.25	0.25 U
PCE	7.19	0.25 U
TCE	0.811 J	0.25 U
Vinyl Chloride	<0.25	0.25 U

58DPT03	10/08
1,1-DCE	<0.5
1,1,2-TCA	<0.25
PCE	<0.25
TCE	<0.25
Vinyl Chloride	<0.25

35AWW05	09/04	11/08
1,1-DCE	ND	0.551 J
1,1,2-TCA	ND	<0.25
PCE	ND	<0.25
TCE	ND	<0.25
Vinyl Chloride	ND	<0.25

1004TW001	12/03
1,1-DCE	24
1,1,2-TCA	ND
PCE	ND
TCE	0.2 J
Vinyl Chloride	4.1

35AWW04	09/04	11/08
1,1-DCE	ND	Dry
1,1,2-TCA	ND	
PCE	ND	
TCE	ND	
Vinyl Chloride	ND	

58DPT04	10/08
1,1-DCE	<5
1,1,2-TCA	<2.5
PCE	520
TCE	93.1
Vinyl Chloride	<2.5

35AWW01	09/04	02/08
1,1-DCE	ND	ND
1,1,2-TCA	ND	ND
PCE	ND	ND
TCE	ND	ND
Vinyl Chloride	ND	ND

35AWW02	09/04	11/08
1,1-DCE	ND	<0.5
1,1,2-TCA	ND	<0.25
PCE	ND	<0.25
TCE	ND	<0.25
Vinyl Chloride	ND	<0.25

03WW01	11/08	05/11
1,1-DCE	<10	1.25 U
1,1,2-TCA	<5	0.625 U
PCE	2570	418
TCE	196	69.1
Vinyl Chloride	<5	0.625 U

LHSMW05	09/04	02/07	11/08
1,1-DCE	ND	Dry	Dry
1,1,2-TCA	ND		
PCE	5100		
TCE	230		
Vinyl Chloride	ND		

35AWW08	11/08	05/11
1,1-DCE	<50	12.5 U
1,1,2-TCA	<25	6.25 U
PCE	9590	6480
TCE	675	1150
Vinyl Chloride	<25	6.25 U

35AWW03	09/04	11/08
1,1-DCE	ND	Dry
1,1,2-TCA	ND	
PCE	ND	
TCE	ND	
Vinyl Chloride	ND	

LHSMW11	05/98	03/08
1,1-DCE	ND	ND
1,1,2-TCA	ND	ND
PCE	ND	ND
TCE	ND	ND
Vinyl Chloride	ND	ND

LHSMW09	05/98	03/08
1,1-DCE	ND	ND
1,1,2-TCA	ND	ND
PCE	ND	ND
TCE	ND	ND
Vinyl Chloride	ND	ND

LHSMW10	05/98
1,1-DCE	ND
1,1,2-TCA	ND
PCE	ND
TCE	ND
Vinyl Chloride	ND

58DPT07	10/08
1,1-DCE	<0.5
1,1,2-TCA	<0.25
PCE	<0.25
TCE	<0.25
Vinyl Chloride	<0.25

58DPT05	10/08
1,1-DCE	<0.5
1,1,2-TCA	<0.25
PCE	1.43
TCE	3.31
Vinyl Chloride	<0.25

35AWW07	11/08
1,1-DCE	<0.5
1,1,2-TCA	<0.25
PCE	<0.25
TCE	<0.562
Vinyl Chloride	<0.25

LHSMW04	09/04	02/07	01/08	11/08
1,1-DCE	ND	ND	ND	<0.5
1,1,2-TCA	ND	ND	ND	<0.25
PCE	ND	6.4	8.74	25.7
TCE	ND	4.6	5.74	11.3
Vinyl Chloride	ND	ND	ND	<0.25

58DPT08	10/08
1,1-DCE	<0.5
1,1,2-TCA	<0.25
PCE	<0.25
TCE	<0.25
Vinyl Chloride	<0.25

LHSMW03	05/98	11/08
1,1-DCE	ND	<0.25
1,1,2-TCA	ND	<0.5
PCE	ND	<0.25
TCE	ND	<0.25
Vinyl Chloride	ND	<0.25

LEGEND

- DPT Sample Location
- Shallow Monitoring Well
- Shallow/Intermediate Monitoring Well
- Intermediate Monitoring Well
- Deep Monitoring Well
- Plexus Temporary Monitoring Well
- Estimated 1,1-DCE Contamination Extent at Concentration = 7 µg/L
- Estimated TCE Contamination Extent at Concentration = 5 µg/L
- Estimated PCE Contamination Extent at Concentration = 5 µg/L
- Estimated Vinyl Chloride Contamination Extent at Concentration = 2 µg/L
- Stream
- Road
- Other LHAAP Site
- Former Building or Tank
- LHAAP-35A(58) Site
- COC Concentration Exceeds MCL

Safe Drinking Water Act Maximum Contaminant Levels (MCL)	
1,1-DCE	7
1,1,2-TCA	5
PCE	5
TCE	5
Vinyl Chloride	2

Notes:

Concentrations are in µg/L (micrograms per liter).

1,1-DCE: 1,1-dichloroethene
1,1,2-TCA: 1,1,2-trichloroethane
PCE: tetrachloroethene
TCE: trichloroethene
ND: not detected
COC: chemical of concern

0 100 200 400 Feet

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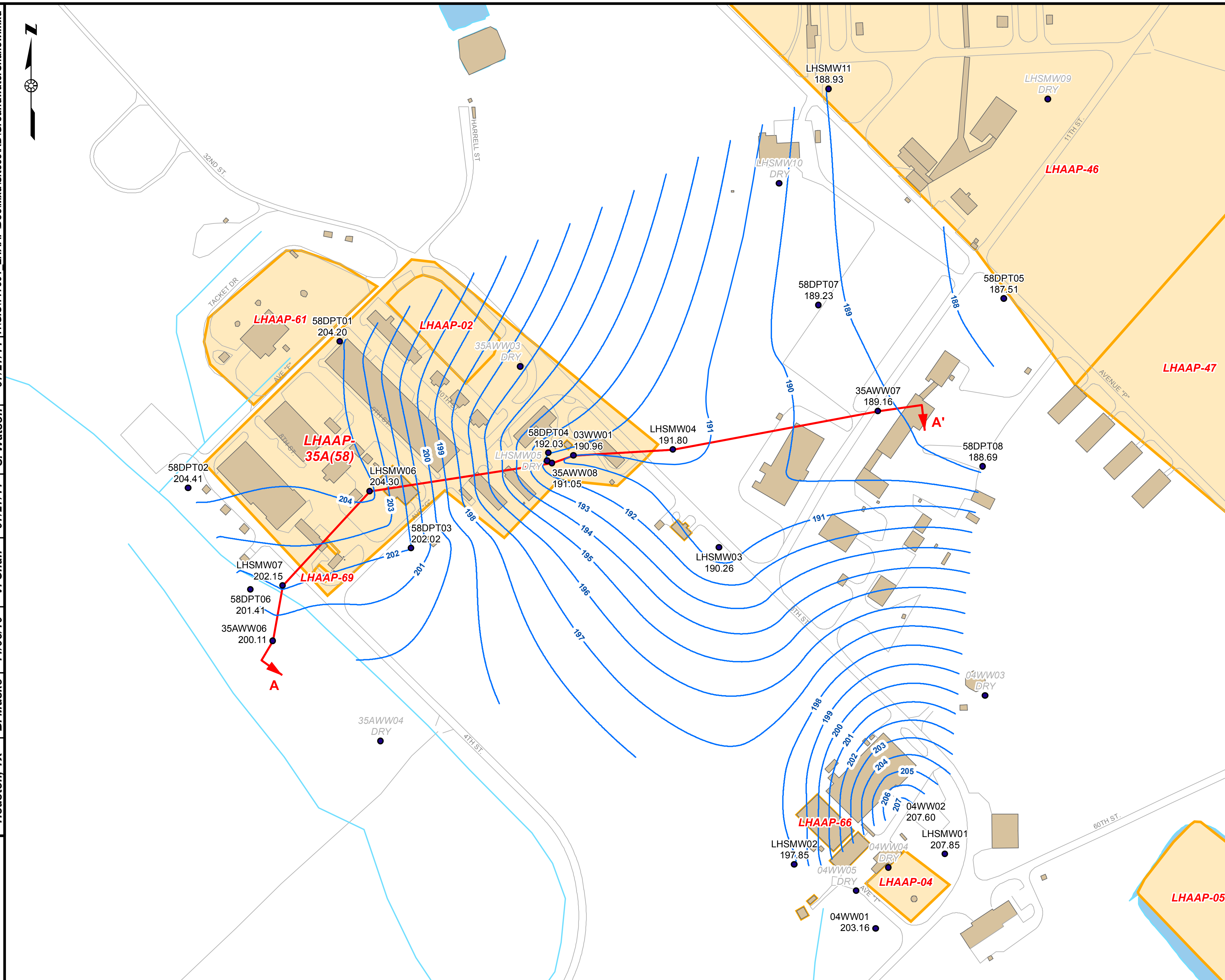
FIGURE 1-4

GROUNDWATER RESULTS FOR VOCs
2003 THROUGH 2011
LHAAP-35A(58), GROUP 4

LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS



LEGEND

- SampleLocation
- Groundwater Elevation Contour
- Cross-Section Line
- Stream
- Road
- Former Building or Tank
- Site

0 125 250 500 Feet

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FIGURE 1-5

GROUNDWATER ELEVATION MAP
SHALLOW ZONE, 2008
LHAAP-35A(58), GROUP 4

LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

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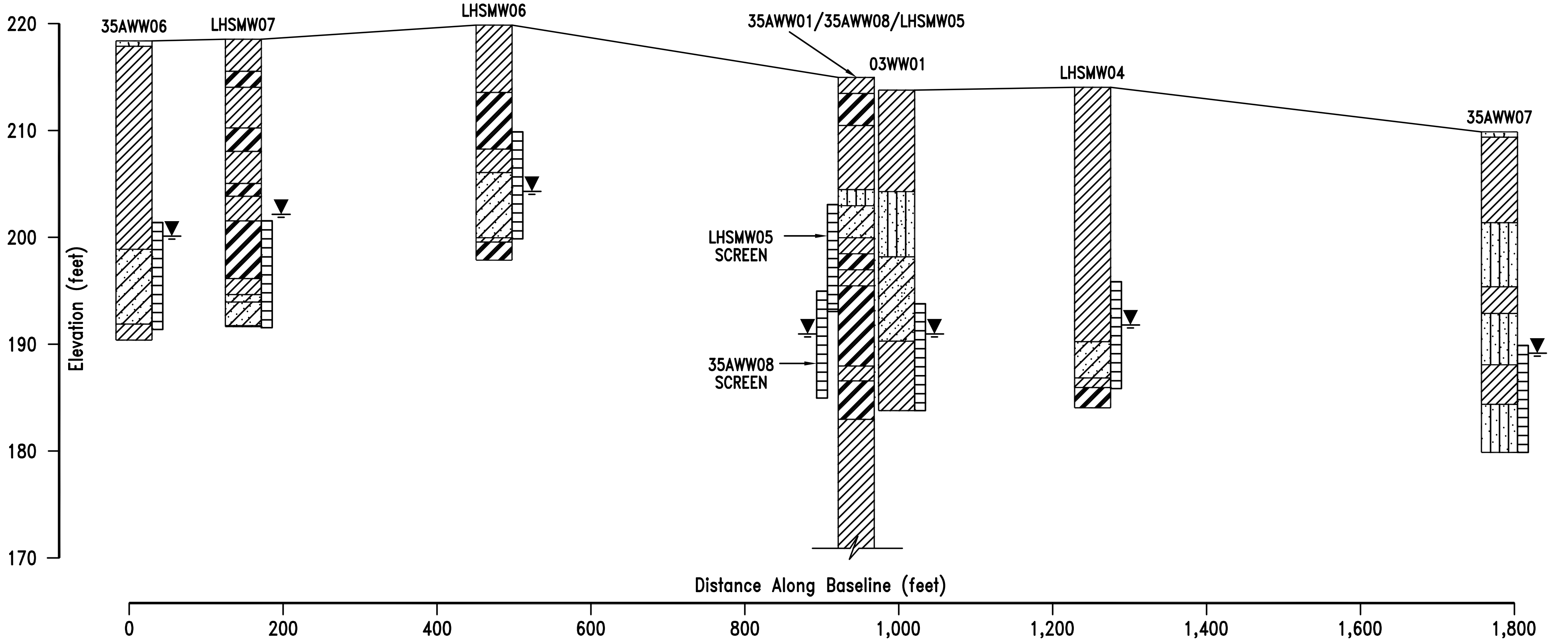
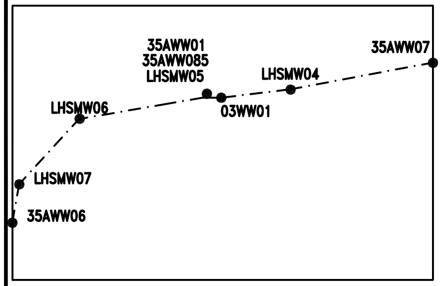
Houston, TX	B. Muske 11/05/10	V. Chan 07/27/11	S. Watson 07/27/11	T:\GIS\117591 LHAAP\Doc\Mxd\Site58\RD\GroundwaterShallow.mxd

PLOT DATE: 05/12/10 FORMAT REVISION	IMAGE	X-REF	OFFICE	DRAWN BY		CHECKED BY		APPROVED BY		DRAWING NUMBER	117591-A70
	---	---	HOUSTON, TX	S. MCCAWLEY	7/27/11	K. EVERETT	7/27/11	S. WATSON	7/27/11		





LEGEND:

(CH) FAT CLAY

(CL) LEAN CLAY

(SC) CLAYEY SAND

(MLS) SANDY SILT

STATIC WATER LEVEL (11/08)

SCREEN

HORIZONTAL SCALE

0 200 400

VERTICAL SCALE: AS SHOWN

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FIGURE 1-6

CROSS SECTION A-A'
LHAAP-35A(58), GROUP 4

LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

2.0 LAND USE CONTROL

The objective of the LUC at LHAAP-35A(58) is to 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 site for anything other than environmental monitoring and testing until cleanup goals are met. Notification of the groundwater use restriction will accompany all transfer documents and will be recorded at the Harrison County Courthouse in accordance with Texas Administrative Code (TAC) Title 30, §335.566. **Appendix A** provides sample LUC compliance certification documentation.

The LUC addresses the two groundwater plumes at LHAAP-35A(58) with levels of contamination that require implementation of a remedy (see **Section 1.3**). The U.S. Army is responsible for implementing, maintaining, monitoring, reporting on, and enforcing the LUC.

U.S. Army and regulators will consult to determine appropriate enforcement actions should there be a failure of an LUC objective at this site after it has transferred. U.S. Army shall obtain USEPA and Texas Commission on Environmental Quality (TCEQ) concurrence prior to termination or significant modification of the LUC, or implementation of a change in land use inconsistent with the LUC objectives and use assumptions of the remedy. Although not a remedy, the land use assumption for LHAAP-35A(58) forms the basis for the remedy. The future use of the site as part of a national wildlife refuge is consistent with the industrial risk exposure scenario. Notification of the land use assumption of this site will be made in transfer documentation and will be recorded in the Harrison County Courthouse in accordance with TAC Title 30, §335.566. Compliance with the use assumption will be documented in the five-year review reports.

3.0 MONITORED NATURAL ATTENUATION DESIGN

As part of the remedy, monitoring will be conducted of the groundwater and surface water. The groundwater monitoring plan was designed to evaluate and monitor natural attenuation in the shallow plume, and to monitor for any potential migration of shallow zone groundwater contaminants into the intermediate zone or to surface water. Generally the MNA performance monitoring network will be designed to provide at least two wells along the axis inside the plume boundary to evaluate MNA effectiveness; four wells to evaluate lateral plume expansion; and at least one well to evaluate vertical migration. This section discusses the rationale of MNA performance monitoring program designed to meet the following objectives:

<u>Objectives for Performance Monitoring of MNA (USEPA, 1999)</u>

1) Demonstrate that natural attenuation is occurring

2) Detect changes in environmental conditions (e.g., hydrogeologic, geochemical, microbiological, or other changes) that may reduce the efficacy of any of the natural attenuation processes,

3) Identify any potentially toxic and/or mobile transformation products,

4) Verify that the plume(s) is/are not expanding downgradient, laterally, or vertically,

5) Verify no unacceptable impact to downgradient receptors,

6) Detect new releases of contaminants to the environment that could impact the effectiveness of the natural attenuation remedy,

7) Verify attainment of remediation objectives.

3.1 Monitored Natural Attenuation Performance Monitoring Well Locations

In November 2007 a full set of groundwater elevation readings were collected of the entire northern area of LHAAP including LHAAP-35A(58). Each existing well completion was evaluated and wells were assigned to a shallow, shallow-intermediate, or intermediate zone. Based on these designations, the groundwater contamination is located in one zone at LHAAP-35A(58), the shallow groundwater zone. Intermediate and deep groundwater zones also exist, but contamination has not been observed there. The coordinates and well information are located in **Table 3-1**.

3.1.1 Direct-Push Technology Groundwater Sampling and Installation of Monitoring Wells

The site hydrogeology is important when designing a monitoring system. The shallow groundwater elevations are approximately 10 to 25 feet bgs. The groundwater flows radially from near the central southwestern part of the site with an east flow on the eastern side of the site and a south/southeast flow on the western side of the site. The current shallow zone wells are completed in the sand interval that is approximately 20 to 30 ft bgs on the eastern side and approximately 17 to 28 feet bgs on the western side of the plume. The eastern plume boundary currently contains 4 shallow wells, and will contain 5 shallow wells after the completion of the monitoring well network. The western plume boundary contains 2 shallow wells.

Prior to the installation of new wells, direct-push technology (DPT) will be used for groundwater sampling to optimize the location of new monitoring wells for the MNA evaluation. It is anticipated that up to 17 DPT points will be drilled. Grab samples will be collected from the 17 proposed locations, labeled as 58DPT09 through 58DPT25 on **Figure 3-1**. The samples will be analyzed for VOCs. Location 58DPT11 will serve to confirm that the existing well LHSMW06 provides data that is representative of conditions upgradient of the eastern plume. The screen interval of LHSMW06 is 10 to 20 feet bgs, which is not as deep as the screen intervals of the hot wells in the eastern plume, generally 20 to 30 feet bgs. Therefore, deeper groundwater will be collected from 58DPT11 to confirm that concentrations in these two intervals are the same. Proposed locations for new monitoring wells are shown on **Figure 3-2**, and labeled as 35AWW09 through 35AWW21. The number and locations may be adjusted based on DPT groundwater sampling results.

Table 3-2 provides the rationale for each new and existing monitoring well that will be part of the monitoring well network. **Figure 3-3** identifies the wells to be included in the monitoring well network, and the analytes for each. **Appendix B** provides well construction diagrams and associated boring logs.

3.1.2 Vertical Well Clusters (eastern and western plumes)

The areas of highest concentration in the eastern and western plumes are monitored by a cluster of wells that are installed in different groundwater zones to assess vertical migration. In the eastern plume, the cluster is comprised of 35AWW01, 35AWW02, and 35AWW08. In the western plume, the cluster includes LHSMW07 and 35AWW05. Intermediate groundwater zone wells 35AWW01 and 35AWW05 will be monitored as part of the MNA network.

3.2 Monitored Natural Attenuation Evaluation (western plume)

The schedule for groundwater monitoring for MNA will be quarterly for two years. This data will be used to evaluate seasonal variation, and attenuation rates. Historical data will be used to evaluate MNA effectiveness and determine if monitoring should continue or a contingent action should be implemented. All collected groundwater samples will be analyzed for VOCs and field parameters (pH, dissolved oxygen [DO], and oxidation reduction potential [ORP]). A subset of the groundwater samples, those from wells historically within the groundwater plume, will also be tested for MNA parameters (*Dehalococcoides* sp. [DHC], alkalinity, chloride, nitrate/nitrite, sulfate/sulfide, total organic carbon [TOC], carbon dioxide, ferric iron, dissolved manganese and iron, and phosphorus). After the first two years, the effectiveness of MNA will be evaluated (**Section 7.1**). LTM will begin if the MNA evaluation determines MNA to be effective.

3.3 Long-Term Monitoring (eastern and western plumes)

LTM will be initiated in the following year after the 2 years of MNA evaluation. For LTM, the analytical suite will be VOCs, and the frequency of sampling will be semiannual for three years, then annually until the next five-year review. Further reductions in sampling frequency will depend on results of five-year reviews, but sampling will continue at least once every five years until cleanup levels are achieved. Based on the LTM results, a reduction in the number of wells to be sampled may be included in the five-year review. Recommendations for reducing the number of wells will be included in monitoring and/or five-year reports.

3.4 Five-Year Reviews (eastern and western plumes)

Reviews will be conducted every five years to ensure that the remedy continues to provide adequate protection of human health and the environment. Groundwater sampling will continue for VOCs as determined in the five-year review. Groundwater monitoring results, site inspections, regulatory changes, and other information will be evaluated to determine whether the current remedy should continue or if a change is required. U.S. Army shall obtain regulatory concurrence prior to termination or significant modification of LTM activities.

3.5 Surface Water Monitoring

One surface water sample (35ASW03) will be collected quarterly for two years from a ditch that runs parallel to 4th Street, and is downstream of where groundwater-to-surface water interaction would potentially exist (**Figure 3-4**). The location may be adjusted based on the DPT investigation. The sample will be analyzed for VOCs. The purpose of the sampling will be to ensure that groundwater contaminants are not migrating into surface water.

Evaluation of this data will be included in the annual reports. The frequency and location of sampling may be modified after evaluation of data. If VOC levels in the ditch are consistently above TCEQ groundwater MSC for residential use (GW-Res) after two years of monitoring, then additional evaluation will be conducted and any proposed actions will be included in the annual evaluation report to be submitted after Year 2. The need to continue surface water sampling will be evaluated during the five-year reviews.

Table 3-1
Monitoring Wells to be Sampled at LHAAP-35A(58)

Well	Groundwater Zone	Approximate depth [a] (ft bgs)	Location		Ground Elevation (ft MSL)	Top of Casing (ft MSL)
			Northing	Easting		
Eastern Plume Target Area (in situ bioremediation) [b]						
03WW01	Shallow	30	6960156.55	3305145.17	213.78	216.29
35AWW08	Shallow	30	6960152.00	3305091.27	214.25	216.95
35AWW09	Shallow	TBD	TBD	TBD	TBD	TBD
Eastern Plume (MNA)						
35AWW01	Intermediate	70	6960170.97	3305092.61	214.96	218.03
35AWW10	Shallow	TBD	TBD	TBD	TBD	TBD
35AWW11	Shallow	TBD	TBD	TBD	TBD	TBD
35AWW12	Shallow	TBD	TBD	TBD	TBD	TBD
35AWW13	Shallow	TBD	TBD	TBD	TBD	TBD
35AWW14	Shallow	TBD	TBD	TBD	TBD	TBD
35AWW21	Shallow	TBD	TBD	TBD	TBD	TBD
LHSMW04	Shallow	28.2	6960185.99	3305398.12	214.04	216.95
Western Plume (MNA)						
35AWW05	Intermediate	71	6959849.64	3304426.14	219.01	221.41
35AWW06	Shallow	27	6959701.31	3304382.89	218.38	220.43
35AWW15	Shallow	TBD	TBD	TBD	TBD	TBD
35AWW16	Shallow	TBD	TBD	TBD	TBD	TBD
35AWW17	Shallow	TBD	TBD	TBD	TBD	TBD
35AWW18	Shallow	TBD	TBD	TBD	TBD	TBD
35AWW19	Shallow	TBD	TBD	TBD	TBD	TBD
35AWW20	Shallow	TBD	TBD	TBD	TBD	TBD
LHSMW06	Shallow	20	6960079.99	3304628.53	219.86	223.18
LHSMW07	Shallow	27	6959841.17	3304408.12	218.54	221.27

Notes and Abbreviations:

[a] *Approximate depth is the bottom of the screen interval.*

[b] *Well 35AWW08 will be used for MNA monitoring post in situ bioremediation. Well 03WW01 may need to be abandoned as a consequence of excavation activities at LHAAP-03, in which case a replacement well will be installed for performance monitoring at LHAAP-35A(58)..*

Coordinate system is Texas State Plane, NAD 1983

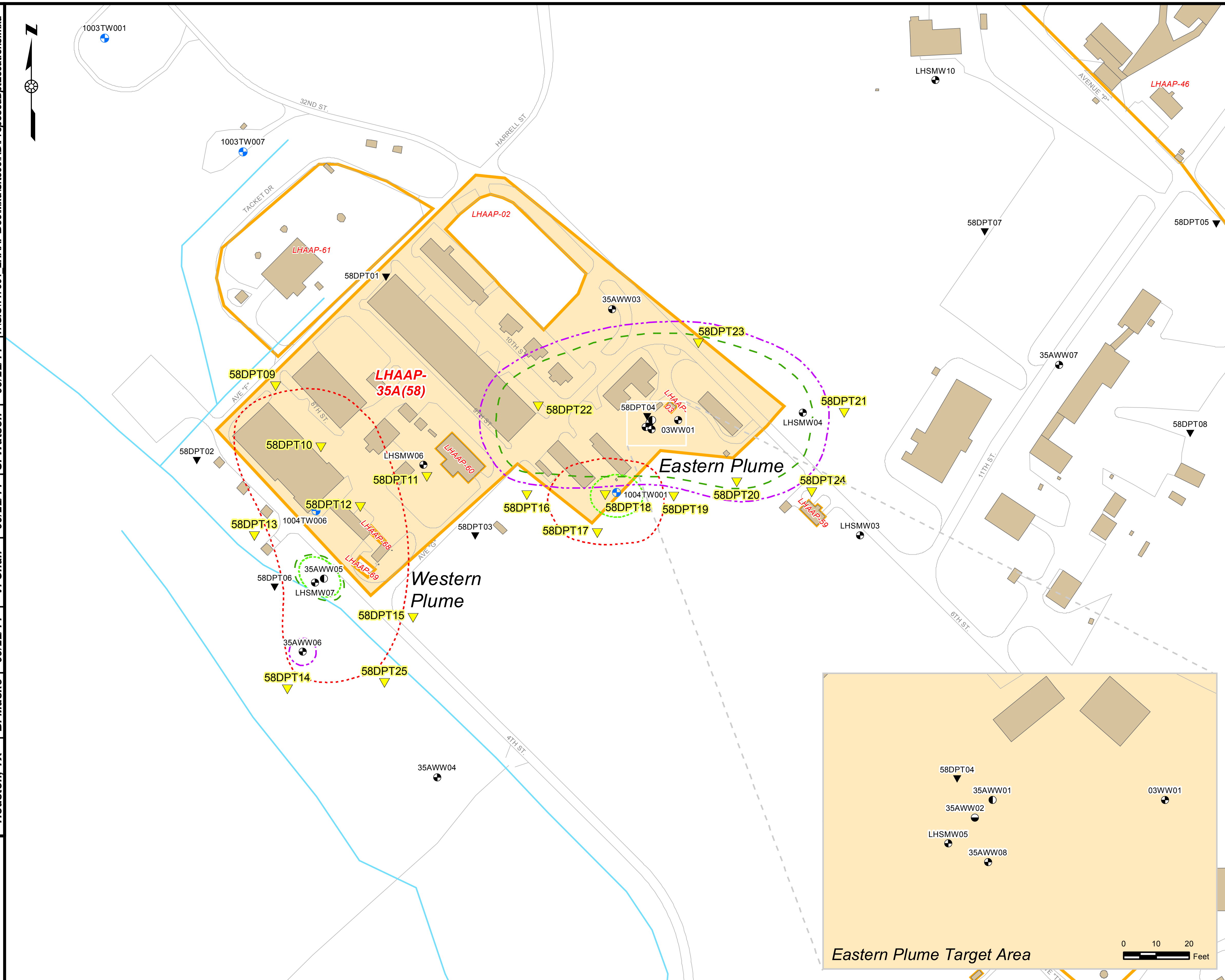
ft bgs *feet below ground surface*
ft MSL *feet mean sea level*
MNA *monitored natural attenuation*
TBD *to be determined*

Table 3-2
Rationale for Performance Monitoring Wells at LHAAP-35A(58)

Performance Monitoring Well Location	Monitoring Well Location Relative to the Plume	Well ID	Purpose
Eastern Plume Target Area (in situ bioremediation)			
In plume	Highest concentrations in eastern plume	35AWW08	Evaluate in situ enhanced bioremediation (ISEB)
In plume	Downgradient from highest concentrations in eastern plume	03WW01	Evaluate ISEB; this well may be abandoned as part of a remedial action at LHAAP-03, and will be replaced with 35AWW09
In plume	Downgradient from highest concentrations in eastern plume	35AWW09 (new well)	Evaluate ISEB; replaces 03WW01 after it is abandoned
Eastern Plume (MNA)			
Below plume (intermediate zone)	Below plume (intermediate zone)	35AWW01	Evaluate any vertical migration
In plume	Eastern edge of plume	LHSMW04	Evaluate presence of daughter products, geochemical, geochemical and microbiological changes of the dissolved plume to evaluated monitored natural attenuation (MNA) processes; calculate distance based attenuation rate; evaluate plume stability
In plume	Inside west half of plume	35AWW10 (new well)	Evaluate presence of daughter products, geochemical , geochemical and microbiological changes of the dissolved plume to evaluated MNA processes; calculate distance based attenuation rate; evaluate plume stability
In plume	On south side of plume	35AWW11 (new well)	Evaluate presence of daughter products, geochemical , geochemical and microbiological changes of the dissolved plume to evaluated MNA processes; calculate distance based attenuation rate; evaluate plume stability; replaces temporary well 1004TW001
Downgradient	Outside east edge of plume	35AWW12 (new well)	Evaluate downgradient expansion; replaces 35AWW07 and LHSMW03 whose locations were not satisfactory to serve as downgradient wells
Downgradient	Outside southeast edge of plume	35AWW21 (new well)	Evaluate downgradient expansion; replaces 35AWW07 and LHSMW03 whose locations were not satisfactory to serve as downgradient wells
Cross gradient	Outside north edge of plume	35AWW13 (new well)	Evaluate lateral plume expansion; replaces 35AWW03 which was dry in 2008
Cross gradient	Outside south edge of plume	35AWW14 (new well)	Evaluate lateral plume expansion
Upgradient	Outside west edge of plume	LHSMW06	Detect any new contamination flowing into the plume; evaluate lateral plume expansion

Table 3-2 *(continued)*
Rationale for Performance Monitoring Wells at LHAAP-35A(58)

Western Plume (MNA)			
Below plume (intermediate zone)	Below plume (intermediate zone)	35AWW05	Evaluate any vertical migration
In plume	Highest concentrations in western plume	LHSMW07	Evaluate presence of daughter products, geochemical , geochemical and microbiological changes of the dissolved plume to evaluated MNA processes; calculate distance based attenuation rate; evaluate plume stability
In plume	Downgradient from highest concentrations in western plume	35AWW06	Evaluate presence of daughter products, geochemical , geochemical and microbiological changes of the dissolved plume to evaluated MNA processes; calculate distance based attenuation rate; evaluate plume stability
In plume	On north side of plume	35AWW20	Evaluate presence of daughter products, geochemical , geochemical and microbiological changes of the dissolved plume to evaluated MNA processes; calculate distance based attenuation rate; evaluate plume stability
Upgradient	Outside north edge of plume	35AWW15 (new well)	Detect any new contamination flowing into the plume; evaluate lateral plume expansion
Cross gradient	Outside west edge of plume	35AWW16 (new well)	Evaluate lateral plume expansion
Downgradient	Outside south edge of plume	35AWW17 (new well)	Evaluate downgradient expansion; replaces 35AWW04 which was dry in 2008
Down gradient	Outside southeast edge of plume	35AWW18 (new well)	Evaluate downgradient expansion; replaces 35AWW04 which was dry in 2008
Cross gradient	Outside east edge of plume	35AWW19 (new well)	Evaluate lateral plume expansion
Cross gradient	Outside east edge of plume	LHSMW06	Evaluate lateral plume expansion



LEGEND

- Proposed DPT Locations
- Plexus Temporary Monitoring Well
- Shallow Monitoring Well
- Shallow/Intermediate Monitoring Well
- Intermediate Monitoring Well
- Deep Monitoring Well
- Previous DPT Location
- Estimated 1,1-DCE Concentration Contour (7 µg/L)
- Estimated TCE Concentration Contour (5 µg/L)
- Estimated PCE Concentration Contour (5 µg/L)
- Estimated Vinyl Chloride Concentration Contour (2 µg/L)
- Stream
- Road
- Former Building or Tank
- Other LHAAP Site
- LHAAP-35A(58) Site

Notes:

1. Concentration contours are based on data from 2003 through 2008.

1,1-DCE: 1,1-dichloroethene
PCE: tetrachloroethene
TCE: trichloroethene
µg/L: micrograms per liter

0 100 200 400 Feet

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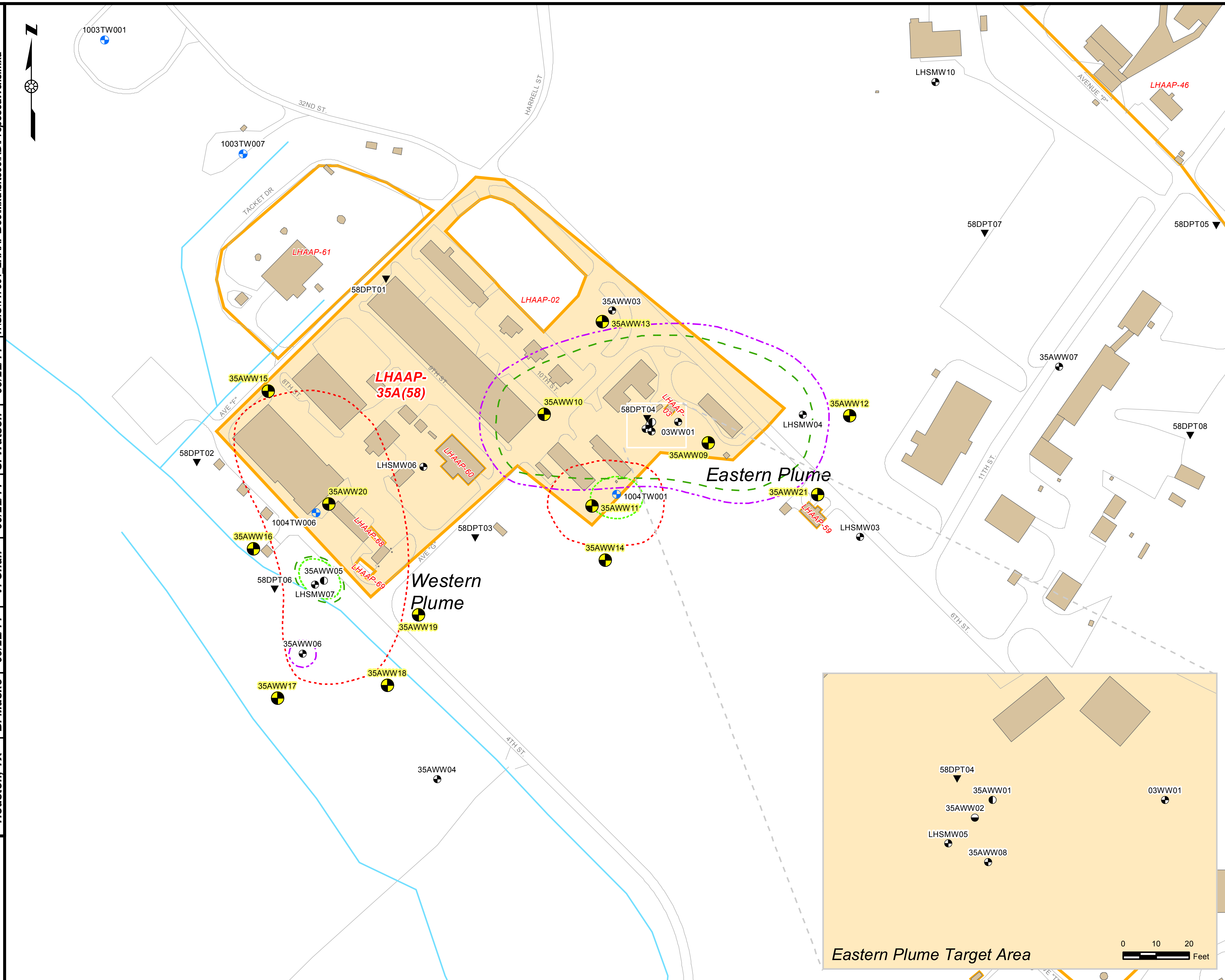
TULSA, OKLAHOMA

FIGURE 3-1

PROPOSED DPT LOCATIONS
LHAAP-35A(58), GROUP 4

LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

OFFICE	DRAWN BY	CHECKED BY	APPROVED BY	FILE PATH
Houston, TX	B. Muske 09/22/11	V. Chan 09/22/11	S. Watson 09/22/11	T:\GIS\117591 LHAAP\Doc\Mxd\Site58\RD\ProposedDptLocations.mxd



LEGEND

- Proposed Well
- Plexus Temporary Monitoring Well
- Shallow Monitoring Well
- Shallow/Intermediate Monitoring Well
- Intermediate Monitoring Well
- Deep Monitoring Well
- Previous DPT Location
- Estimated 1,1-DCE Concentration Contour (7 µg/L)
- Estimated TCE Concentration Contour (5 µg/L)
- Estimated PCE Concentration Contour (5 µg/L)
- Estimated Vinyl Chloride Concentration Contour (2 µg/L)
- Stream
- Road
- Former Building or Tank
- Other LHAAP Site
- LHAAP-35A(58) Site

Notes:

1. Concentration contours are based on data from 2003 through 2008.

1,1-DCE: 1,1-dichloroethene
PCE: tetrachloroethene
TCE: trichloroethene
µg/L: micrograms per liter

0 100 200 400 Feet

Shaw

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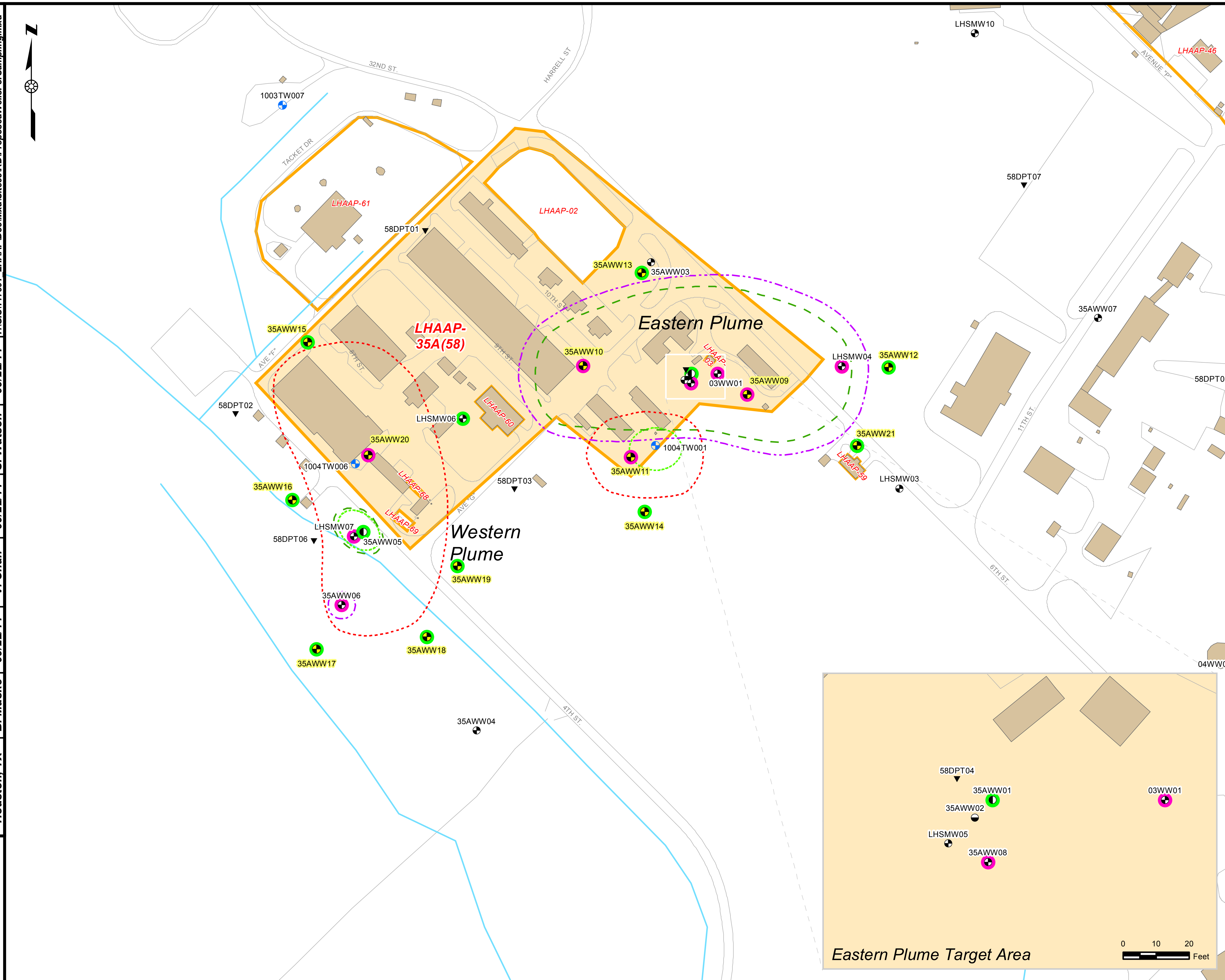
TULSA, OKLAHOMA

FIGURE 3-2

PROPOSED WELL LOCATIONS
LHAAP-35A(58), GROUP 4

LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

OFFICE	DRAWN BY	CHECKED BY	APPROVED BY	FILE PATH
Houston, TX	B. Muske 09/22/11	V. Chan 09/22/11	S. Watson 09/22/11	T:\GIS\117591 LHAAP\Doc\Mxd\Site58\RD\ProposedWells.mxd



LEGEND

- Proposed Well
- Plexus Temporary Monitoring Well
- Shallow Monitoring Well
- Shallow/Intermediate Monitoring Well
- Intermediate Monitoring Well
- Deep Monitoring Well
- DPT Location
- VOCs and Field Parameters Only (12)
- VOCs, Field Parameters, and MNA Parameters (9)
- Estimated 1,1-DCE Concentration Contour (7 µg/L)
- Estimated TCE Concentration Contour (5 µg/L)
- Estimated PCE Concentration Contour (5 µg/L)
- Estimated Vinyl Chloride Concentration Contour (2 µg/L)
- Stream
- Road
- Former Building or Tank
- Other LHAAP Site
- LHAAP-35A(58) Site

Notes:

1. Concentration contours are based on data from 2003 through 2008.

2. Well 03WW01 may need to be abandoned as a consequence of excavation activities at LHAAP-03. 35AWW09 would be the replacement well.

MNA: Monitored Natural Attenuation
VOC: Volatile Organic Compund
1,1-DCE: 1,1-dichloroethene
PCE: tetrachloroethene
TCE: trichloroethene
µg/L: micrograms per liter

0 100 200 400 Feet

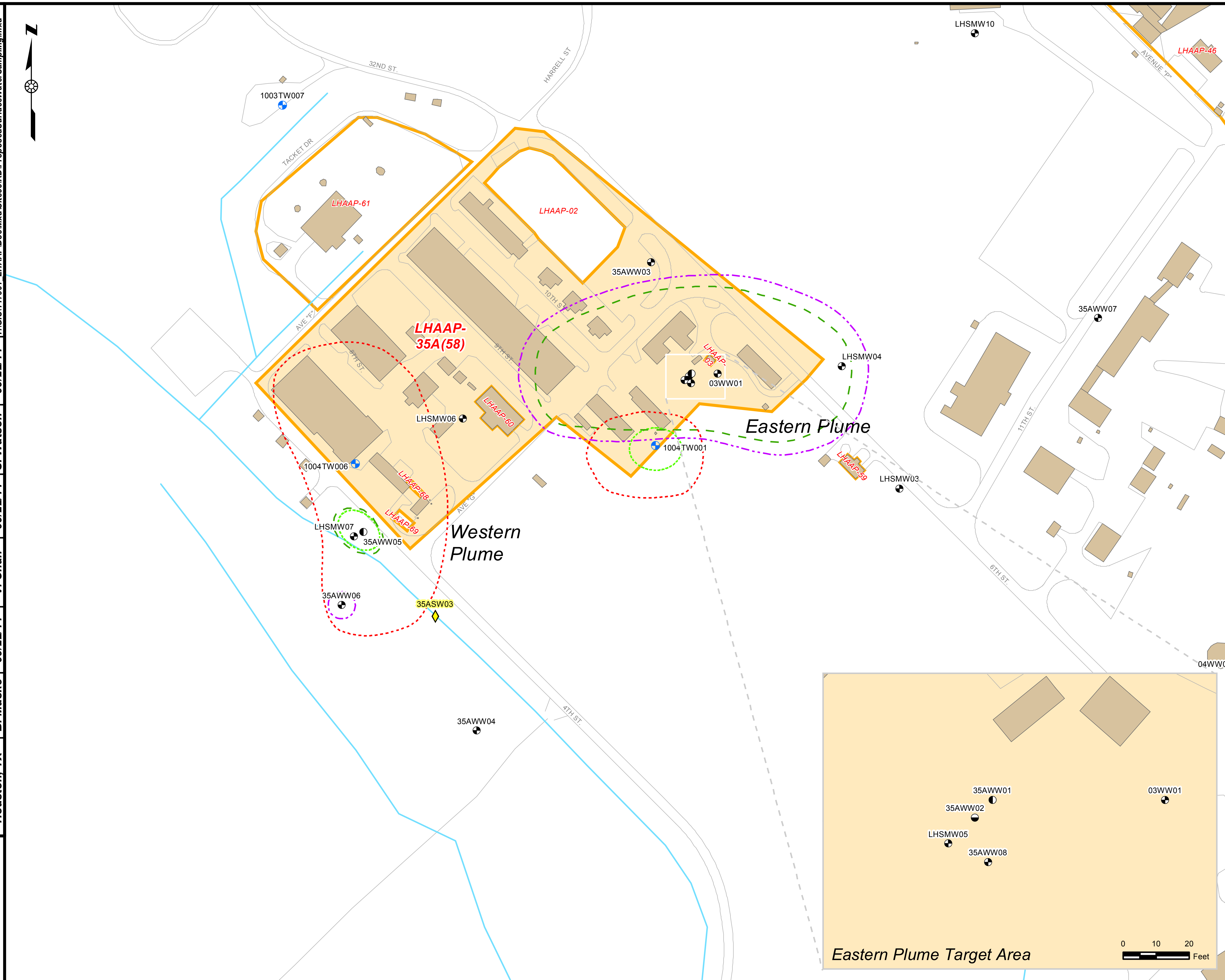
U.S. ARMY CORPS OF ENGINEERS
TULSA DISTRICT
TULSA, OKLAHOMA

FIGURE 3-3

PROPOSED WELLS FOR SAMPLING
LHAAP-35A(58), GROUP 4

LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

OFFICE	DRAWN BY	CHECKED BY	APPROVED BY	FILE PATH
Houston, TX	B. Muske 09/22/11	V. Chan 09/22/11	S. Watson 09/22/11	T:\GIS\117591 LHAAP\Doc\Mxd\Site58\RD\ProposedWellsForSampling.mxd



LEGEND

- New Surface Water Sample Location
- Plexus Temporary Monitoring Well
- Shallow Monitoring Well
- Shallow/Intermediate Monitoring Well
- Intermediate Monitoring Well
- Deep Monitoring Well
- Estimated 1,1-DCE Concentration Contour (7 µg/L)
- Estimated TCE Concentration Contour (5 µg/L)
- Estimated PCE Concentration Contour (5 µg/L)
- Estimated Vinyl Chloride Concentration Contour (2 µg/L)
- Stream
- Road
- Former Building or Tank
- Other LHAAP Site
- LHAAP-35A(58) Site

Notes:

1. Concentration contours are based on data from 2003 through 2008.

MNA: Monitored Natural Attenuation
VOC: Volatile Organic Compund
1,1-DCE: 1,1-dichloroethene
PCE: tetrachloroethene
TCE: trichloroethene
µg/L: micrograms per liter

0 100 200 400
Feet

Shaw

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

FIGURE 3-4

SURFACE WATER SAMPLING LOCATION
LHAAP-35A(58), GROUP 4

LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

OFFICE	DRAWN BY	CHECKED BY	APPROVED BY	FILE PATH
Houston, TX	B. Muske 09/22/11	V. Chan 09/22/11	S. Watson 09/22/11	T:\GIS\117591_LHAAP\Doc\Mxd\Site58\RD\ProposedSurfaceWaterSampling.mxd

4.0 LAND USE CONTROL DESIGN AND IMPLEMENTATION PLAN

This section describes the LUC design and implementation activities for LHAAP-35A(58). The activities will result in a surveyed and recorded groundwater use restriction boundary and an operation and maintenance plan for the LUC.

The objective of the LUC at LHAAP-35A(58) is to 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 site for anything other than environmental monitoring and testing until cleanup goals are met. Notification of the groundwater use restriction will accompany all transfer documents. The U.S. Army is responsible for long-term implementation, maintenance, inspection, reporting, and enforcement of the LUC.

The LUC will address the area of LHAAP-35A(58) that includes two groundwater plumes with levels of contamination that require implementation of a remedy (see **Section 1.3**). The Land Use Control Operation and Maintenance (LUC O&M) Plan will identify the measures required for monitoring and enforcement of the groundwater use restriction. Upon review and concurrence of this RD, the LUC O&M Plan will be coordinated with regulators, finalized, and distributed as part of the Comprehensive LUC Management Plan.

4.1 Land Use Control Implementation

The U.S. Army will undertake the following actions to implement the groundwater restriction LUC for LHAAP-35A(58):

- Define the Area of the Groundwater Use Restriction. The groundwater use restriction boundary will be defined based on the review of the first round of groundwater sampling data in conjunction with historic data. The extent of plume will be bounded by a buffer and may extend to natural groundwater and surface water boundaries.

- Survey the LUC Boundary. The proposed boundary will be finalized after all wells are installed and sampled. Concurrence by USEPA and TCEQ will be obtained, and the LUC boundary will be surveyed by a State-licensed surveyor. A legal description of the surveyed area will be appended to the survey plat.

- Record the LUC in Harrison County. The LUC plat, legal description and groundwater use restriction language will be recorded in the Harrison County Courthouse in accordance with TAC Title 30, §335.566.

- Notify the Texas Department of Licensing and Regulation of the LUC. The Texas Department of Licensing and Regulation will be notified of the groundwater restriction which includes the prohibition of water well installation for any purpose other than environmental monitoring and testing without prior approval from the Army, the USEPA, and the TCEQ. The survey plat, legal boundary and description of the groundwater restriction, in conjunction with a locator map, will be provided in hard and electronic copy.

- Develop the LUC O&M Plan. A LUC O&M Plan for LHAAP-35A(58) will be developed. It will include the elements presented in **Section 4.2**, the county recordation of the LUC survey plat, legal description and restriction language, and the inspection/certification form.

4.2 Land Use Control Operation and Maintenance

The U.S. Army or its representatives will be responsible for the operation and maintenance of the LHAAP-35A(58) LUC. This includes certification, reporting and enforcement activities. The U.S. Army shall address LUC problems within its control that are likely to impact remedy integrity and shall address problems as soon as practicable. To facilitate long-term operation and maintenance of the groundwater use restriction LUC remedy, the U.S. Army will develop a plan that will encompass the elements described in the following subsections.

4.2.1 Site Certification and Reporting

Beginning with finalization of this RD and approval of the inspection form, the U.S. Army will undertake inspections and certify continued compliance with the LUC objectives. The U.S. Army, or the transferee after transfer, will retain the LUC Inspection Certification documents in the project files for incorporation into the five-year review reports, and these documents will be made available to USEPA and TCEQ upon request. In addition, should any violations be found during the certification, the U.S. Army will provide to USEPA and TCEQ, along with the document, a separate written explanation indicating the specific violations found and what efforts or measures have or will be taken to correct those violations. The need to continue certifications will be revisited at five year reviews.

4.2.2 Notice of Planned Property Conveyances

The U.S. Army shall provide notice to USEPA and TCEQ of plans to convey the LHAAP-35A(58) acreage. The notice shall describe the mechanism by which the LUC will continue to be implemented, maintained, inspected, reported, and enforced. Upon transfer, such responsibilities may shift to the transferee via appropriate provisions placed in the Environmental Condition of Property (ECP) or other environmental document for transfer. Although the U.S. Army may transfer responsibility for various implementation actions, the U.S. Army shall retain its responsibility for remedy integrity. This means that the U.S. Army is responsible for addressing substantive violations of the LUC performance objective that would undermine the U.S. Army's CERCLA remedy. The U.S. Army also will be responsible for incorporating RD information and outlining the transferee's LUC obligations into property transfer documentation.

4.2.3 Opportunity to Review Text of Intended Land Use Controls

U.S. Army will provide a copy of the groundwater use restriction notification to TCEQ for review and approval prior to its recordation in Harrison County. USEPA will also receive a copy for review. In addition, the U.S. Army will produce an ECP or other environmental document for transfer of LHAAP-35A(58), but before executing transfer, the U.S. Army will provide USEPA and TCEQ with a copy of the ECP or other environmental document for transfer so that they may have reasonable opportunity, before transfer, to review all LUC-related provisions.

4.2.4 Notification Should Action(s) Which Interfere with Land Use Control Effectiveness be Discovered Subsequent to Conveyance

Should the U.S. Army discover after conveyance of the site any activity on the property inconsistent with the LUC performance objective, the U.S. Army shall notify USEPA and TCEQ within 72 hours of such discovery. Consistent with **Section 4.2.5** below, the U.S. Army will then work with USEPA, TCEQ and the transferee to correct the problem(s) discovered. This reporting requirement does not preclude the U.S. Army from taking immediate action pursuant to its CERCLA authorities to prevent any perceived risk(s) to human health or the environment.

4.2.5 Land Use Control Enforcement

Should the LUC remedy reflected in this RD fail, the U.S. Army will coordinate with USEPA and TCEQ to ensure that appropriate actions are taken to reestablish its protectiveness. These actions may range from informal resolutions with the United States Fish and Wildlife Service (USFWS) or its lessee, to the institution of judicial action against non-federal third-parties. Alternatively, should the circumstances warrant such, the U.S. Army could choose to exercise its response authorities under CERCLA. Should the U.S. Army become aware that any future owner or user of the property has violated any LUC requirement over which a local agency may have independent jurisdiction, the U.S. Army may notify those agencies of such violation(s) and work cooperatively with them to re-achieve owner/user compliance with the LUC.

4.2.6 Modification or Termination of Land Use Controls

The U.S. Army shall not, without USEPA and TCEQ concurrence, make a significant modification to, or terminate a LUC, or make a land use change inconsistent with the LUC objective. Likewise, the U.S. Army shall seek prior USEPA and TCEQ concurrence before commencing actions that may impact remedy integrity. In the case of an emergency action, the U.S. Army shall obtain prior USEPA and TCEQ concurrence as appropriate to the exigencies of the situation.

The LUC shall remain in effect until such time as the U.S. Army and USEPA agree that the concentrations of COCs have met cleanup levels. When this occurs, the LUC will be terminated as needed. The decision to terminate the LUC will be documented consistent with the NCP process for post-ROD changes, potentially including an explanation of significant differences or a remedial action completion report. If the property has been transferred and a determination by the U.S. Army and USEPA has been made to terminate the LUC, the U.S. Army shall provide to the owner of the property an appropriate release for recordation pertaining to the site and will also timely advise other local stakeholders of the action.

4.2.7 Comprehensive Land Use Control Management Plan

Upon finalization of the LUC O&M Plan, a copy will be inserted into the Comprehensive LUC Management Plan for Longhorn. The Comprehensive LUC Management Plan figure and table will be updated to reflect the inclusion of LHAAP-35A(58).

The Comprehensive LUC Management Plan consists of LHAAP RD documents and a survey plat showing the locations where LUCs being implemented at LHAAP are applied. The purpose of this Comprehensive LUC Management Plan is to ensure all site specific LUCs are compiled into one comprehensive location for both pre-transfer use by the installation and for post-transfer use by the transferee. This document will be provided to USEPA and TCEQ, and is also accessible to the local government and the public. The Comprehensive LUC Management Plan is located in the Marshall Public Library to accompany LHAAP's Administrative Record.

The land use assumption of industrial use as part of a national wildlife refuge forms the basis for the remedy at LHAAP-35A(58) and this land use assumption will be included in the Comprehensive LUC Management Plan with supporting documentation.

5.0 IN SITU BIOREMEDIATION DESIGN (EASTERN PLUME TARGET AREA)

The purpose of the in situ bioremediation design at LHAAP-35A(58) is to accelerate the rate of biological degradation of chlorinated ethenes in the shallow groundwater zone of the eastern plume and to create subsurface conditions that are favorable for MNA. In situ bioremediation will be implemented in accordance with the approved Remedial Action Work Plan in a target area where PCE and TCE hotspots are present. The target area encompasses shallow wells 03WW01, 35AWW08, and LHSMW05.

Active treatment was selected for the eastern plume and not the western plume based on the findings of the MNA evaluation of the site, which is provided in Appendix A of the FS (Shaw, 2009). For the western plume, indicators of natural attenuation were adequate to estimate a cleanup time of approximately 200 years. For the eastern plume, indicators of natural attenuation were not adequate to estimate a cleanup time. Thus, a remedy was selected to reduce contaminant mass in the eastern plume and to create more favorable conditions for natural attenuation. In the course of the remedy, additional data will be collected and used to estimate the time to attain cleanup levels.

The active treatment involves injecting a carbon source and a dechlorinating microbial consortium that includes DHC. The role of the carbon source is to provide a food source for indigenous and bioaugmented microorganisms. As the carbon source is metabolized, hydrogen is released which provides available protons required for reductive dechlorination. Competing processes include those that involve other electron acceptors such as oxygen and sulfate. Reductive dechlorination may be delayed until competing electron acceptors have decreased below competing levels.

The microbial consortium SDC-9™ has been shown to completely degrade PCE and TCE to ethene via reductive dechlorination (Environmental Security Technology Certification Program, 2005; Lo, 2008). During reductive dechlorination, the chlorinated ethenes (such as PCE) serve as an electron acceptor and chlorine atoms are sequentially replaced with protons to yield TCE, cis-1,2-DCE, VC, and ethene as daughter products. A common observation is that PCE and TCE are reductively dechlorinated under relatively mild reducing conditions (e.g., sulfate-reducing conditions), whereas reductive dechlorination of cis-1,2-DCE and VC require increasingly stronger reducing conditions (e.g., methanogenic conditions).

A conceptual design of the in situ bioremediation system is presented but the specific design parameter for field implementation is subject to change based on the result of the treatability study. A Remedial Action Work Plan providing more specific design details will be submitted and approved prior to field implementation.

5.1 Injections

The in situ bioremediation injections will utilize ten injection points with a spacing of approximately 20 feet, and with an expected radius of influence of 10 feet, to distribute amendments in the target area, as shown in **Figure 1-3**. The target area is approximately 3,600 square feet. The actual injection spacing will be determined after the completion of the treatability study.

The amendment solution will be injected in the range of 23 to 30 ft bgs. The actual interval will depend on the local lithology at each injection point and the current groundwater elevation. The injection interval was determined by the local lithology as documented in soil borings logs, cross-sections, and the monitoring well construction logs for LHSMW05 and 03WW01. The contaminated saturated zone was determined to be between approximately 23 to 30 feet bgs and therefore is the target interval for this injection.

5.2 Amendments

This section discusses the role of the various amendments, and the bench-scale treatability study that will be conducted. The tentative quantities of amendments to be injected are also presented but are subject to change based on the treatability study. The material safety data sheets for the amendments are included in **Appendix C**.

5.2.1 Components

The injection of the following amendments into the contaminated groundwater will provide the needed elements to reduce the chlorinated ethene mass at LHAAP-35A(58):

- **Emulsified vegetable oil.** A long lasting (3 to 5 years) carbon source to provide both a food and a hydrogen source for the indigenous and bioaugmented microorganisms
- **Sodium bicarbonate or equivalent product.** A buffering agent to maintain the pH of the groundwater at approximately seven, which is optimal for microbial growth
- **SDC-9™ (Shaw's dechlorinating culture) or equivalent product.** A microbial consortium shown to reductively dechlorinate PCE and its degradation daughter products, ultimately yielding harmless by-products

5.2.2 Treatability Study

A treatability test will be conducted to aid in the design and confirm the effectiveness of in situ bioremediation treatment at LHAAP-35A(58). The purpose of the study is to determine the requirements for carbon sources, nutrients, pH buffer, and the microbial consortium

SDC-9™ to stimulate the complete anaerobic reductive dechlorination of PCE and its daughter products. This study will also provide specific parameters for field implementation. A Treatability Study Work Plan will be prepared and submitted prior to the implementation of the Treatability Study.

5.3 Performance Monitoring and Transition to Monitored Natural Attenuation

A baseline sampling event will take place prior to the in situ bioremediation injections. Performance monitoring for in situ bioremediation will be detailed in the Remedial Action Work Plan. Performance monitoring will be used to evaluate the effectiveness of the bioremediation treatment and to determine if additional amendment injections will be necessary.

The duration of the in situ bioremediation segment of the remedy is considered to be from the start of field work in the target area (such as baseline sampling) to the end of the performance sampling program. After six quarters of performance monitoring for in situ bioremediation, the data will be evaluated to determine the effectiveness of the bioremediation in meeting the RAOs. After the end of performance monitoring for in situ bioremediation, the monitoring schedule for the target area will be aligned with the schedule for the rest of the eastern plume.

6.0 FIELD ACTIVITIES

Field activities to be conducted at LHAAP-35A(58) including the field implementation of the in situ bioremediation treatment system will be fully described in the subsequent Remedial Action Work Plan. This section generally describes the field activities planned at LHAAP-35A(58). Site-specific activities are described in associated subsections. The field activities to be conducted under this RD are outlined below:

- Pre-mobilization activities
- Preliminary activities/mobilization
- Site clearing
- DPT groundwater sampling and well installation
- Groundwater and surface water sampling
- Waste management
- Decontamination
- Well abandonment
- Demobilization
- Health and safety
- Quality assurance/quality control

The field activities will be conducted in accordance with the Site-Specific Supplement to Health and Safety Plan (HASP) in **Appendix D**. The work will be routinely inspected in accordance with the Contractor Quality Control Plan (CQCP) in **Appendix E**. Additional information regarding these tasks and standard operating procedures (SOP) can be found in Appendix C, Chemical Data Acquisition Plan (CDAP), and Appendix D, Field Procedures of the *Final Installation-Wide Work Plan* (Shaw, 2006).

6.1 Pre-mobilization Activities

A pre-construction meeting will be held for the U.S. Army, USEPA, TCEQ, and Shaw prior to the initiation of field activities.

The survey to determine the metes-and-bounds for the LUC and the notification of non-residential use will be conducted. The survey will be done by a state-licensed surveyor and the coordinate system will be Texas State Plane, NAD 1983. **Figure 6-1** indicates the LUC boundary that will be surveyed.

Prior to mobilization, Shaw will secure any applicable permits and notifications. These may include federal, state and local requirements, such as obtaining an underground injection control permit and notifying Texas811. Shaw will also secure utility clearance for water, sewer, gas, electric, and communication.

Shaw will inspect LHAAP-35A(58) to identify underground and overhead obstructions that may restrict groundwater monitoring activities or in situ bioremediation and may relocate injection locations to avoid underground and surface obstructions. If power must be shut down, the power outage will be coordinated with groundwater treatment plant (GWTP) and fire station operations.

6.2 Preliminary Activities/Mobilization

Shaw anticipates mobilizing the following personnel:

- Quality control/safety manager
- One laborer/sample technician
- Field engineer for injections
- Geologist
- Drilling subcontractor crew

Those personnel will utilize the following equipment:

- Pickup trucks
- Groundwater monitoring field parameters test equipment
- Groundwater sampling pumps
- Injection rig/DPT rig and injection trailer

Additional equipment will be mobilized as necessary if the field conditions or planned activities merit additional site clearing or well installation.

6.3 Site Clearing

Site maps and a global positioning system (GPS) will be used to locate and identify monitoring wells selected for sampling as shown on **Figure 3-3**. Monitoring wells to be sampled will be cleared of vegetation and biohazards (e.g., poison ivy, stinging insects) to ensure safe access for groundwater sampling.

6.4 Direct-Push Technology Groundwater Sampling and Well Installation

Figures 3-1 and **3-2** show the proposed DPT groundwater sampling locations and 9 proposed new monitoring well locations. The DPT groundwater sampling will improve the delineation of the plumes and aid in finalizing the locations and screen intervals of the new wells. The purposes of the new well locations are provided in **Table 3-2**.

6.5 Groundwater and Surface Water Sampling

Groundwater and surface water sampling will be performed in accordance with the requirements presented in the CQCP (**Appendix E**). Additional details for sampling and analysis are found in the *Final Installation-Wide Work Plan*, Appendix C, CDAP and Appendix D, Field Procedures (Shaw, 2006). Once the RD is approved, the schedule for sampling will be determined and added to the LHAAP-wide monitoring schedule.

6.5.1 Monitored Natural Attenuation

The monitoring portion of MNA will be accomplished by collecting groundwater samples from the 17 wells shown on **Figure 3-3**. In the eastern plume MNA area and the western plume, performance monitoring for MNA begins with the start of field work. In the eastern plume target area, performance monitoring for MNA will follow the in situ bioremediation segment of the remedy. Groundwater elevations will be measured in these and several surrounding wells to evaluate groundwater flow direction. Groundwater elevations are particularly important at LHAAP-35A(58) because the water table has been changing over the years, and has generally been getting deeper.

The electronic interface probe used to measure depth to groundwater in monitoring wells and pumps used for well development, purging and sampling will be decontaminated prior to use at each well. The equipment will be decontaminated using a non-phosphate detergent (such as Alconox, Liquinox, or equivalent), followed by two potable water rinses, one deionized water rinse, and air dried. Decontamination fluids will be containerized for subsequent disposal. Clean single use disposable equipment (tubing or bailers) may be used for sampling a well without this decontamination process.

Groundwater monitoring for MNA will be conducted quarterly for two years. All collected groundwater samples will be analyzed for VOCs and the following field parameters: pH, temperature, ORP, DO, conductivity, and turbidity. A subset of the groundwater samples (03WW01, 35AWW06, 35AWW08, 35AWW09, LHSMW04, LHSMW07), those from wells historically within the groundwater plume, will also be tested for the following MNA parameters: DHC, alkalinity, common anions (chloride, sulfate, nitrate, nitrite), sulfide, TOC, dissolved iron and manganese, total phosphorus, carbon dioxide and dissolved gases (methane, ethane, ethene), total iron, and ferric iron. Also, the following additional MNA parameters are considered optional, and may be collected: hydrogen and volatile fatty acids. **Table 6-1** indicates the analytical parameters for each well. **Table 6-2** lists the test methods, sample container, and sample preservation requirements.

Any performance monitoring well found to be dry during quarterly sampling of the MNA performance monitoring will be replaced in the same quarter. The location of the replacement well will be adjacent to the dry well.

6.5.2 Long-Term Monitoring

After the first two years, the effectiveness of MNA will be evaluated (**Section 7.1**). If the MNA evaluation determines MNA to be effective, the analytical suite will be reduced to only VOCs, and the frequency of sampling will be reduced to semiannual sampling for three years, then annually until the next five-year review. Further reductions in sampling will depend on results of five-year reviews, but sampling will continue at least once every five years until cleanup levels are attained.

6.5.3 Surface Water Sampling

Annual sampling of the surface water location indicated in **Figure 3-4** will be conducted as described in **Section 3.6**.

6.6 In Situ Bioremediation

Field implementation of the in situ bioremediation will be performed in accordance with the approved Remedial Action Work Plan.

6.7 Waste Management

This section specifies methods and procedures to be implemented by Shaw to verify that waste generated during site activities are handled, transported, stored, and disposed in compliance with applicable federal, state, and local rules and regulations. Waste management activities will be conducted in accordance with the requirements presented in Task 3 of the CQCP (**Appendix E**).

Description of Wastes. Groundwater sampling activities at LHAAP-35A(58) are expected to generate the following waste streams:

Waste Type	Estimated Quantity	Disposal Method
Decontamination Water – Non-Hazardous Waste	100 gallons [(2) 55-gallon drums]	LHAAP Groundwater Treatment Plant (GWTP)
Miscellaneous Wastes (personal protective equipment, paper towels, rags, well casings, etc.)	---	Municipal Solid Waste

Waste Handling. The liquid waste will be disposed at the GWTP at LHAAP-18/24. If at some point in the future when the GWTP may cease its operations, water will be handled in accordance with current regulations at that time, and will be transported and disposed of off-site. Additional details for disposal sampling are found in the *Final Installation-Wide Work Plan*, Appendix C, CDAP and Appendix D, Field Procedures (Shaw, 2006).

The non-hazardous decontamination and purge water will be stored in 55-gallon drums until disposal at the LHAAP GWTP. The miscellaneous wastes will be placed in plastic bags until disposal.

The miscellaneous wastes will be disposed of at an off-site municipal solid waste facility.

6.8 Decontamination of Equipment and Personnel

A permanent decontamination station is located at the on-site GWTP at LHAAP-18/24 and can accommodate large equipment. Temporary decontamination pads will be constructed at an approved on-site location as needed to decontaminate equipment and prevent cross-contamination between well locations. The decontamination pad will be approximately 15 feet in length and width, bermed, and covered with high-density polyethylene sheeting. Wash water will be contained and transported to the GWTP for disposal when necessary. Reusable equipment will be decontaminated between groundwater sampling locations and prior to leaving the site. Further information on decontamination procedures are found in the *Final Installation-Wide Work Plan*, Appendix D, Field Procedures (Shaw, 2006).

6.9 Well Abandonment

Wells that have been dry, are not needed to gather groundwater level measurements, or are not part of the planned monitoring system, will be abandoned. The wells tentatively planned to be abandoned are indicated on **Figure 6-2**. Final recommendation for well abandonment will be submitted as part of the LTM recommendations in the MNA Performance Evaluation Report. Well abandonment will follow the well abandonment procedures in the *Final Installation-Wide Work Plan*, Section 3.9 (Shaw, 2006).

A separate mobilization will be made for well abandonment activities. The waste generated from these activities (concrete, well casings, etc.) will be disposed off site at an approved solid waste landfill.

Once the well abandonment has been completed, Shaw will restore the areas and demobilize. Areas disturbed in the course of well abandonment will be regraded to blend with the surrounding topography.

6.10 Demobilization

Upon completion of well abandonment operations, Shaw will remove any temporary facilities, perform final equipment decontamination, and demobilize personnel and equipment.

6.11 Health and Safety

The HASP (the latest revision of Appendix A of the *Final Installation-Wide Work Plan* [Shaw, 2006]) incorporates health and safety policies and safe operating procedures for individual project site activities. These procedures allow work activities to be carried out in a controlled, effective manner, consistent with Shaw policies and USACE requirements (USACE, 2008).

Information specific to the activities at the LHAAP-35A(58) is provided in **Appendix D**. This information includes personal protective equipment levels, air monitoring requirements, and activity hazard analyses. These items supplement the HASP; they do not replace it. This information is not addressed by the site-wide HASP because the hazards are unique to the proposed work.

Prior to initiating work at the facility for any site, workers will have signed the HASP in the designated area to indicate they have read and understood the document. Also, daily safety meetings will be held with all field crew members prior to starting work each day in order to review the day's scope of work, any site conditions expected, and any hazards that need to be addressed or acknowledged.

6.12 Quality Assurance/Quality Control

The CQCP provides information on quality assurance/quality control (QA/QC) procedures for this project. The CQCP identifies personnel, procedures, controls, instructions, tests, verifications, documents, and forms to be used and the types of records to be maintained. The CQCP addresses quality control requirements specific to each major feature of work, including special steps that apply to LHAAP-35A(58). The CQCP is provided in **Appendix E**.

The USACE Three-Phase QC process will be used to enforce QA/QC requirements and include preparatory inspections, initial inspections, and follow-up inspections. The three-phases of inspections will target each definable feature of work during the execution of project activities.

Table 6-1
Sample Parameters

Well	Groundwater Zone	VOCs	Field Parameters	MNA Parameters
Eastern Plume Target Area (in situ bioremediation)				
03WW01 [a]	Shallow	✓	✓	✓
35AWW08	Shallow	✓	✓	✓
35AWW09 (proposed)	Shallow	✓	✓	✓
Eastern Plume (MNA)				
35AWW01	Intermediate	✓	✓	
35AWW10 (proposed)	Shallow	✓	✓	✓
35AWW11 (proposed)	Shallow	✓	✓	✓
35AWW12 (proposed)	Shallow	✓	✓	
35AWW13 (proposed)	Shallow	✓	✓	
35AWW14 (proposed)	Shallow	✓	✓	
35AWW21 (proposed)	Shallow	✓	✓	
LHSMW04	Shallow	✓	✓	✓
Western Plume (MNA)				
35AWW05	Intermediate	✓	✓	
35AWW06	Shallow	✓	✓	✓
35AWW15 (proposed)	Shallow	✓	✓	
35AWW16 (proposed)	Shallow	✓	✓	
35AWW17 (proposed)	Shallow	✓	✓	
35AWW18 (proposed)	Shallow	✓	✓	
35AWW19 (proposed)	Shallow	✓	✓	
35AWW20 (proposed)	Shallow	✓	✓	✓
LHSMW06	Shallow	✓	✓	
LHSMW07	Shallow	✓	✓	✓

Notes and Abbreviations:

[a] *If 03WW01 is abandoned as a consequence of excavation activities at LHAAP-03, a replacement well will be installed.*

Field parameters: pH, temperature, oxidation reduction potential, dissolved oxygen, conductivity, and turbidity.

MNA parameters (only first two years): dehalococcoides, alkalinity, common anions (chloride, sulfate, nitrate, nitrite), sulfide, total organic carbon, dissolved iron and manganese, total phosphorus, carbon dioxide and dissolved gases (methane, ethane, ethene), total iron, and ferric iron. Optional parameters: hydrogen and volatile fatty acids.

MNA monitored natural attenuation
VOCs volatile organic compounds included in the COC list in ***Table 1-1***

Table 6-2
Sample Methods, Containers, and Preservation

Parameter	Minimum Sample Volume	Holding Time	Preservation	Method
Water				
Volatile organic compounds (VOCs)	3x40 mL glass vial with PTFE septa cap	14 days	pH < 2 HCl, Cool to 4°C, no headspace	8260B (or latest method)
Dehalococcoides (DHC)	2x1 L amber glass bottles with teflon-lined cap(s)	14 days	Cool to 4°C	polymerase chain reaction (PCR)
Alkalinity (total, carbonate and bicarbonate)	250 mL polyethylene bottles	14 days	Cool to 4°C	EPA 310.2
Common anions (chloride [Cl], sulfate [SO4], nitrate [NO3], nitrite	250 mL polyethylene bottles	28 days (Cl/SO4) and 48 hours (individual NO3 and NO2)	Cool to 4°C	EPA 300.0
Nitrate/nitrite as N	500 mL polyethylene bottles	28 days	pH<2 H2SO4, Cool to 4°C	EPA 353.2
Sulfide	250 mL polyethylene bottles	7 days	pH>9 zinc acetate plus NaOH, Cool to 4°C	EPA 376.1
Total organic carbon (TOC)	125 mL polyethylene bottles	28 days	pH<2 H2SO4 or HCl, Cool to 4°C	EPA 415.1
Dissolved iron and manganese	500 mL polyethylene bottles	6 months	pH<2 HNO3, Cool to 4°C	6010B
Phosphorus, total	100 mL polyethylene bottles	28 days	pH<2 H2SO4, Cool to 4°C	EPA 365.4
Carbon dioxide and dissolved gases (methane/ethane/ethene)	3x40 mL glass vial with PTFE septa cap	14 days	Cool to 4°C	RSK 175
Iron, total	500 mL polyethylene bottles	6 months	pH<2 HNO3, Cool to 4°C	6010B
Ferrous iron	100 mL polyethylene bottles	Immediate	Cool to 4°C	3500-Fe
**Ferric iron	NA	NA	NA	NA

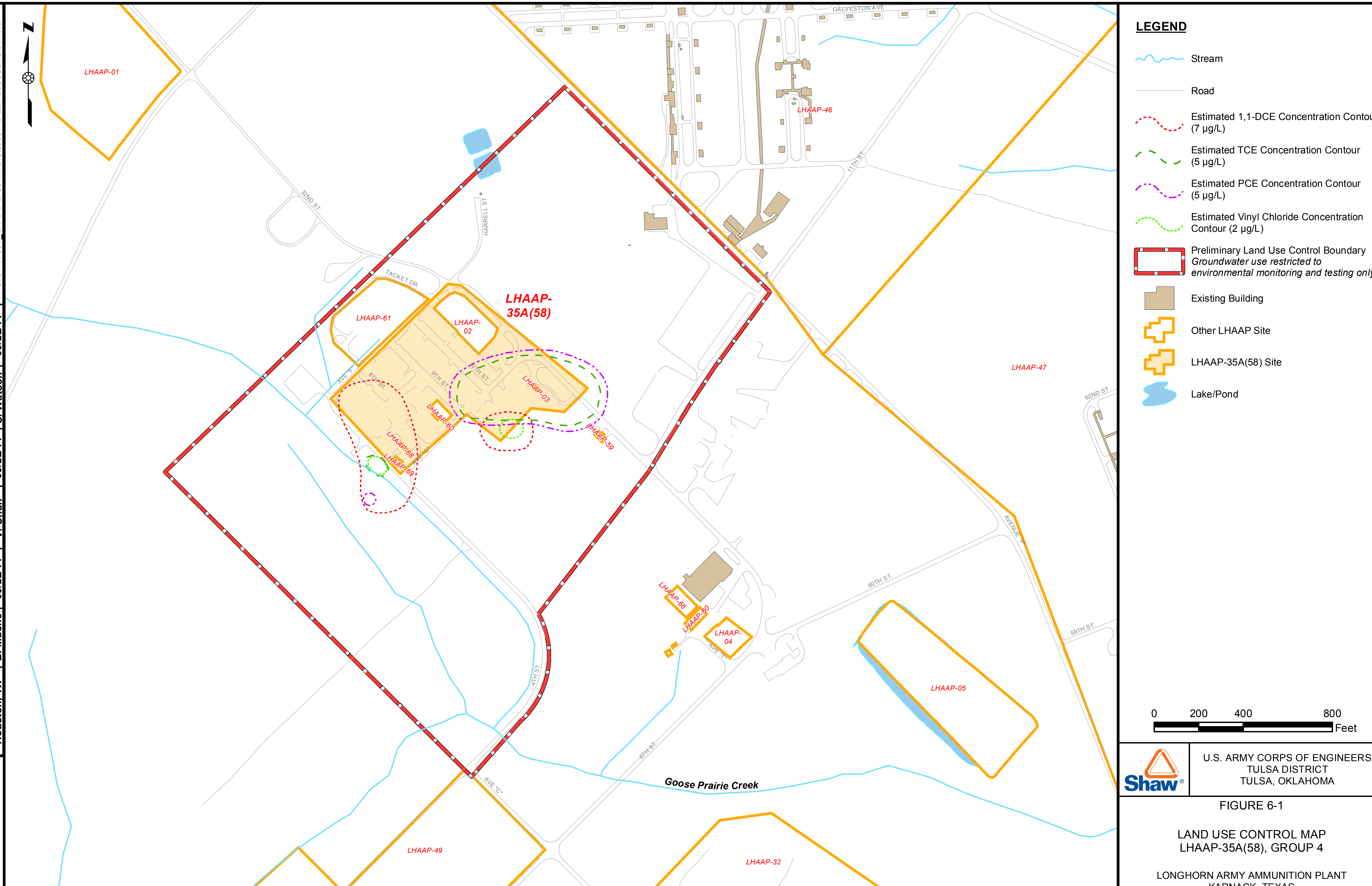
Notes and Abbreviations:

The above listed volumes provide an adequate quantity of samples to anaylyze a matrix spike (MS) and matrix spike duplicate (MSD).

** Ferric Iron is difference between total iron and ferrous iron

°C - degrees centigrade

EPA - Environmental Protection Agency
H2SO4 - sulfuric acid
HCl - hydrochloric acid
HNO_3 - nitric acid
L - liter
mL - milliliter
NA - not analyzed
PTFE - polytetrafluoroethylene



OFFICE	DRAWN BY	CHECKED BY	APPROVED BY	FILE PATH
Houston, TX	B. Muske 09/22/11	V. Chan 09/22/11	S. Watson 09/22/11	T:\GIS\117591 LHAAP\Doc\Mxd\Site58\RD\LanduseControl.mxd

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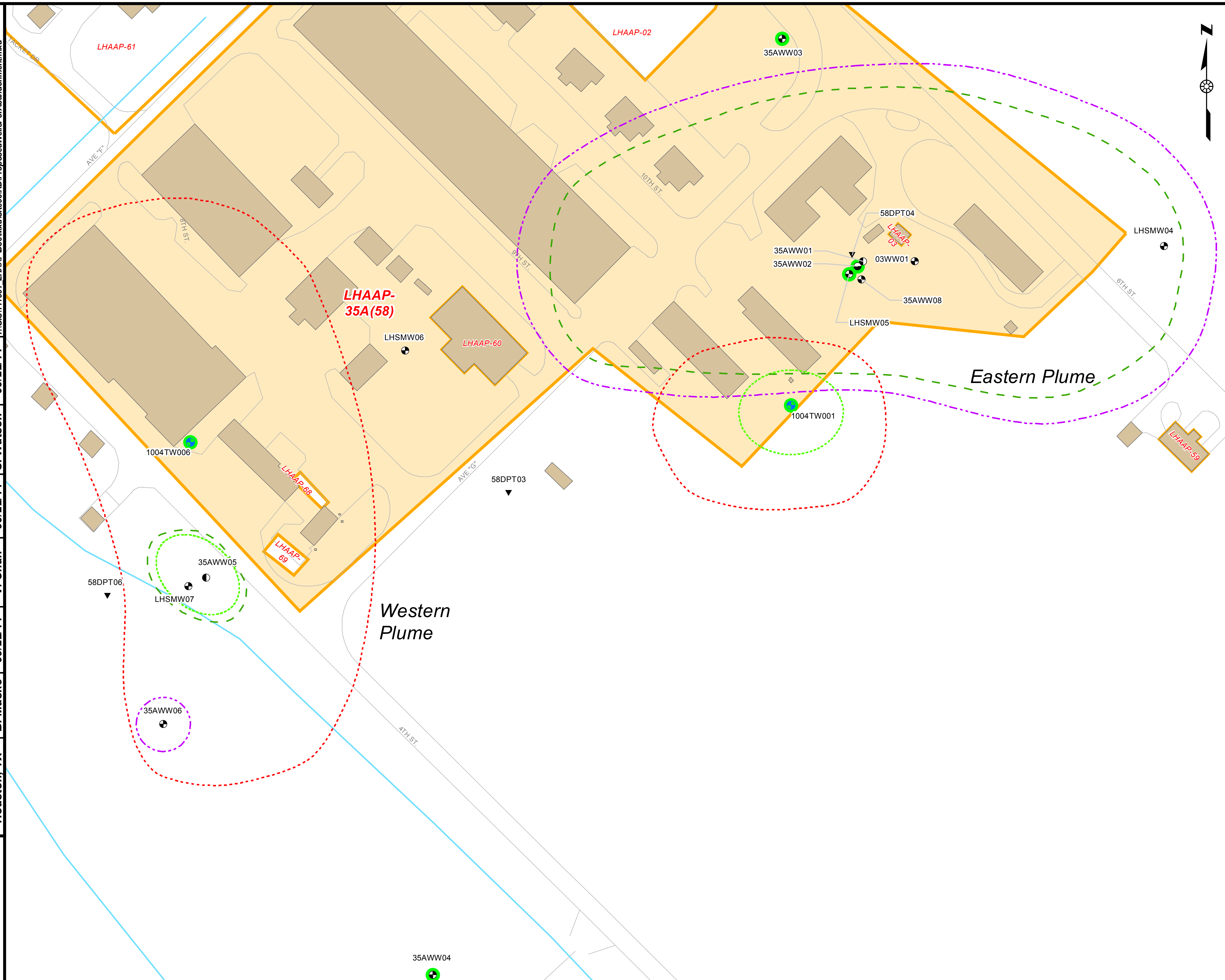
TULSA DISTRICT
TULSA, OKLAHOMA

FIGURE 6-1

LAND USE CONTROL MAP
LHAAP-35A(58), GROUP 4

LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS



LEGEND

- Plexus Temporary Monitoring Well
- Shallow Monitoring Well
- Shallow/Intermediate Monitoring Well
- Intermediate Monitoring Well
- Deep Monitoring Well
- DPT Location
- Proposed Wells for Abandonment (6)
- Estimated 1,1-DCE Concentration Contour (7 µg/L)
- Estimated TCE Concentration Contour (5 µg/L)
- Estimated PCE Concentration Contour (5 µg/L)
- Estimated Vinyl Chloride Concentration Contour (2 µg/L)
- Stream
- Road
- Former Building or Tank
- Other LHAAP Site
- LHAAP-35A(58) Site

Notes:

1. Concentration contours are based on data from 2003 through 2008.

1,1-DCE: 1,1-dichloroethene
PCE: tetrachloroethene
TCE: trichloroethene
µg/L: micrograms per liter

0 50 100 200 Feet

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FIGURE 6-2

PROPOSED WELLS FOR ABANDONMENT
LHAAP-35A(58), GROUP 4

LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

OFFICE	DRAWN BY	CHECKED BY	APPROVED BY	FILE PATH
Houston, TX	B. Muske 09/22/11	V. Chan 09/22/11	S. Watson 09/22/11	T:\GIS\117591 LHAAP\DocMxd\Site58\RD\ProposedWellsForAbandonment.mxd

7.0 REMEDY PERFORMANCE REPORTING

Reporting will consist of annual reports, the MNA evaluation report for the western plume and eastern plume MNA area, the in situ bioremediation evaluation report for the eastern plume target area, and five-year review reports. Annual reports will be prepared at the end of each calendar year in which groundwater samples are collected. The MNA evaluation will be prepared once, using the eight episodes of quarterly sampling results from the first two years combined with historical sampling results. The in situ bioremediation report will be prepared once, using the six episodes of quarterly sampling results for the eastern plume target area. The five-year reviews will be prepared once every five years for as long as groundwater sampling is required (until cleanup levels are achieved).

7.1 Monitored Natural Attenuation Evaluation

After eight quarters of groundwater monitoring have been completed, an MNA evaluation will be conducted and an MNA Evaluation Report prepared. MNA performance criteria are listed in **Table 7-1**. Compilation of the information for the evaluation will occur throughout the first two years of quarterly groundwater monitoring. The MNA Evaluation Report will include:

- Figures of the site, wells, and groundwater level contours
- Tables of groundwater and surface water sample results
- Comparison of plume extent and concentration over time (**Table 7-1**, Performance Criteria 1)
- Consideration of the first and second lines of evidence for MNA and optionally the third line if necessary (**Table 7-1**, Performance Criteria 2 through 4)
- An evaluation of the effectiveness of MNA at the site
- A recommendation for continued MNA, in situ bioremediation, or another remedy

7.1.1 Migration/Expansion

For the evaluation of MNA at LHAAP-35A(58) to be favorable, the MNA evaluation should demonstrate decreasing plumes, although stable plumes may be considered acceptable in the short term. A groundwater plume is stable when pollutant concentrations and the plume's footprint are stable. A stable plume shows that pollutant migration in groundwater is under control. The determination of plume dynamics should be performed for all relevant contaminants and their biodegradation daughter products.

A decreasing plume is diminishing in concentration and its location is not migrating or expanding. This occurs when the attenuation rates for dissolved-phase pollutants exceed their generation rates from all sources. Sources that are sustaining the dissolved-phase plume may include pollutants sorbed to fine-grained, low-permeability materials located throughout the plume. A decreasing plume supports natural attenuation as a viable remedial alternative.

Table 7-1
Monitored Natural Attenuation Evaluation Performance Criteria

Performance Criteria	Type	Expected Performance	Commentary
1) Migration/Expansion	Qualitative	Stable or shrinking size, stable position	An expanding or migrating plume indicates MNA should not be continued
2) Concentrations	Quantitative	Falling concentrations or mass in the majority of performance wells	First Line of Evidence
3) Aquifer Conditions	Qualitative	Conditions favorable for natural attenuation	Second Line of Evidence
4) Microcosm Studies	Qualitative	Detectable presence of appropriate microorganisms	Third Line of Evidence

Monitoring must occur over a time period sufficient to demonstrate plume stability or plume reduction under natural conditions. This may take up to several years depending on site-specific conditions, including the monitoring data trend analysis, potential threats to beneficial uses, and other uncertainties. If monitoring data do not demonstrate plume stability/decrease, this may indicate that further plume remediation is necessary. The two years of quarterly sampling, combined with historic sampling data, will provide sufficient data for stability and trend analysis. MNA cannot continue as a sole remedy if the plume is clearly migrating.

7.1.2 First Line of Evidence

The first line of evidence is to evaluate historical groundwater data seeking to demonstrate a clear and meaningful trend of decreasing contaminant mass and/or concentration over time at appropriate monitoring or sampling points. In the case of a groundwater plume, decreasing concentrations should not be solely the result of plume migration. Thus, other performance wells will be evaluated to determine if the plume is migrating.

Concentrations of COCs can be evaluated at individual wells to calculate a time-based attenuation rate. They can be evaluated across multiple wells through the centerline of a plume to calculate a distance–based attenuation rate. Average plume concentrations or mass can be evaluated if a consistent set of wells is sampled over multiple sampling episodes.

These calculations will be performed using the methods contained in the *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater* (USEPA, 1998).

Time-based attenuation rates will be calculated for any monitoring well that shows COC concentration exceedances of cleanup levels during the eight episodes of quarterly sampling. Distance-based attenuation rates will be calculated through the highest concentration wells along the direction of groundwater flow. Attenuation rates based on average plume concentrations or mass will be calculated if the dataset will support the process. Monitoring wells 35AWW08 and 03WW01 are expected to be the primary focus of analysis at LHAAP-35A(58) because they represent the highest concentration area at LHAAP-35A(58). Thus, the data from these wells will be evaluated to determine if there is a clear and meaningful trend of decreasing concentrations and/or mass.

7.1.3 Second Line of Evidence

Decreasing concentration trends by themselves are not sufficient evidence that COCs are being destroyed. The second line of evidence uses chemical analytical data in mass balance to show that decreases in contaminant and electron acceptor/donor concentrations can be directly correlated to increases in metabolic end products or daughter compounds. The evidence can be used to show the groundwater conditions are sufficiently favorable to natural attenuation so that degradation of chlorinated solvent contaminants can occur.

The second line of evidence evaluates parameters such as nitrates, sulfates, ferrous iron, dissolved oxygen, ORP, nitrate, ferrous iron, sulfate, methane, ethane and ethene, chloride, TOC, carbon dioxide, alkalinity, pH and phosphorous. The results of tests for these analytes will be interpreted using the *Technical Protocol for Evaluating Attenuation of Chlorinated Solvents in Ground Water* (USEPA, 1998).

For the MNA evaluation, if COC concentrations are decreasing and the groundwater geochemistry in the plume area are favorable for the occurrence of degradation, then MNA may continue to be applied at the site. If groundwater conditions are unfavorable to the extent that any decrease in concentrations must be attributed to migration, then more aggressive treatment will be evaluated as a contingency remedy.

7.1.4 Third Line of Evidence

The third line of evidence consists of data from field or microcosm studies (conducted in or with actual contaminated site media) which directly demonstrate the occurrence of natural attenuation processes at the site and its ability to degrade the contaminants of concern (typically used to demonstrate biological degradation processes only).

For the MNA evaluation, the presence of microorganisms (DHC) in the groundwater capable of degrading the COCs would be favorable to continued MNA. If such organisms are absent, and the first two lines of evidence are not favorable, then more aggressive treatment should be evaluated as a contingency remedy.

7.1.5 Monitored Natural Attenuation Performance Evaluation

The completed Preliminary Draft Monitored Natural Attenuation Evaluation will be submitted to the U.S. Army for review and comment. Following this, a Draft Final Monitored Natural Attenuation Evaluation will be submitted to the regulatory agencies for review and comment. A Draft Final Monitored Natural Attenuation Evaluation will address the regulatory comments and will be submitted for review. When regulatory agency comments have been resolved, the Final Monitored Natural Attenuation Evaluation will be issued. The Final Monitored Natural Attenuation Evaluation will determine whether MNA continues to be the remedial action applied at LHAAP-35A(58), or whether another more aggressive treatment should be evaluated as a contingency remedy.

The first and second lines of evidence will be evaluated for decreasing COC concentrations and optimal geochemical conditions to demonstrate MNA. The third line of evidence will be evaluated if necessary. If the MNA evaluation determines that MNA is not an effective sole remedy, then an explanation of significant difference will be prepared and an amendment to this document will be made to design and implement a contingency remedy. This contingency remedy is expected to be a form of bioremediation as included in the ROD (U.S. Army, 2010), but the final design of the contingency remedy will be determined by the results of groundwater samples collected during the MNA performance monitoring period. The MNA Performance Evaluation Report will also include recommendations for future LTM and well abandonments.

7.2 In Situ Bioremediation Evaluation

After six quarters of performance monitoring have been completed in the eastern plume target area, an in situ bioremediation evaluation will be conducted and the report will be prepared. The objective of the evaluation will be to determine whether the injections in the eastern plume target area have been effective, or whether a second round of injections is appropriate. If there is a second round of injections, the final design for that will be determined by the results of groundwater sampling during performance monitoring. The report will include:

- Figures of the site, wells, and groundwater level contours
- Tables of groundwater sample results for the target area

- Comparison of plume extent and concentrations over time; the overall level of VOCs is anticipated to be reduced by approximately 90% over the course of the 1.5 years of performance monitoring
- An evaluation of the effectiveness of in situ bioremediation in the target area at creating conditions favorable for MNA, based on the first and second lines of evidence
- A recommendation on whether a second round of injections is appropriate; if there is a second round of injections, the final design for that will be determined by the results of groundwater samples collected during performance monitoring

The completed Preliminary Draft In Situ Bioremediation Evaluation will be submitted to the U.S. Army for review and comment. Following this, a Draft In Situ Bioremediation Evaluation will be submitted to the regulatory agencies for review and comment. A Draft Final In Situ Bioremediation Evaluation will address the regulatory comments and will be submitted for review. When regulatory agency comments have been resolved, the Final In Situ Bioremediation Evaluation will be issued.

7.3 Annual Reports

An annual report will be prepared at the end of each year of LTM in which groundwater samples are collected to present groundwater sample results, a description of field activities, and to document other relevant information that may be considered useful for the five-year review. The annual report will include:

- A narrative of field activities
- Figures of the site and wells and groundwater levels
- Tables of groundwater and surface water sample results
- Copies of field paperwork, including disposal documentation
- Relevant photographs

Perimeter well data will be evaluated for plume migration while the data from wells within the plume areas will be evaluated for MNA performance.

7.4 Five-Year Review Reports

Five-year reviews will be performed for LHAAP-35A(58) (U.S. Army, 2010). While the intent is to perform these reviews every 5 years after the implementation of the remedy (i.e., remedy in place), the performance of the first Five-Year Review will be aligned with the Base-Wide Five-Year Review. The Five-Year Review report will present summaries of information from the annual reports and from the five-year sampling event, evaluate that information, and recommend the future course of action. The Five-Year Review will include:

- A narrative of field activities for the past five years
- Figures of the site and well locations
- Summary of groundwater and surface water sample results
- Site inspection with relevant photographs
- Evaluation of progress toward cleanup levels
- Results/summary of the annual LUC inspections
- Revisions to the LUC or monitoring schedules
- Recommendations for future actions

The progress toward cleanup levels will be evaluated in the five-year report. The Five-Year Review offers the periodic opportunity to declare the site successfully and completely remediated, progressing satisfactorily toward remediation, or in need of more aggressive remedy. When cleanup levels are reached, monitoring may cease as recommended in the Five-Year Review.

8.0 SCHEDULE

The estimated length of time for groundwater monitoring activities including site setup, clearing, groundwater sampling, waste management and site restoration is approximately one week for each sampling episode. The estimated length of time to complete eight quarters of groundwater sampling and prepare the MNA evaluation report is approximately two and one half years. The estimated lengths of time for the treatability study and for injection field work are two months and one week, respectively. **Tables 8-1** and **8-2** show the anticipated duration for each of the major site activities for the eastern plume target area and the MNA areas, respectively. Shaw's mobilization to LHAAP-35A(58) for the first round of MNA performance sampling is anticipated to begin in July 2011 after final approval of this document.

Table 8-1
Durations for Major Site Activities – Eastern Plume Target Area

Activities	Duration	Elapsed Time
Establish land use control	1 month	1 month
DPT GW sampling and well installation	1 month	1 month
Treatability study	2 months	2 months
In situ bioremediation injections	1 week	3 months
Mobilization / site setup	1 day	-
Production of anaerobic water	1 day	-
Direct push injections	5 days	-
Demobilization	1 day	-
Quarterly monitoring for bioremediation, quarter 1	3 months	6 months
Mobilization / site setup	1 day	-
Groundwater sampling	4 days	-
Demobilization	1 day	-
Estimated duration	6 days per episode	-
Quarterly monitoring, quarters 2 through 6	15 months	2 years
In situ bioremediation evaluation	0.5 year	2.5 years
Quarterly monitoring for MNA	2 years	4 years
MNA evaluation (final document)	0.5 year	4.5 years
Well abandonment	2 days	4.5 years
Five-year review	0.5 year	5 years
Semi-annual monitoring	3 years	7 years
Annual monitoring (years 8 through 10)	2 years	10 years
Sample once every 5 years (repeat until cleanup levels are met)	-	15, 20, 25 years, etc.
Achieve cleanup levels	-	Estimate TBD

Notes and Abbreviations:

Does not include pre-mobilization activities or rerouting of utilities.
Includes expectation of favorable in situ bioremediation and MNA evaluations.
Schedule revision expected after MNA evaluation and five-year review.

MNA monitored natural attenuation
TBD to be determined

Table 8-2
Durations for Major Site Activities – Eastern Plume Monitored Natural Attenuation Area and Western Plume

Activities	Duration	Elapsed Time
Establish land use control	1 month	1 month
DPT GW sampling and well installation	1 month	1 month
Quarterly monitoring for MNA (quarter 1)	3 months	3 months
Mobilization / site setup	1 day	-
Groundwater sampling	4 days	-
Demobilization	1 day	-
Estimated duration	6 days per episode	-
Quarterly monitoring, quarters 2 through 8	1.75 year	2 years
MNA Evaluation (final document)	0.5 year	2.5 years
Well abandonment	2 days	2.5 years
Semi-annual monitoring	3 years	5 years
Five-year review	0.5 year	5 years
Annual monitoring (years 5 through 10)	5 years	10 years
Sample once every 5 years (repeat until cleanup levels are met)	-	15, 20, 25 years, etc.
Achieve cleanup levels	-	200 years

Notes and Abbreviations:

Does not include pre-mobilization activities or rerouting of utilities.
Includes expectation of favorable MNA evaluation.
Schedule revision expected after MNA evaluation and five-year review.

MNA monitored natural attenuation

9.0 REFERENCES

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Lo et al, 2008, *Comparison of Two Bioaugmentation Cultures for Trichloroethene Reductive Dechlorination in the Presence of Chloroform and Trichloroethane*, Proceedings of the Sixth International Conference of Remediation of Chlorinated Recalcitrant Compounds, May.

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USACE, 2008, *Safety and Health Requirements Manual*, EM 385-1-1, September.

U.S. Environmental Protection Agency (USEPA), 1998, *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater,* EPA/600/R-98/128, September.

USEPA, 1999, *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites*, Directive 9200.4-17P. USEPA Office of Solid Waste and Emergency Response, Washington, DC.

Appendix A

Inspection/Certification Form

Sample Annual Land Use Control Compliance Certification Documentation

In accordance with the Remedial Design dated __________ for LHAAP-35A(58) a certification of site was conducted by _____________________ [indicate transferee] on __________.

A summary of land use control mechanisms is as follows:

- Groundwater restriction –restriction of the use of groundwater to environmental monitoring and testing until cleanup goals are met [Indicate whether groundwater restrictions are still required at LHAAP-35A(58)]

A summary of compliance with land use and restriction covenants is as follows:

- No use of groundwater, installation of new groundwater wells, or tampering with existing wells at LHAAP-35A(58)

I, the undersigned, do document that the certification was performed as indicated above, and that the above information is true and correct to the best of my knowledge, information, and belief.

Date: ______________________________

Name/Title: ____

Signature: ______________________________

Annual compliance certification forms shall be completed no later than March 1 of each year for the previous calendar year.

Attachments

- **Metes and Bound Survey of Area for LUC Implementation**
- **Monitoring Well Logs**
- **Notice of Filed Land Use Controls for LHAAP-35A(58)**

The attachments will be submitted once the surveys are completed; the well system is defined and wells are installed; and the notification is filed.

Appendix B

Well Construction Diagrams and Boring Logs

03WW01

WELL COMPLETION FORM (Stickup or Above Grade Completion Well)

FIELD REPRESENTATIVE: Allen Willmore

DRILLING CONTRACTOR: ETTL

DRILLING TECHNIQUE: H.S.A.
AUGER SIZE AND TYPE: 8" I.D.

BOREHOLE IDENTIFICATION: 03WW01
BOREHOLE DIAMETER: 4"
WELL IDENTIFICATION: 07WW01

WELL CONSTRUCTION START DATE: 11/18/08
WELL CONSTRUCTION COMPLETE DATE: 11/18/08

SCREEN MATERIAL: sch. 40 PVC
SCREEN DIAMETER: 4"
STRATUM-SCREENED INTERVAL (FT): 10'

CASING MATERIAL: sch. 40 PVC
CASING DIAMETER: 4"

TYPE OF FILTER PACK: Silica Sand
GRADIATION: 20/40
AMOUNT OF FILTER PACK USED: 9-bags 50lbs

TYPE OF BENTONITE: pellets
AMOUNT BENTONITE USED: 1-50lb bucket

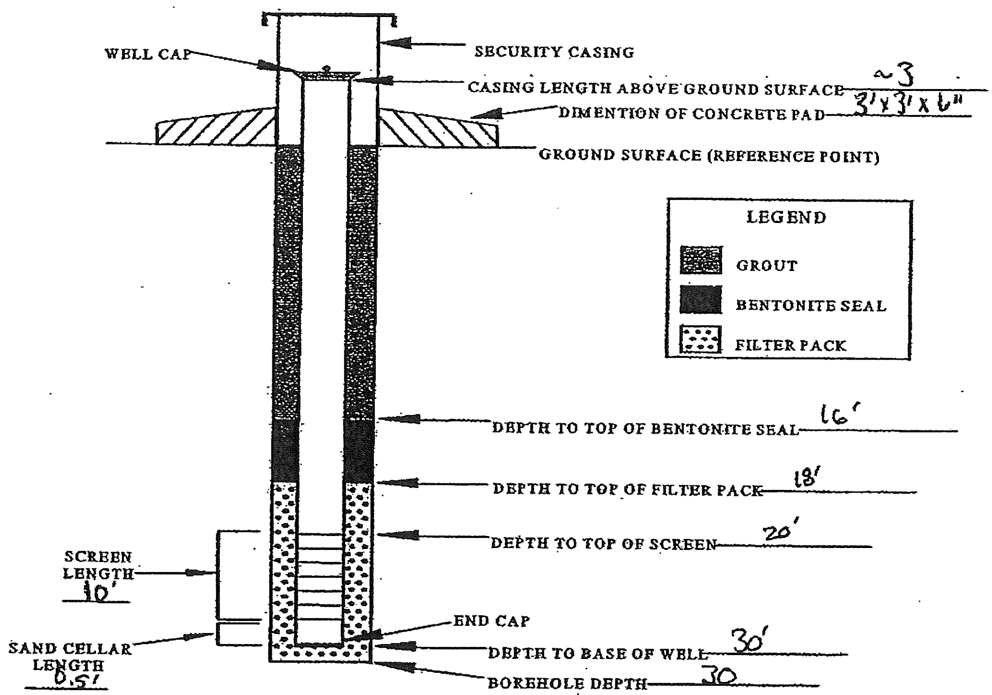
TYPE OF CEMENT: portland cement
AMOUNT CEMENT USED: NR
GROUT MATERIALS USED: Bent.

DIMENSIONS OF SECURITY CASING: 8" x 8" x ~3'

TYPE OF WELL CAP: plugging cap
TYPE OF END CAP: sch. 40 PVC

COMMENTS:

SPECIAL CONDITIONS
(describe and draw)



NOT TO SCALE

INSTALLED BY: Doug Hinds/Billy Rogers INSTALLATION OBSERVED BY: Allen Willmore

DISCREPANCIES: none

HOLE NO. 03WW01

DRILLING LOG	DIVISION: FEDERAL	INSTALLATION: Longhorn	SHEET 1 OF 3 SHEETS

1. PROJECT: LHAAP	10. SIZE AND TYPE OF BIT: 8" I.D. HSA
2. LOCATION (Coordinates or Station): Karnack, Texas	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
3. DRILLING AGENCY: ETTL	12. MANUFACTURER'S DESIGNATION OF DRILL: 5500 CME
4. HOLE NO. (As shown on drawing title and file number): 03WW01	13. OVERBURDEN SAMPLES — DISTURBED: — UNDISTURBED: ✓
5. NAME OF DRILLER: Doug Hinds	14. TOTAL NUMBER CORE BOXES: NR
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED 0° DEG. FROM VERT.	15. ELEVATION GROUND WATER:
	16. DATE HOLE — STARTED: 11/18/08 — COMPLETED: 11/18/08
7. THICKNESS OF OVERBURDEN: 30'	17. ELEVATION TOP OF HOLE: NR
8. DEPTH DRILLED INTO ROCK: 0'	18. TOTAL CORE RECOVERY FOR BORING: NR %
9. TOTAL DEPTH OF HOLE: 30'	INSPECTOR: Allen Willmore

~~ELEVATION~~ PID (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	% CORE RECOVERY (e)	BOX OR SAMPLE NO. (f)	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)
0.0		CL	CLAY, SANDY, LOW TO NO PLASTICITY, BROWN, MOIST, NO ODOR, STIFF, iron staining	90%		
			- Becomes DRY			
0.0						
0.0			- Becomes hard			
	5					
0.0				100%		
0.0			- Becomes more sandy			
0.0						
0.0	10	SM	SAND, SILTY, Brownish-gray, moist	100%	X	- Sample collected from 10'-11' bgs
0.0						
0.0						

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE NR		Hole No. 03WW01
PROJECT LHAAP - MARC	INSTALLATION LHAAP		SHEET 2 OF 3 SHEETS

~~ELEVATION~~ PID a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Same as above			
0.0		SM				
	15			90%	X	- Sample collected 14'-15' bgs (bottom of vadose) ~~(above~~ AC
0.0						▼
		SC	Sand, clayey, wet, dense, brown, poorly-sorted, no odor			
0.0						
			~~CLAY, sandy, dark gray to gray, very stiff, low plasticity, moist~~ AC 11/18/08			
0.0	20			95%		
0.0			- becomes more moist			
0.0			CLAY, SANDY, dark gray to gray, very stiff, low plasticity, moist			
	25	CL		85%		
0.0						
0.0				100%		

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MAR 71

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE NR	Hole No. 03WW01
PROJECT LHAAP-MARC	INSTALLATION LHAAP	SHEET 3 OF 3 SHEETS

~~ELEVATION~~ PID (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	% CORE RECOVERY (e)	BOX OR SAMPLE NO. (f)	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)
		CL	SAME AS Above	100%		
	30		End of boring @ 30' bgs			

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MAR 71

35AWW01(I)

MONITORING WELL CONSTRUCTION INFORMATION

JOB. NO. 000187

BORING/WELL NO. 35AWW01 (I)

DATE 9-29-98

CHIEF/UNIT BB / Mobile B-61

1. PROTECTIVE CASING YES NO

LOCKING YES NO

2. TYPE OF SURFACE SEAL (IF INSTALLED) Cement

3. SOLID PIPE TYPE stainless steel

SOLID PIPE LENGTH 63.0' ft.

JOINT TYPE SLIP/GLUED/THREADED

4. TYPE OF BACKFILL Bent./cement. grout

HOW INSTALLED – TREMIE (1" I.D.) FROM SURFACE

5. TYPE OF LOWER SEAL (IF INSTALLED) Bentonite seal (hydrated)

6. TYPE OF SECONDARY FILTER PACK Sand (30-70)

7. SCREEN TYPE Stainless steel

SCREEN LENGTH 10.0' ft.

SLOT SIZE #10 machine in.

SCREEN DIAMETER 4 in. (I.D

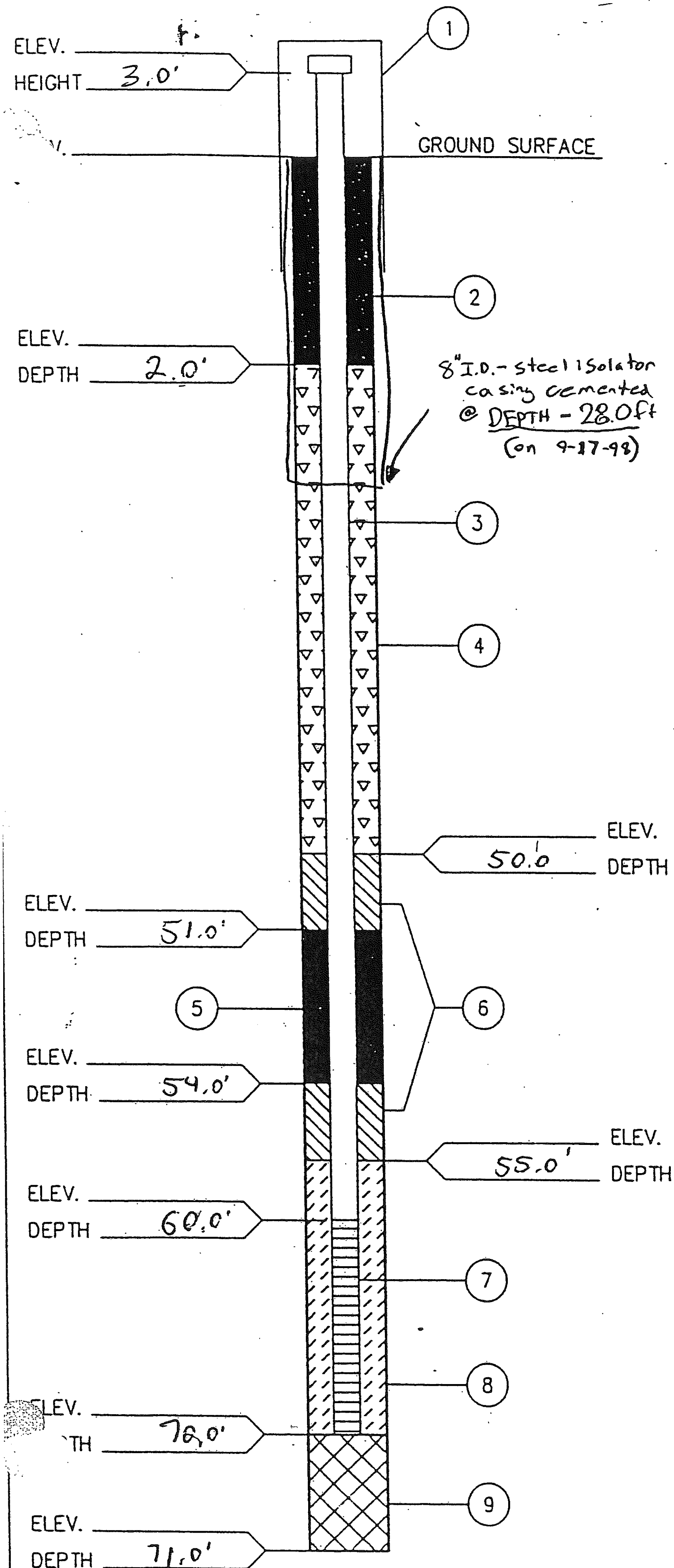
8. TYPE OF PRIMARY FILTER PACK Primary Sand (16-30)

9. TYPE OF BACKFILL (as above)

10. DRILLING METHOD Mud Rotory (8" tricone sawtooth)

WATER LEVEL ______ DATE ______

*ALL DEPTHS MEASURED FROM GROUND SURFACE



Sverdrup

ENVIRONMENTAL

Drilling Log

Monitoring Well **35AWW05** (58)

Project: Longhorn Army Ammunition Plant — Owner: Shaw E&I, Inc.
Location: Karnack, Texas — Proj. No. 845714
Surface Elev. 219.0 ft. — Total Hole Depth 75.5 ft. — North 6959849.641 ft. — East 3304426.136 ft.
Top of Casing 221.41 ft. — Water Level Initial 43.5 ft. — Static 38.2 ft. — Diameter 10 in.
Screen: Dia 4 in. — Length 10 ft. — Type/Size PVC/0.01 in.
Casing: Dia 4 in. — Length 67.91 ft. — Type Sch. 40 PVC
Fill Material 20/40 Sand, Bentonite Grout — Rig/Core Foremost 5500/5' Core Barrel
Drill Co. ETTL — Method Hollow Stem Auger w/Mud Rotary Capabilities
Driller Doug Hines — Log By Dale Jayne — Date 4/18/04 — Driller # NA
Checked By Kay Everett — License No. NA

COMMENTS
12" CARBON STEEL SURFACE CASING SET AT 38' BGS; APPROXIMATE DIAMETER OF SECTION 1 BOREHOLE IS 19" AND SECTION 2 IS 9"

Depth (ft.)	PID (ppm)	Sample ID / % Recovery	USCS Class.	Description (Color, Texture, Structure) Geologic Descriptions are Based on the USCS.	Elevation (ft.)
				4'x4'x6" Conc. Pad w/ 4" diameter bollards	
0	0.0	NA / 75%	ML	SILT, YELLOWISH-RED, MEDIUM STIFF, DRY	219.01
2	0.0	NA / 50%	CL	CLAY, RED-GRAY, MOTTLING PRESENT	217
4–6	0.0	NA / 100%	CL		214
7			CL	-BECOMES LIGHT BLUISH-GRAY IN COLOR	212
10	0.0	NA / 80%	CL		209
11.8			SP	SAND, FINE-GRAINED	
12.3			CL	SILTY CLAY, LIGHT BLUISH GRAY	
13			ML	CLAYEY SILT, LIGHT BLUISH GRAY, SOFT, MOIST	206
15	0.0	NA / 100%	ML		204
18			ML	-BECOMES LIGHT GREENISH-GRAY	201
20	0.0	NA / 100%	CL	SILTY CLAY, LAYER OF LIGNITE, LIGHT GREENISH-GRAY, SOFT, MOIST	199
23			CL	-BECOMES MEDIUM STIFF	196
23.5			SP	SAND, FINE GRAINED, TRACES OF CLAY, LIGHT BLUISH GRAY	
25.5	0.0	NA / 100%	ML	SILT, TRACES OF CLAY, LIGHT GREENISH-GRAY, SOFT, MOIST	194
27.8	0.0	NA / 100%	CL	SILTY CLAY, LIGHT BLUISH-GREEN, SOFT, MOIST -BECOMES BROWN AND LIGHT BLUISH GRAY IN COLOR	191
30					189

Continued Next Page

Drilling Log

Shaw™

Monitoring Well **35AWW05**

Project: *Longhorn Army Ammunition Plant* Owner: *Shaw E&I, Inc.*

Location: *Karnack, Texas* Proj. No. *845714*

Depth (ft.)	PID (ppm)	Sample ID / % Recovery	USCS Class.
30–34	0.0	NA / 100%	
34–38	0.0	NA / 100%	
38–43	0.0	NA / 100%	
43–48	0.0	NA / 100%	
48–49	0.0	NA / 100%	
49–54	0.0	NA / 100%	CL
54–59	0.0	NA / 100%	
59–64	0.0	NA / 100%	
64–69	0.0	NA / 100%	
69–70	0.0		

Depth (ft.): 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52, 54, 56, 58, 60, 62, 64, 66, 68, 70

Elevation (ft.): 188, 186, 184, 182, 180, 178, 176, 174, 172, 170, 168, 166, 164, 162, 160, 158, 156, 154, 152, 150

Description (Color, Texture, Structure)
Geologic Descriptions are Based on the USCS.

Continued

- -BECOMES DARK BLUISH-GREEN
- -ALTERNATING BLACK AND GREEN LAMINATION
- -BECOMES DARK BLUISH-GRAY IN COLOR
- -BECOMES DRY, FISSILE, HOMOGENOUS
- -BECOMES HARD
- -NO RECOVERY
- -BECOMES VERY STIFF
- -BECOMES WET
- -0.4' LAYER OF LIGNITE, PURE BLACK, ORGANIC, LOW DENSITY, SATURATED
- -CLAY BECOMES MOIST
- -BECOMES SOFT AND STIFF
- -BECOMES STIFF TO VERY STIFF, WET
- -2.3' LAYER OF LIGNITE, BLACK, LIGNITE, WET
- -CLAY HAS FRACTURES ALONG HORIZONTAL PLANES
- -BECOMES SOFT TO STIFF
- -REAMED HOLE TO 75.5' BGS TO INSTALL WELL, NO LITHOLOGIC LOG

Continued Next Page

Drilling Log

Monitoring Well **35AWW05**

Project *Longhorn Army Ammunition Plant* Owner *Shaw E&I, Inc.*

Location *Karnack, Texas* Proj. No. *845714*

Depth (ft.)	Well Completion	PID (ppm)	Sample ID / % Recovery	Graphic Log	USCS Class.	Description (Color, Texture, Structure) Geologic Descriptions are Based on the USCS.	Elevation (ft.)
70						*Continued*	148
72		0.0	NA / 100%		CL		146
74		0.0	NA / 100%				144
76						END OF BORING	142
78							140
80							138
82							136
84							134
86							132
88							130
90							128
92							126
94							124
96							122
98							120
100							118
102							116
104							114
106							112
108							110
110							

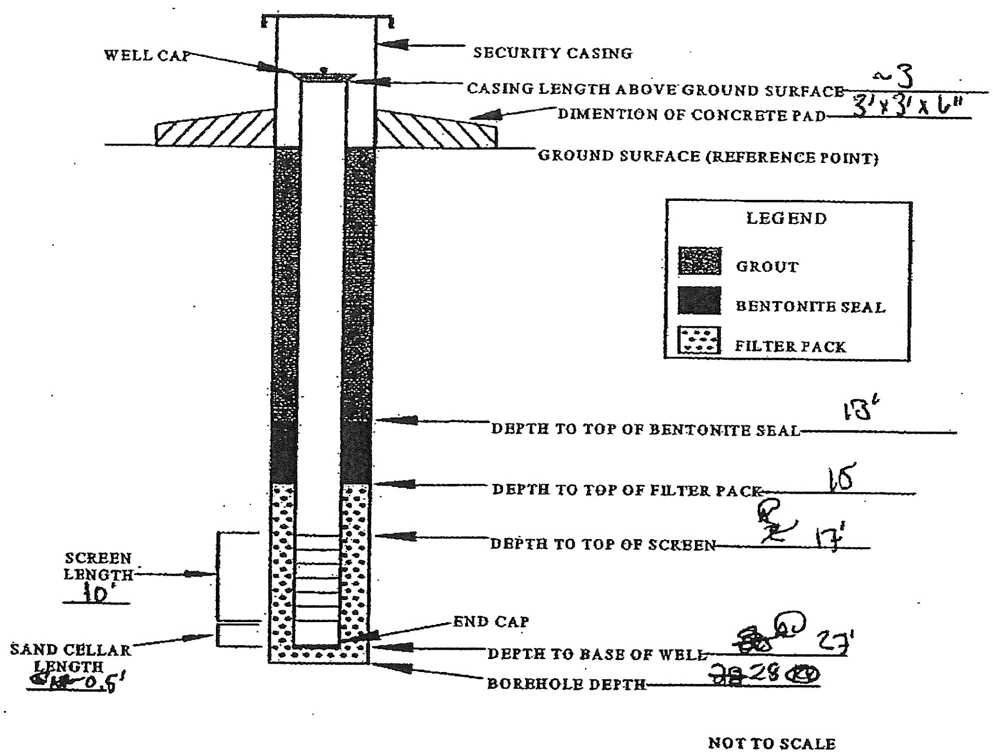
35AWW06

WELL COMPLETION FORM (Stickup or Above Grade Completion Well)

FIELD REPRESENTATIVE: Allen Willmore
DRILLING CONTRACTOR: ETTL
DRILLING TECHNIQUE: H.SA.
AUGER SIZE AND TYPE: 8" I.D.
BOREHOLE IDENTIFICATION: 35A WW06
BOREHOLE DIAMETER: 4"
WELL IDENTIFICATION: 35AWW06
WELL CONSTRUCTION START DATE: 11/14/08
WELL CONSTRUCTION COMPLETE DATE: 11/19/08
SCREEN MATERIAL: sch. 40 PVC
SCREEN DIAMETER: 4"
STRATUM-SCREENED INTERVAL (FT):
CASING MATERIAL: sch. 40 PVC
CASING DIAMETER: 4"

TYPE OF FILTER PACK: Silica Sand
GRADIATION: 20/40
AMOUNT OF FILTER PACK USED: 9-bags 50lbs
TYPE OF BENTONITE: pellets
AMOUNT BENTONITE USED: 1-50lb bucket
TYPE OF CEMENT: portald-cement
AMOUNT CEMENT USED: NR
GROUT MATERIALS USED: Bent.
DIMENSIONS OF SECURITY CASING: 8" x 8" x ~3'
TYPE OF WELL CAP: plugging cap
TYPE OF END CAP: sch. 40 pvc
COMMENTS:

SPECIAL CONDITIONS
(describe and draw)



INSTALLED BY: Doug Hinds/Billy Rogers INSTALLATION OBSERVED BY: Allen Willmore
DISCREPANCIES: none

HOLE NO. 35AWW06

DRILLING LOG	DIVISION FEDERAL	INSTALLATION Longhorn AAP	SHEET 1 OF 2 SHEETS

1. PROJECT Longhorn MARC	10. SIZE AND TYPE OF BIT 10" HSA
2. LOCATION (Coordinates or Station) Karnack, Tx	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
3. DRILLING AGENCY ETTL	12. MANUFACTURER'S DESIGNATION OF DRILL Foremost 550
4. HOLE NO. (As shown on drawing title and file number) 35AWW06	13. OVERBURDEN SAMPLES — DISTURBED ✓ — UNDISTURBED
5. NAME OF DRILLER Billy Ragon	14. TOTAL NUMBER CORE BOXES NR
6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED 0° DEG. FROM VERT.	15. ELEVATION GROUND WATER NR
	16. DATE HOLE — STARTED 11/14/00 — COMPLETED 11/14/00
7. THICKNESS OF OVERBURDEN 28'	17. ELEVATION TOP OF HOLE NR
8. DEPTH DRILLED INTO ROCK 0'	18. TOTAL CORE RECOVERY FOR BORING NR %
9. TOTAL DEPTH OF HOLE 28'	Allen Willmore INSPECTOR

~~ELEVATION~~ PID (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	% CORE RECOVERY (e)	BOX OR SAMPLE NO. (f)	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)
			TOPSOIL, CLAY, MOIST, SOFT, DISTURBED			
0.0			CLAY, SILTY, HARD, NO PLASTICITY, DRY GRAY, IRON STAINING, NO ODOR	60%		
0.0						
0.0		CL				
0.0	5			100%		
6.0						
0.0						
0.0	10			100%		
6.0			— BECOMES SOFTER, MORE SAND CONTENT			
0.0						

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE	Hole No. 35AWW06

PROJECT	INSTALLATION	SHEET 2
Longhorn MARC	Longhorn AAP	OF 2 SHEETS

~~ELEVATION~~ PID (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	% CORE RECOVERY (e)	BOX OR SAMPLE NO. (f)	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)
0.0			Same as above			
0.0	15	SC-SP	~~SAND, very clayey, gray, moist, dense, poorly-sorted, no odor~~ AW 11/14/07	100%		
		CL				
0.0						
0.0						
0.0	20	SC-SP	SAND, very clayey, gray, moist, dense, poorly-sorted, no odor	100%	▼	
0.0						
0.0						
0.0	25			100%		
0.0		CL	CLAY, SILTY, GRAY, HARD, NO PLASTICITY DRY TO DAMP, NO ODOR.			
			END OF BORING @ 28' bgs			

ENG FORM 1836--A PREVIOUS EDITIONS ARE OBSOLETE.
MAR 71

PROJECT	HOLE NO.
Longhorn MARC	35AWW06

35AWW08

WELL COMPLETION FORM (Stickup or Above Grade Completion Well)

FIELD REPRESENTATIVE: Allen Willmore

DRILLING CONTRACTOR: ETTL

DRILLING TECHNIQUE: H.S.A.
AUGER SIZE AND TYPE: 8" I.D.

BOREHOLE IDENTIFICATION: 35A WW08
BOREHOLE DIAMETER: 4"
WELL IDENTIFICATION: 35AWW08

WELL CONSTRUCTION START DATE: 11/18/08
WELL CONSTRUCTION COMPLETE DATE: 11/18/08

SCREEN MATERIAL: sch. 40 pvc
SCREEN DIAMETER: 4"
STRATUM-SCREENED INTERVAL (FT): 10'

CASING MATERIAL: sch. 40 pvc
CASING DIAMETER: 4"

TYPE OF FILTER PACK: Silica Sand
GRADIATION: 20/40
AMOUNT OF FILTER PACK USED: 9 bags 50lbs

TYPE OF BENTONITE: pellets
AMOUNT BENTONITE USED: 1 - 50lb bucket

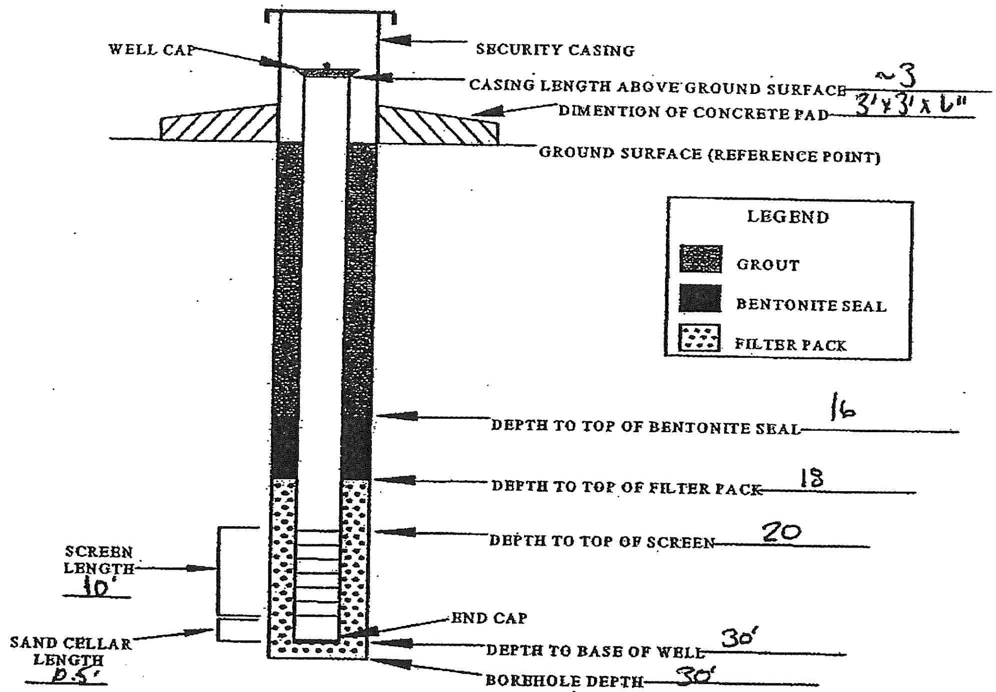
TYPE OF CEMENT: portald cement
AMOUNT CEMENT USED: NR
GROUT MATERIALS USED: bent.

DIMENSIONS OF SECURITY CASING: 8" x 8" x ~3'

TYPE OF WELL CAP: plugging cap
TYPE OF END CAP: sch. 40 pvc

COMMENTS:

SPECIAL CONDITIONS
(describe and draw)



NOT TO SCALE

INSTALLED BY: Doug Hinds/Billy Rogers INSTALLATION OBSERVED BY: Allen Willmore

DISCREPANCIES: none

HOLE NO. 35AWW08

DRILLING LOG

DIVISION: FEDERAL	INSTALLATION: Longhorn	SHEET 1 OF 1 SHEETS	
1. PROJECT: LHAAP	10. SIZE AND TYPE OF BIT: 8" I.D. HSA		
2. LOCATION (Coordinates or Station): Karnack, Texas	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL		
3. DRILLING AGENCY: ETTL	12. MANUFACTURER'S DESIGNATION OF DRILL: 5500 CME		
4. HOLE NO. (As shown on drawing title and file number): 35AWW08	13. OVERBURDEN SAMPLES	DISTURBED	UNDISTURBED: ✓
5. NAME OF DRILLER: Doug Hinds	14. TOTAL NUMBER CORE BOXES: NR		
6. DIRECTION OF HOLE: ☑ VERTICAL ☐ INCLINED 0° DEG. FROM VERT.	15. ELEVATION GROUND WATER: NR		
7. THICKNESS OF OVERBURDEN: 30'	16. DATE HOLE	STARTED: 11/18/08	COMPLETED: 11/18/08
8. DEPTH DRILLED INTO ROCK: 0'	17. ELEVATION TOP OF HOLE: NR		
9. TOTAL DEPTH OF HOLE: 30'	18. TOTAL CORE RECOVERY FOR BORING: NR %		
	Allen Willmore INSPECTOR		

~~ELEVATION~~ PID (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	% CORE RECOVERY (e)	BOX OR SAMPLE NO. (f)	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)
NR			Same lithology as 35AWW01. See boring log ~~35AWW01~~ LHSMW05 (B) for lithologic decription. This boring ends @ 30' bgs			Well completed to replace well LHSMW05; however this well was completed @ a deeper depth.
	30'		END OF BORING			
	5					
	10					

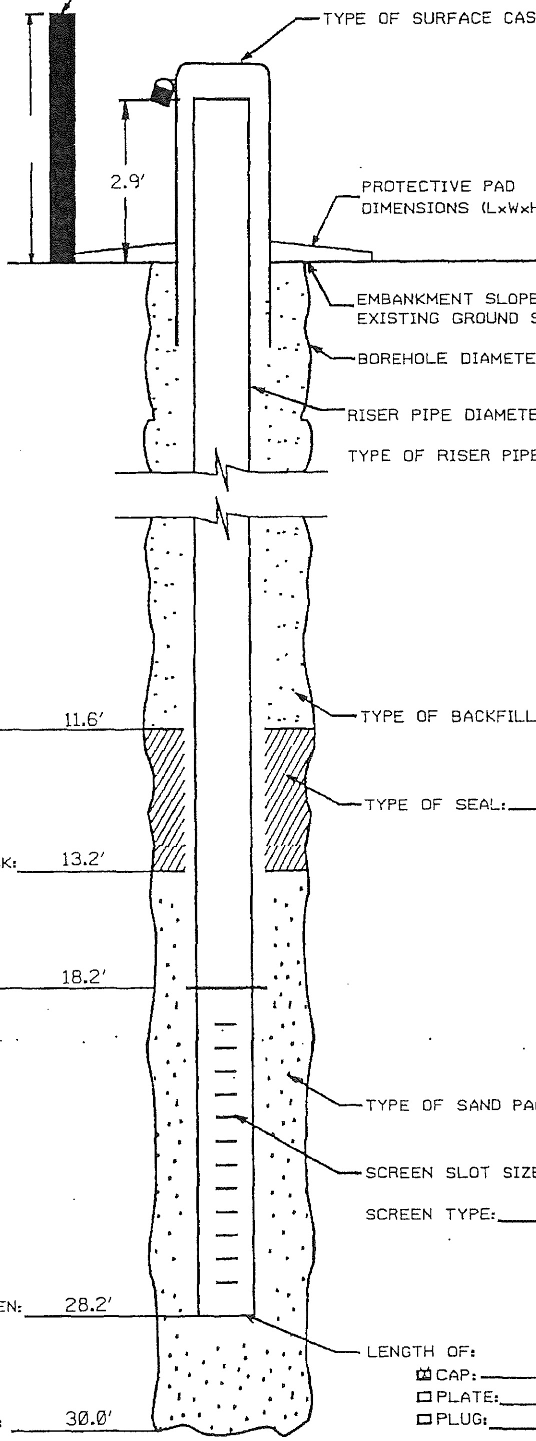
WELL NO. LHS-MW4

MONITORING WELL SHEET

PROJECT & INSTALLATION:
LONGHORN ARMY AMMUNITION PLANT - SUMPS

DATE STARTED:
8-22-1994

DATE COMPLETED:
8-23-1994



4 PROTECTIVE STEEL POSTS

TYPE OF SURFACE CASING: STEEL

PROTECTIVE PAD DIMENSIONS (LxWxH): 4'X4'X6'

EMBANKMENT SLOPE OR EXISTING GROUND SURFACE.

GROUNDWATER DEPTH: 13.2'

GROUNDWATER DATE: 8-23-1994

BOREHOLE DIAMETER: 8'

RISER PIPE DIAMETER: 4'

TYPE OF RISER PIPE: PVC

TOP OF SEAL: 11.6'

TYPE OF BACKFILL: GROUT/5% BENTONITE

TYPE OF SEAL: BENTONITE

TOP OF SAND PACK: 13.2'

TOP OF SCREEN: 18.2'

TYPE OF SAND PACK: 16/30

SCREEN SLOT SIZE: .010'

SCREEN TYPE: 316 SS

BOTTOM OF SCREEN: 28.2'

LENGTH OF:
☒ CAP: 6'
☐ PLATE:
☐ PLUG:

BOTTOM OF HOLE: 30.0'

INSPECTOR:
STEVE BREWER

LHWCD.DGN LORI KRUSE

LHS-MW04

KDB 7/28/04

HOLE NO. LHS-MW4

DRILLING LOG	DIVISION SOUTHWEST	INSTALLATION LHAAP	SHEET 1 OF 1 SHEETS

1. PROJECT: LHAAP-WASTE SUMPS	10. SIZE AND TYPE OF BIT: 8" AUGER
2. LOCATION (Coordinates or Station): 6960183.80 3305398.40	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
3. DRILLING AGENCY: TULSA DISTRICT COE	12. MANUFACTURER'S DESIGNATION OF DRILL: CME 75
4. HOLE NO. (As shown on drawing title and file number): LHS-MW4	13. OVERBURDEN SAMPLES: DISTURBED 12, UNDISTURBED 0
5. NAME OF DRILLER: TOM BEAVERS	14. TOTAL NUMBER CORE BOXES: 0
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER: SEE REMARKS
	16. DATE HOLE: STARTED 08/22/1994, COMPLETED 08/23/1994
7. THICKNESS OF OVERBURDEN: 30.0	17. ELEVATION TOP OF HOLE: 214.0
8. DEPTH DRILLED INTO ROCK: 0.0	18. TOTAL CORE RECOVERY FOR BORING: 0.0 %
9. TOTAL DEPTH OF HOLE: 30.0	STEVE BREWER

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0–9.0		LEAN CLAY (CL) (0.0 – 9.0) SANDY, OLIVE BROWN TO BROWNISH GRAY, MOIST, ROOTS TO 3.4'.		J-1, J-2, J-3	WATER ENCOUNTERED @ 13.2'
205.0	9		LEAN CLAY (CL) (9.0 – 16.0) OLIVE YELLOW, MOIST.		J-4, J-5	
198.0	16		LEAN CLAY (CL) (16.0 – 18.9) SANDY, LIGHT YELLOWISH BROWN, MOIST.		J-6	
195.1	18.9		LEAN CLAY (CL) (18.9 – 23.8) WITH SAND, YELLOWISH BROWN, MOIST, SILTY.		J-7	
190.2	23.8		CLAY SAND (SC) (23.8 – 25.2) WITH GRAVEL, REDDISH BROWN, MOIST, GRAVELS TO 1/2".		J-8	
188.8	25.2		CLAY SAND (SC) (25.2 – 27.2) PALE BROWN, MOIST, ROOTS.		J-9	
186.8	27.2		LEAN CLAY (CL) (27.2 – 28.1) SANDY, REDDISH BROWN, MOIST, GRAVELS TO 1/2".		J-10	
185.9	28.1		FAT CLAY (CH) (28.1 – 29.0) SANDY, REDDISH BROWN, MOIST, GRAVEL TO 1/2".		J-11	
185.0	29.0		FAT CLAY (CH) (29.0 – 30.0) WITH SAND, LIGHT BROWNISH GRAY MOIST.		J-12	
184.0	30					

Remarks (continued):

SAMPLE TYPE: SPLITSPOON — ZONE: 0.0– 30.0

SAMPLE	DEPTH
J-1	0.3– 1.2
J-2	1.2– 3.4
J-3	3.4– 9.0
J-4	9.0– 13.2
J-5	13.2– 16.0
J-6	16.0– 18.9
J-7	18.9– 23.8
J-8	23.8– 25.2
J-9	25.2– 27.2
J-10	27.2– 28.1
J-11	28.1– 29.0
J-12	29.0– 30.0

PROJECT: LHAAP-WASTE SUMPS | HOLE NO. LHS-MW4

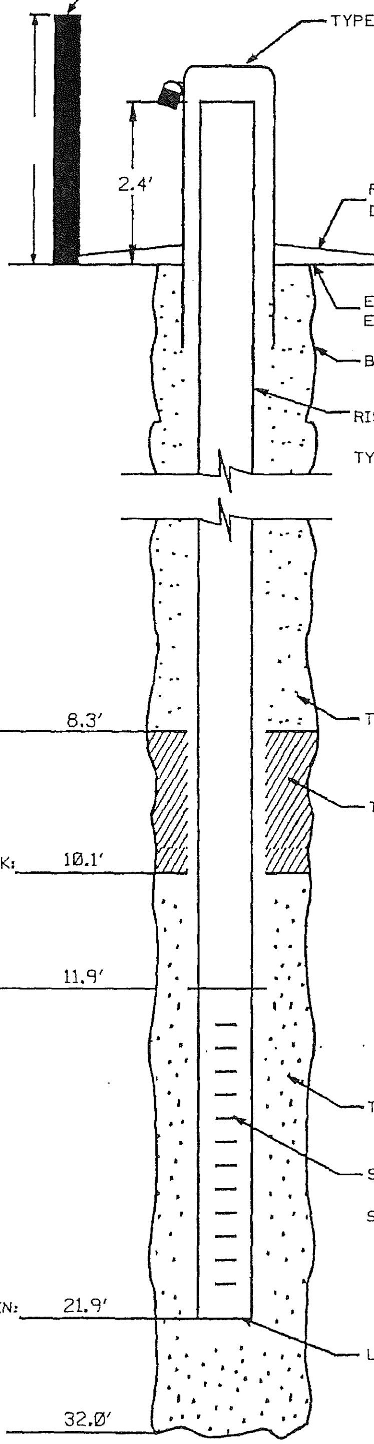
WELL NO. LHS-MW5

MONITORING WELL SHEET

PROJECT & INSTALLATION: LONGHORN ARMY AMMUNITION PLANT - SUMPS

DATE STARTED: 8-22-1994

DATE COMPLETED: 8-22-1994



4 PROTECTIVE STEEL POSTS

TYPE OF SURFACE CASING: STEEL

PROTECTIVE PAD DIMENSIONS (LxWxH): 4'X4'X6"

EMBANKMENT SLOPE OR EXISTING GROUND SURFACE.

GROUNDWATER DEPTH: NOT OBSERVED

GROUNDWATER DATE:

BOREHOLE DIAMETER: 8"

RISER PIPE DIAMETER: 4"

TYPE OF RISER PIPE: PVC

TOP OF SEAL: 8.3'

TYPE OF BACKFILL: GROUT/5% BENTONITE

TYPE OF SEAL: BENTONITE

TOP OF SAND PACK: 10.1'

TOP OF SCREEN: 11.9'

TYPE OF SAND PACK: 16/30

SCREEN SLOT SIZE: .010"

SCREEN TYPE: 316 SS

BOTTOM OF SCREEN: 21.9'

LENGTH OF:
☒ CAP: 6"
☐ PLATE:
☐ PLUG:

BOTTOM OF HOLE: 32.0'

INSPECTOR: MERLIN DEAN

LHWCD.DGN LORI KRUSE

LHS-MW05

KDB 7/28/04

HOLE NO. LHS-MW5

DRILLING LOG	DIVISION: SOUTHWEST
INSTALLATION: LHAAP	SHEET 1 OF 2 SHEETS
1. PROJECT: LHAAP-WASTE SUMPS	10. SIZE AND TYPE OF BIT: 8" AUGER
2. LOCATION (Coordinates or Station): 6960159.80 3305079.10	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
3. DRILLING AGENCY: TULSA DISTRICT COE	12. MANUFACTURER'S DESIGNATION OF DRILL: FAILING 1500
4. HOLE NO. (As shown on drawing title and file number): LHS-MW5	13. OVERBURDEN SAMPLES: DISTURBED 9, UNDISTURBED 13
5. NAME OF DRILLER: RAY VOILS	14. TOTAL NUMBER CORE BOXES: 0
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.	15. ELEVATION GROUND WATER: NOT DETERMINED
	16. DATE HOLE: STARTED 08/22/1994; COMPLETED 08/22/1994
7. THICKNESS OF OVERBURDEN: 32.0	17. ELEVATION TOP OF HOLE: 215.1
8. DEPTH DRILLED INTO ROCK: 0.0	18. TOTAL CORE RECOVERY FOR BORING: 0.0 %
9. TOTAL DEPTH OF HOLE: 32.0	STEVE BREWER

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f
213.6			LEAN CLAY (CL) (0.0 – 1.5) SANDY, BROWNISH GRAY, MOIST, VERY STIFF, NUMEROUS ROOTS IN TOP, BLACK IRON-OXIDE STAINS, ASPHALTIC MATERIAL FROM 0.7'–0.8', GRAYISH BROWN FAT CLAY IN BOTTOM 0.7'.		ST-1
212.1	2		FAT CLAY (CH) (1.5 – 3.0) WITH SAND, BROWNISH GRAY WITH RED, VERY MOIST, STIFF.		ST-2
210.6	4		FAT CLAY (CH) (3.0 – 4.5) WITH SAND, RED ANDY GRAY, MOIST, STIFF TO VERY STIFF, FEW NODULES.		ST-3
209.1	6		LEAN CLAY (CL) (4.5 – 6.0) WITH SAND, GRAY WITH YELLOW AND RED, HARD, SCATTERED BLACK IRON-OXIDE STAINS, TOP 0.5'.		ST-4
206.1	8		LEAN CLAY (CL) (6.0 – 9.0) SANDY, GRAY WITH YELLOW, MOIST HARD TO VERY STIFF.		ST-5 ST-6
204.6	10		LEAN CLAY (CL) (9.0 – 10.5) WITH SAND, LIGHT GRAY WITH YELLOW, MOIST, HARD, BECOMING SANDY WITH DEPTH.		ST-7
203.1	12		SILTY SAND (SM) (10.5 – 12.0) LIGHT GRAY WITH YELLOW, VERY MOIST.		ST-8
201.6			CLAY SAND (SC) (12.0 – 13.5) SILTY, YELLOW WITH LIGHT GRAY, VERY MOIST.		ST-9
200.1	14		CLAY SAND (SC) (13.5 – 15.0) YELLOW WITH LIGHT GRAY, VERY MOIST, VERY STIFF, TOP 0.9' SILTY SAND (SM), VERY SOFT.		ST-10
198.6	16		LEAN CLAY (CL) (15.0 – 16.5) SANDY, DARK YELLOW WITH LIGHT GRAY, MOIST, VERY STIFF, SMALL POCKET OF GRAVEL AT 15.9'.		ST-11
197.1	18		FAT CLAY (CH) (16.5 – 18.0) WITH SAND, YELLOW AND LIGHT GRAY, MOIST, VERY STIFF TO HARD SCATTERED BLACK IRON-OXIDE STAINS, TOP 0.6' SANDY LEAN CLAY, VERY MOIST.		ST-12
195.6			LEAN CLAY (CL) (18.0 – 19.5) WITH SAND, YELLOW AND LIGHT GRAY, MOIST, VERY STIFF.		ST-13
195.1	20		FAT CLAY (CH) (19.5 – 23.0) LIGHT BROWNISH GRAY, MOIST		J-1

REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g

SAMPLE TYPE	ZONE
SHELBY	0.0– 19.5
SPLITSPOON	19.5– 32.0

SAMPLE	DEPTH
ST-1	0.0– 1.5
ST-2	1.5– 3.0
ST-3	3.0– 4.5
ST-4	4.5– 6.0
ST-5	6.0– 7.5
ST-6	7.5– 9.0
ST-7	9.0– 10.5
ST-8	10.5– 12.0
ST-9	12.0– 13.5
ST-10	13.5– 14.7
ST-11	15.0– 16.5
ST-12	16.5– 18.0
ST-13	18.0– 19.5
J-1	19.5– 21.0
J-2	21.0– 22.5
J-3	23.0– 24.5
J-4	24.5– 26.0
J-5	26.0– 27.0
J-6	27.0– 28.0
J-7	28.0– 28.4
J-8	28.4– 30.0
J-9	30.0– 32.0

LHSMW05 KDB 7/28/04

HOLE NO. LHS-MW5

DRILLING LOG	DIVISION SOUTHWEST	INSTALLATION LHAAP	SHEET 2 OF 2 SHEETS
1. PROJECT LHAAP-WASTE SUMPS		10. SIZE AND TYPE OF BIT 8" AUGER	
2. LOCATION (Coordinates or Station) 6960159.80 3305079.10		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL	
3. DRILLING AGENCY TULSA DISTRICT COE		12. MANUFACTURER'S DESIGNATION OF DRILL FAILING 1500	
4. HOLE NO. (As shown on drawing title and file number) LHS-MW5		13. OVERBURDEN SAMPLES	DISTURBED 9 / UNDISTURBED 13
5. NAME OF DRILLER RAY VOILS		14. TOTAL NUMBER CORE BOXES 0	
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER NOT DETERMINED	
		16. DATE HOLE	STARTED 08/22/1994 / COMPLETED 08/22/1994
		17. ELEVATION TOP OF HOLE 215.1	
7. THICKNESS OF OVERBURDEN 32.0		18. TOTAL CORE RECOVERY FOR BORING 0.0 %	
8. DEPTH DRILLED INTO ROCK 0.0			
9. TOTAL DEPTH OF HOLE 32.0		STEVE BREWER	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
192.1	22		FAT CLAY (CH) (19.5 – 23.0) LIGHT BROWNISH GRAY, MOIST.		J–1, J–2	
190.6	24		FAT CLAY (CH) (23.0 – 24.5) WITH SAND, LIGHT YELLOWISH BROWN, MOIST.		J–3	
188.1	26		FAT CLAY (CH) (24.5 – 27.0) LIGHT YELLOWISH BROWN TO GRAY, MOIST.		J–4, J–5	
186.7	28		LEAN CLAY (CL) (27.0 – 28.4) GRAY TO DARK GRAY, MOIST.		J–6, J–7	
183.1	30, 32		FAT CLAY (CH) (28.4 – 32.0) GRAY TO LIGHT BROWNISH GRAY, MOIST.		J–8, J–9	
	34, 36, 38, 40					

PROJECT LHAAP-WASTE SUMPS | HOLE NO. LHS-MW5

000014

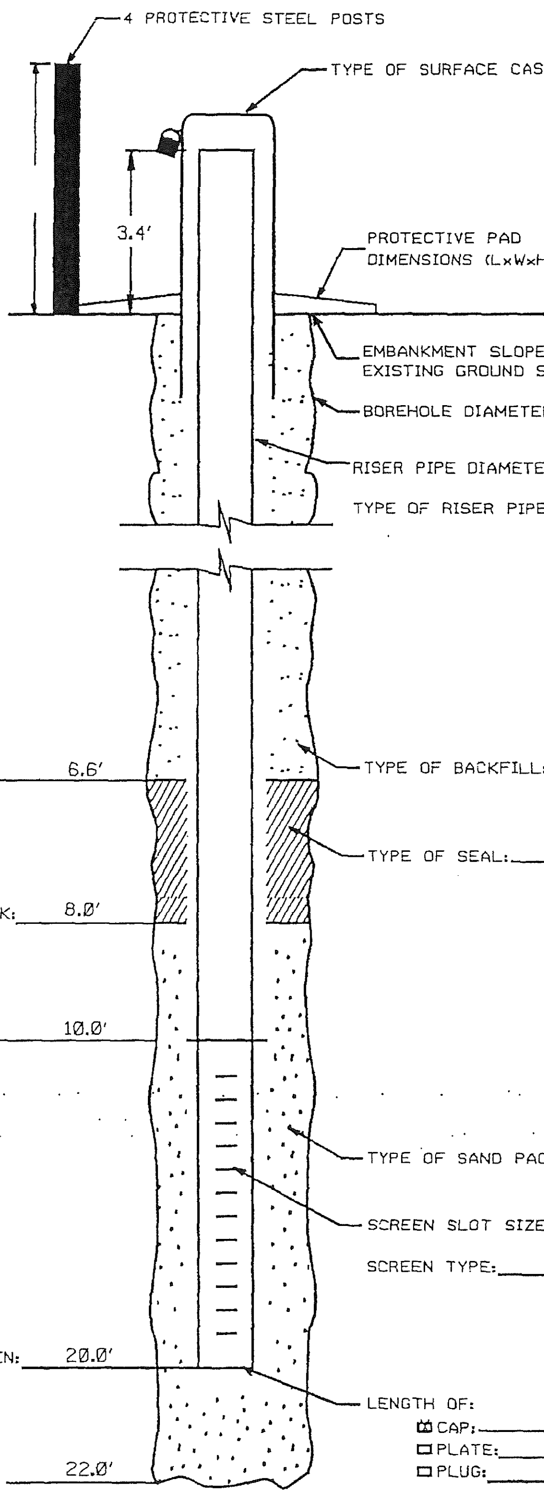
WELL NO. LHS-MW6

MONITORING WELL SHEET

PROJECT & INSTALLATION:
LONGHORN ARMY AMMUNITION PLANT - SUMPS

DATE STARTED:
8-23-1994

DATE COMPLETED:
8-24-1994



TYPE OF SURFACE CASING: STEEL

PROTECTIVE PAD DIMENSIONS (LxWxH): 4'X4'X6"

EMBANKMENT SLOPE OR EXISTING GROUND SURFACE.

GROUNDWATER DEPTH: 10.0'
GROUNDWATER DATE: 8-24-1994

BOREHOLE DIAMETER: 8"

RISER PIPE DIAMETER: 4"

TYPE OF RISER PIPE: PVC

TOP OF SEAL: 6.6'

TYPE OF BACKFILL: GROUT/5% BENTONITE

TYPE OF SEAL: BENTONITE

TOP OF SAND PACK: 8.0'

TOP OF SCREEN: 10.0'

TYPE OF SAND PACK: 16/30

SCREEN SLOT SIZE: .010"

SCREEN TYPE: 316 SS

BOTTOM OF SCREEN: 20.0'

LENGTH OF:
☒ CAP: 6"
☐ PLATE:
☐ PLUG:

BOTTOM OF HOLE: 22.0'

INSPECTOR:
STEVE BREWER

LHWCD.DGN LORI KRUSE

LHSMW06

KDB
7/28/04

HOLE NO. LHS-MW6

DRILLING LOG	DIVISION SOUTHWEST	INSTALLATION LHAAP	SHEET 1 OF 1 SHEETS
1. PROJECT LHAAP-WASTE SUMPS		10. SIZE AND TYPE OF BIT 8" AUGER	
2. LOCATION (Coordinates or Station) 6960080.10 3304630.70		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL	
3. DRILLING AGENCY TULSA DISTRICT COE		12. MANUFACTURER'S DESIGNATION OF DRILL FAILING 1500	
4. HOLE NO. (As shown on drawing title and file number) LHS-MW6		13. OVERBURDEN SAMPLES	DISTURBED 10 / UNDISTURBED 0
5. NAME OF DRILLER RAY VOILS		14. TOTAL NUMBER CORE BOXES 0	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER SEE REMARKS	
		16. DATE HOLE	STARTED 08/23/1994 / COMPLETED 08/24/1994
7. THICKNESS OF OVERBURDEN 22.0		17. ELEVATION TOP OF HOLE 219.9	
8. DEPTH DRILLED INTO ROCK 0.0		18. TOTAL CORE RECOVERY FOR BORING 0.0 %	
9. TOTAL DEPTH OF HOLE 22.0		STEVE BREWER	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
219.0			LEAN CLAY (CL) (0.0 – 0.9) WITH SAND, DARK YELLOWISH BROWN, MOIST.		J-1	WATER ENCOUNTERED @ 13.8'
217.8			LEAN CLAY (CL) (0.9 – 2.1) SANDY, DARK REDDISH BROWN, MOIST, ROOTS.		J-2	OVERNIGHT WATER LEVEL @ 10.0'
213.6	3		LEAN CLAY (CL) (2.1 – 6.3) WITH SAND, DARK YELLOWISH BROWN, MOIST.		J-3 J-4	SAMPLE TYPE: SPLITSPOON — ZONE: 0.0– 22.0
208.3	6, 9		FAT CLAY (CH) (6.3 – 11.6) WITH SAND, DARK YELLOWISH BROWN TO OLIVE, MOIST.		J-5 J-6	
206.1	12		LEAN CLAY (CL) (11.6 – 13.8) SANDY, OLIVE, MOIST.		J-7	
200.0	15, 18		CLAY SAND (SC) (13.8 – 19.9) OLIVE, MOIST.		J-8	
199.6			LEAN CLAY (CL) (19.9 – 20.3) WITH SAND, OLIVE, MOIST.		J-9	
197.9	21		FAT CLAY (CH) (20.3 – 22.0) LIGHT OLIVE GRAY, MOIST.		J-10	
	24, 27, 30					

SAMPLE	DEPTH
J-1	0.2– 0.9
J-2	0.9– 2.1
J-3	2.1– 2.8
J-4	2.8– 6.3
J-5	6.3– 10.1
J-6	10.1– 11.6
J-7	11.6– 13.8
J-8	13.8– 19.9
J-9	19.9– 20.3
J-10	20.3– 22.0

PROJECT	HOLE NO.
LHAAP-WASTE SUMPS	LHS-MW6

WELL NO. LHS-MW7

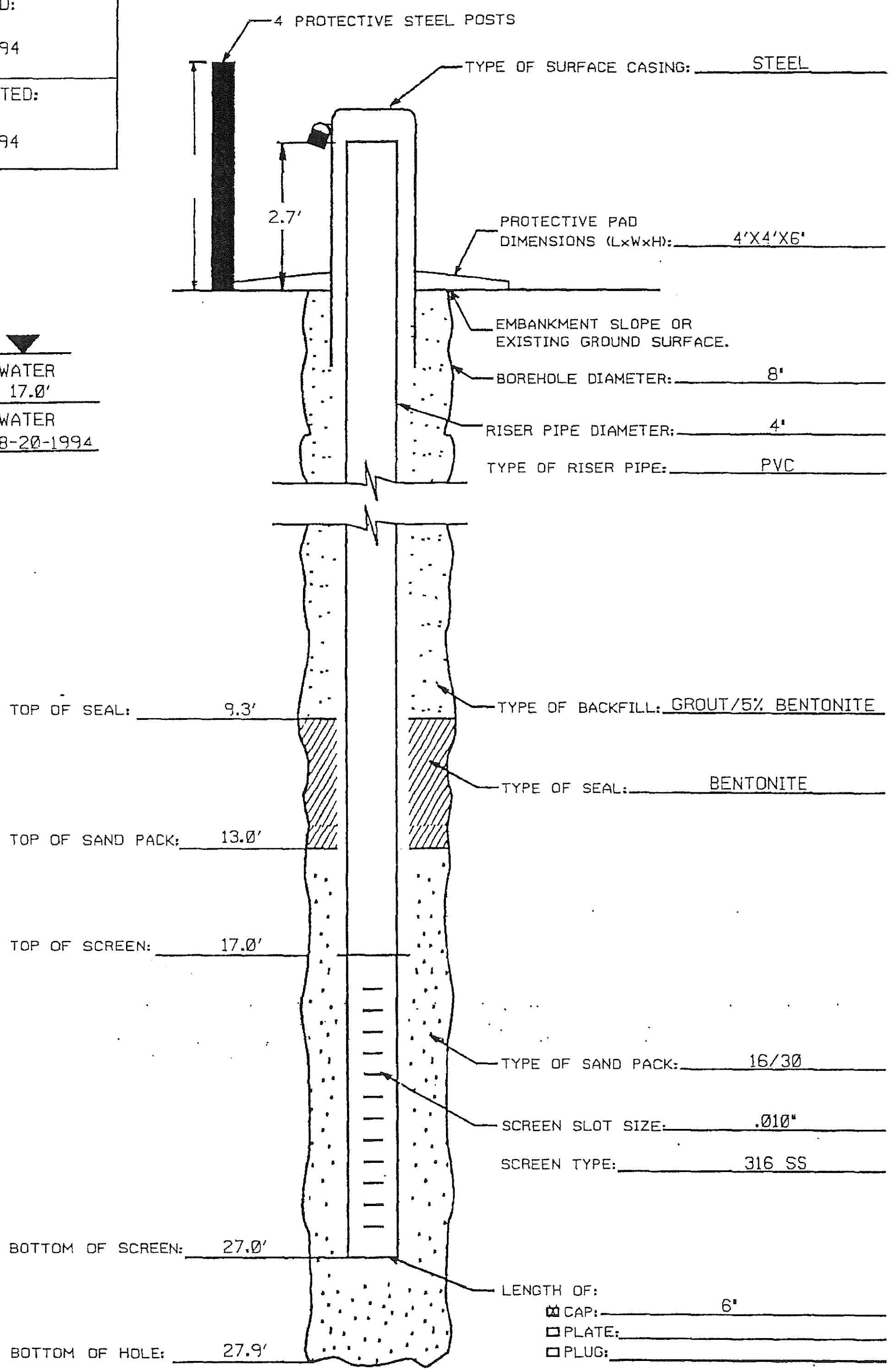
MONITORING WELL SHEET

PROJECT & INSTALLATION:
LONGHORN ARMY AMMUNITION PLANT - SUMPS

DATE STARTED:
8-20-1994

DATE COMPLETED:
8-20-1994

GROUNDWATER DEPTH: 17.0'
GROUNDWATER DATE: 8-20-1994



INSPECTOR:
STEVE BREWER

LHWCD.DGN LORI KRUSE

LHSMW07 KDB 7/28/04

HOLE NO. LHS-MW7

DRILLING LOG	DIVISION SOUTHWEST	INSTALLATION LHAAP	SHEET 1 OF 2 SHEETS

1. PROJECT	LHAAP-WASTE SUMPS
2. LOCATION (Coordinates or Station)	6959841.50 3304410.30
3. DRILLING AGENCY	TULSA DISTRICT COE
4. HOLE NO. (As shown on drawing title and file number)	LHS-MW7
5. NAME OF DRILLER	RAY VOILS
6. DIRECTION OF HOLE	☒ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN	27.9
8. DEPTH DRILLED INTO ROCK	0.0
9. TOTAL DEPTH OF HOLE	27.9
10. SIZE AND TYPE OF BIT	8" AUGER
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	MSL
12. MANUFACTURER'S DESIGNATION OF DRILL	FAILING 1500
13. OVERBURDEN SAMPLES	DISTURBED 3 / UNDISTURBED 17
14. TOTAL NUMBER CORE BOXES	0
15. ELEVATION GROUND WATER	SEE REMARKS
16. DATE HOLE	STARTED 08/20/1994 / COMPLETED 08/20/1994
17. ELEVATION TOP OF HOLE	218.6
18. TOTAL CORE RECOVERY FOR BORING	0.0 %
19. SIGNATURE OF INSPECTOR	STEVE BREWER

ELEVATION (a)	DEPTH (b)	CLASSIFICATION OF MATERIALS (Description) (d)	% CORE RECOVERY (e)	BOX OR SAMPLE NO. (f)
217.1		LEAN CLAY (CL) (0.0 - 1.5) SANDY, GRAYISH BROWN WITH RED, MOIST, VERY STIFF, NUMEROUS THIN ROOTS IN TOP 0.5'.		ST-1
215.6	2	LEAN CLAY (CL) (1.5 - 3.0) WITH SAND, BROWN WITH GRAY AND RED, MOIST, VERY STIFF, SCATTERED POCKETS OF FINE SAND		ST-2
214.1	4	FAT CLAY (CH) (3.0 - 4.5) WITH SAND, GRAY AND RED MOIST, VERY STIFF.		ST-3
212.6	6	LEAN CLAY (CL) (4.5 - 6.0) WITH SAND, GRAY AND YELLOW AND RED, MOIST, VERY STIFF.		ST-4
211.8		LEAN CLAY (CL) (6.0 - 6.8) SANDY, GRAY AND YELLOW WITH RED, MOIST, VERY STIFF.		ST-5
210.3	8	LEAN CLAY (CL) (6.8 - 8.3) WITH SAND,OLIVE AND YELLOW AND GRAY, MOIST,VERY STIFF TO HARD SEVERAL BLACK IRON-OXIDE STAIN		J-1, ST-6
208.1	10	FAT CLAY (CH) (8.3 - 10.5) OLIVE YELLOW AND GRAY, MOIST, VERY STIFF, SLIGHTLY SLICKEN-SIDED, BLACK IRON-OXIDE STAINS THROUGHOUT.		J-2, ST-7
205.1	12	LEAN CLAY (CL) (10.5 - 13.5) OLIVE GRAY AND YELLOW, MOIST, STIFF TO VERY STIFF, IRON-OXIDE STAINS, THIN SAND LENSES THROUGHOUT, FRIABLE.		ST-8, ST-9
203.9	14	FAT CLAY (CH) (13.5 - 14.7) OLIVE WITH GRAY, MOIST, VERY STIFF, SEVERAL THIN SAND AND SILT LENSES, FRIABLE.		ST-10
201.6	16	LEAN CLAY (CL) (14.7 - 17.0) OLIVE WITH GRAY, MOIST, VERY STIFF, VERY THIN FINE SAND AND SILT LENSES IN TOP HALF OF SAMPLE, FRIABLE.		ST-11
198.6	18, 20	FAT CLAY (CH) (17.0 - 22.4) LIGHT OLIVE GRAY, MOIST, HARD, SLIGHTLY SLICKENSIDED, FRIABLE		ST-12, ST-13, ST-14

REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)

WATER ENCOUNTERED @ 17.0'

TYPE	ZONE
SHELBY	0.0- 26.9

SAMPLE	DEPTH
ST-1	0.0- 1.5
ST-2	1.5- 3.0
ST-3	3.0- 4.5
ST-4	4.5- 6.0
ST-5	6.0- 6.8
J-1	6.8- 7.5
ST-6	7.5- 8.3
J-2	8.3- 9.0
ST-7	9.0- 10.5
ST-8	10.5- 12.0
ST-9	12.0- 13.5
ST-10	13.5- 14.7
ST-11	14.7- 16.4
ST-12	17.0- 17.7
ST-13	17.7- 19.0
ST-14	19.0- 19.8
ST-15	22.4- 23.9
ST-16	23.9- 24.6
ST-17	24.6- 25.6
J-3	26.8- 26.9

HOLE NO. LHS-MW7

DRILLING LOG	DIVISION SOUTHWEST	INSTALLATION LHAAP	SHEET 2 OF 2 SHEETS

1. PROJECT LHAAP-WASTE SUMPS	10. SIZE AND TYPE OF BIT 8" AUGER
2. LOCATION (Coordinates or Station) 6959841.50 3304410.30	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
3. DRILLING AGENCY TULSA DISTRICT COE	12. MANUFACTURER'S DESIGNATION OF DRILL FAILING 1500
4. HOLE NO. (As shown on drawing title and file number) LHS-MW7	13. OVERBURDEN SAMPLES DISTURBED 3 UNDISTURBED 17
5. NAME OF DRILLER RAY VOILS	14. TOTAL NUMBER CORE BOXES 0
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER SEE REMARKS
	16. DATE HOLE STARTED 08/20/1994 COMPLETED 08/20/1994
	17. ELEVATION TOP OF HOLE 218.6
7. THICKNESS OF OVERBURDEN 26.9	18. TOTAL CORE RECOVERY FOR BORING 0.0 %
8. DEPTH DRILLED INTO ROCK 0.0	
9. TOTAL DEPTH OF HOLE 26.9	STEVE BREWER

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
196.2	22		FAT CLAY (CH) (17.0 – 22.4) LIGHT OLIVE GRAY, MOIST, HARD, SLIGHTLY SLICKENSIDED, FRIABLE			
194.7	24		LEAN CLAY (CL) (22.4 – 23.9) WITH SAND, OLIVE, MOIST, HARD, FRIABLE, LAMINATION OF VERY FINE SAND AND SILT.		ST-15	
194.0			CLAY SAND (SC) (23.9 – 24.6) OLIVE, MOIST, STIFF, SILTY, FRIABLE, CRUMBLES EASILY, TOP 1.0' DISTURBED WITH FALL-IN MATERIAL		ST-16	
					ST-17	
181.8	26		CLAY SAND (SC) (24.6 – 26.8) OLIVE, VERY MOIST, FRIABLE, CRUMBLES EASILY.		J-3	
	28, 30, 32, 34, 36, 38, 40		LEAN CLAY (CL) (26.8 – 26.9) WITH SAND, LIGHT OLIVE BROWN, MOIST, CALCAREOUS.			

Appendix C

MSDSs for In Situ Bioremediation Materials

MATERIAL SAFETY DATA SHEET

EOS® 600 EMULSIFIED EDIBLE OIL SUBSTRATE		----HMIS----	
		HEALTH	1
D.O.T. HAZARD CLASSIFICATION: NONE		FLAMMABILITY	0
		REACTIVITY	0
		PERSONAL PROTECTION	B

MANUFACTURER'S NAME

EOS Remediation, Inc
1101 Nowell Road
Raleigh, NC 27607
www.EOSRemediation.com

DATE OF PREPARATION
01-24-03, Rev. 04-19-05

INFORMATION TELEPHONE NO.
919-873-2204

SECTION I - PRODUCT IDENTIFICATION

PRODUCT NAME	**EOS® 600**
PRODUCT CLASS	**VEGETABLE OIL BASED EMULSION**
CAS NUMBER	**MIXTURE**

SECTION II - HAZARDOUS INGREDIENTS

<u>COMPONENT(S)</u> <u>EXPOSURE LIMIT</u>

THIS PRODUCT IS A MIXTURE OF EDIBLE FOOD GRADE ADDITIVES AND CONTAINS NO HAZARDOUS INGREDIENTS.

SECTION III - PHYSICAL DATA

BOILING POINT:	**212°F**
SPECIFIC GRAVITY:	**0.97; .92 (pure oil phase)**
VAPOR PRESSURE:	**NOT ESTABLISHED**
PERCENT VOLATILE BY VOLUME (%):	**24 (AS WATER)**
VAPOR DENSITY:	**HEAVIER THAN AIR**
EVAPORATION RATE:	**NOT ESTABLISHED**
SOLUBILITY IN WATER:	**SOLUBLE**
APPEARANCE AND ODOR:	**OFF WHITE LIQUID WITH VEGETABLE OIL ODOR**
pH	**NEUTRAL**

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLASH POINT:	**>300°F**
FLAMMABLE LIMITS:	**NOT ESTABLISHED**
EXTINGUISHING MEDIA:	**CO_2, FOAM, DRY CHEMICAL** **NOTE: WATER, FOG, AND FOAM MAY CAUSE FROTHING AND SPATTERING.**
UNUSUAL FIRE AND EXPLOSION HAZARDS:	**BURNING WILL CAUSE OXIDES OF CARBON.**
SPECIAL FIRE FIGHTING PROCEDURES:	**WEAR SELF CONTAINED BREATHING APPARATUS AND CHEMICAL RESISTANT CLOTHING. USE WATER SPRAY TO COOL FIRE EXPOSED CONTAINERS.**

SECTION V - PHYSICAL HAZARDS

STABILITY:	**STABLE**
CONDITIONS TO AVOID:	**NONE**
INCOMPATIBILITY:	**STRONG ACIDS AND OXIDIZERS.**
HAZARDOUS DECOMPOSITION PRODUCTS:	**THERMAL DECOMPOSITION MAY PRODUCT OXIDES OF CARBON.**
HAZARDOUS POLYMERIZATION:	**WILL NOT OCCUR**

SECTION VI - HEALTH HAZARDS

SIGNS AND SYMPTOMS OF EXPOSURE:

1. Acute Overexposure - **NONE**
2. Chronic Overexposure - **NONE**

MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE: **NONE KNOWN**

CHEMICAL LISTED AS CARCINOGEN OR POTENTIAL CARCINOGEN:
N.T.P. - **NO** I.A.R.C. - **NO** OSHA - **NO**

EMERGENCY AND FIRST AID PROCEDURES:

1.) Inhalation-	**REMOVE TO FRESH AIR.**
2.) Eyes-	**FLUSH WITH WATER FOR 15 MINUTES, IF IRRITATION PERSISTS SEE PHYSICIAN.**
3.) Skin-	**WASH WITH MILD SOAP AND WATER.**
4.) Ingestion-	**PRODUCT IS NON-TOXIC. IF NAUSEA OCCURS, INDUCE VOMITING AND SEEK MEDICAL ATTENTION.**

SECTION VII - SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION:	**NOT NORMALLY REQUIRED**
VENTILATION:	**LOCAL EXHAUST**
PROTECTIVE GLOVES:	**NOT NORMALLY REQUIRED**
EYE PROTECTION:	**NOT NORMALLY REQUIRED**
OTHER PROTECTIVE CLOTHING OR EQUIPMENT:	**NONE**

SECTION VIII - SPECIAL PRECAUTIONS AND SPILL/LEAK PROCEDURES

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE:	**DO NOT STORE NEAR EXCESSIVE HEAT OR OXIDIZERS.**
OTHER PRECAUTIONS:	**NONE**
STEPS TO BE TAKEN IN CASE MATERIAL IS SPILLED:	**SOAK UP WITH DRY ABSORBENT AND FLUSH AREA WITH LARGE AMOUNTS OF WATER.**
WASTE DISPOSAL METHODS:	**DISPOSE OF ACCORDING TO FEDERAL, STATE, AND LOCAL REGULATIONS.**

SECTION IX - ADDITIONAL REGULATORY INFORMATION

SARA TITLE III

UNDER THE PROVISIONS OF TITLE 111, SECTION 311/312 OF THE SUPERFUND AMENDMENTS AND REAUTHORIZATIONS ACT, THIS PRODUCT IS CLASSIFIED INTO THE FOLLOWING HAZARD CATEGORIES: **NONE**

THIS PRODUCT DOES <u>**NOT**</u> CONTAIN SECTION 313 REPORTABLE INGREDIENTS.

THE INFORMATION CONTAINED HEREIN IS BASED ON AVAILABLE DATA AND IS BELIEVED TO BE CORRECT. HOWEVER, EOS REMEDIATION, INC. MAKES NO WARRANTY, EXPRESSED OR IMPLIED, REGARDING THE ACCURACY OF THIS DATA OR THE RESULTS TO BE OBTAINED THEREOF. THIS INFORMATION AND PRODUCT ARE FURNISHED ON THE CONDITION THAT THE PERSON RECEIVING THEM SHALL MAKE HIS/HER OWN DETERMINATION AS TO THE SUITABILITY OF THE PRODUCT FOR HIS/HER PARTICULAR PURPOSE.

Material Safety Data Sheet

Shaw Environmental, Inc.
17 PRINCESS ROAD
LAWRENCEVILLE, N.J. 08648
(609) 895-5340

SECTION 1 - MATERIAL IDENTIFICATION AND INFORMATION

Material Name: DHC microbial consortium (SDC-9) MSDS #: ENV 1033

Date Prepared: 10/06/2003 CAS #: N/A (Not Applicable)

Prepared By: Simon Vainberg Formula #: N/A

Material Description: Non-hazardous, naturally occurring non-altered anaerobic microbes and enzymes in a water-based medium.

SECTION 2 - INGREDIENTS

Components	%	OSHA PEL	ACGIH TLV	OTHER LIMITS
Non-Hazardous Ingredients	100	N/A	N/A	N/A

SECTION 3 - PHYSICAL/CHEMICAL CHARACTERISTICS

Boiling Point: 100°C (water)

Specific Gravity (H_2O = 1): 0.9 - 1.1

Vapor Pressure @ 25°C: 24 mm Hg (water)

Melting Point: 0°C (water)

Vapor Density: N/A

Evaporation Rate (H_2O = 1): 0.9 - 1.1

Solubility in Water: Soluble

Water Reactive: No

pH: 6.0 - 8.0

Appearance and Odor: Murky, yellow water. Musty odor.

SECTION 4 - FIRE AND EXPLOSION HAZARD DATA

Flash Point: N/A

Flammable Limits: N/A

Extinguishing Media: Foam, carbon dioxide, water

Special Fire Fighting Procedures: None

Unusual Fire and Explosion Hazards: None

SECTION 5 - REACTIVITY DATA

Stability: Stable

Conditions to Avoid: None

Incompatibility (Materials to Avoid): Water-reactive materials

Hazardous Decomposition Byproducts: None

SECTION 6 - HEALTH HAZARD DATA

HEALTH EFFECTS

The effects of exposure to this material have not been determined. Safe handling of this material on a long-term basis will avoid any possible effect from repetitive acute exposures. Below are possible health effects based on information from similar materials. Individuals hyper allergic to enzymes or other related proteins should not handle.

Ingestion: Ingestion of large quantities may result in abdominal discomfort including nausea, vomiting, cramps, diarrhea, and fever.

Inhalation: Hypersensitive individuals may experience breathing difficulties after inhalation of aerosols.

Skin Absorption: N/A

Skin Contact: May cause skin irritation. Hypersensitive individuals may experience allergic reactions to enzymes.

Eye Contact: May cause eye irritation.

FIRST AID

Ingestion: Get medical attention if allergic symptoms develop (observe for 48 hours). Never give anything by mouth to an unconscious or convulsing person.

Inhalation: Get medical attention if allergic symptoms develop.

Skin Absorption: N/A

Skin Contact: Wash affected area with soap and water. Get medical attention if allergic symptoms develop.

Eye Contact: Flush eyes with plenty of water for at least 15 minutes using an eyewash fountain, if available. Get medical attention if irritation occurs.

NOTE TO PHYSICIANS: All treatments should be based on observed signs and symptoms of distress in the patient. Consideration should be given to the possibility that overexposure to materials other than this material may have occurred.

SECTION 7 - SPILL AND LEAK PROCEDURES

Reportable quantities (in lbs of EPA Hazardous Substances): N/A

Steps to be taken in case of spill or release: No emergency results from spillage. However, spills should be cleaned up promptly. All personnel involved in the cleanup must wear protective clothing and avoid skin contact. Absorb spilled material or vacuum into a container. After clean-up, disinfect all cleaning materials and storage containers that come in contact with the spilled liquid.

Waste Disposal Method: No special disposal methods are required. The material may be sewered, and is compatible with all known biological treatment methods. To reduce odors and permanently inactivate microorganisms, mix 100 parts (by volume) of DHC consortium with 1 part (by volume) of bleach. Dispose of in accordance with local, state and federal regulations.

SECTION 8 - HANDLING AND STORAGE

Hand Protection: Rubber gloves.

Eye Protection: Safety goggles with side splash shields.

Protective Clothing: Use adequate clothing to prevent skin contact.

Respiratory Protection: Surgical mask.

Ventilation: Provide adequate ventilation to remove odors.

Storage & Handling:
Material may be stored for up to 3 weeks at 2-4°C without aeration.

Other Precautions: An eyewash station in the work area is recommended.

While the information and recommendations set forth herein are believed to be accurate as of the date hereof, Shaw Environmental, Inc. MAKES NO WARRANTY WITH RESPECT HERETO AND DISCLAIMS ALL LIABILITY FROM RELIANCE THEREON.

MSDS Number: **S2954** * * * * * *Effective Date:* ***11/26/07*** * * * * * *Supercedes:* ***05/23/06***

24 Hour Emergency Telephone: 908-859-2151
CHEMTREC: 1-800-424-9300

National Response in Canada
CANUTEC: 613-996-6666

Outside U.S. and Canada
Chemtrec: 703-527-3887

MSDS *Material Safety Data Sheet*

From: Mallinckrodt Baker, Inc.
222 Red School Lane
Phillipsburg, NJ 08865

Mallinckrodt CHEMICALS J.T.Baker

NOTE: CHEMTREC, CANUTEC and National Response Center emergency numbers to be used only in the event of chemical emergencies involving a spill, leak, fire, exposure or accident involving chemicals.

All non-emergency questions should be directed to Customer Service (1-800-582-2537) for assistance.

SODIUM BICARBONATE

1. Product Identification

Synonyms: Sodium hydrogen carbonate; sodium acid carbonate; baking soda; bicarbonate of soda
CAS No.: 144-55-8
Molecular Weight: 84.01
Chemical Formula: $NaHCO_3$
Product Codes:
J.T. Baker: 3506, 3508, 3509, 3510
Mallinckrodt: 7285, 7396, 7397, 7412, 7749, 7903

2. Composition/Information on Ingredients

Ingredient	CAS No	Percent	Hazardous
Sodium Bicarbonate	144-55-8	99 - 100%	No

3. Hazards Identification

Emergency Overview

As part of good industrial and personal hygiene and safety procedure, avoid all unnecessary exposure to the chemical substance and ensure prompt removal from skin, eyes and clothing.

SAF-T-DATA(tm) Ratings (Provided here for your convenience)

Health Rating: 1 - Slight
Flammability Rating: 1 - Slight
Reactivity Rating: 1 - Slight
Contact Rating: 1 - Slight
Lab Protective Equip: GOGGLES; LAB COAT
Storage Color Code: Green (General Storage)

Potential Health Effects

Inhalation:
High concentrations of dust may cause coughing and sneezing.
Ingestion:
Extremely large oral doses may cause gastrointestinal disturbances.
Skin Contact:
No adverse effects expected.
Eye Contact:
Contact may cause mild irritation, redness, and pain.
Chronic Exposure:
No information found.
Aggravation of Pre-existing Conditions:
No information found.

4. First Aid Measures

Inhalation:
Remove to fresh air. Get medical attention for any breathing difficulty.
Ingestion:
Give several glasses of water to drink to dilute. If large amounts were swallowed, get medical advice.
Skin Contact:
Not expected to require first aid measures.
Eye Contact:
Wash thoroughly with running water. Get medical advice if irritation develops.

5. Fire Fighting Measures

Fire:

Not considered to be a fire hazard.
Explosion:
Not considered to be an explosion hazard.
Fire Extinguishing Media:
Use any means suitable for extinguishing surrounding fire.
Special Information:
Use protective clothing and breathing equipment appropriate for the surrounding fire.

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6. Accidental Release Measures

Ventilate area of leak or spill. Wear appropriate personal protective equipment as specified in Section 8. Spills: Sweep up and containerize for reclamation or disposal. Vacuuming or wet sweeping may be used to avoid dust dispersal. Small amounts of residue may be flushed to sewer with plenty of water.

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7. Handling and Storage

Keep in a well closed container stored under cold to warm conditions, 2 to 40 C, (36 to 104F). Protect against physical damage. Containers of this material may be hazardous when empty since they retain product residues (dust, solids); observe all warnings and precautions listed for the product.

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8. Exposure Controls/Personal Protection

Airborne Exposure Limits:
None established.
Ventilation System:
In general, dilution ventilation is a satisfactory health hazard control for this substance. However, if conditions of use create discomfort to the worker, a local exhaust system should be considered.
Personal Respirators (NIOSH Approved):
For conditions of use where exposure to dust or mist is apparent and engineering controls are not feasible, a particulate respirator (NIOSH type N95 or better filters) may be worn. If oil particles (e.g. lubricants, cutting fluids, glycerine, etc.) are present, use a NIOSH type R or P filter. For emergencies or instances where the exposure levels are not known, use a full-face positive-pressure, air-supplied respirator. WARNING: Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.
Skin Protection:
Wear protective gloves and clean body-covering clothing.
Eye Protection:
Use chemical safety goggles. Maintain eye wash fountain and quick-drench facilities in work area.

9. Physical and Chemical Properties

Appearance:
White crystalline powder.
Odor:
Odorless.
Solubility:
7.8g/100g water @ 18C (64F).
Density:
2.2
pH:
8.3 (0.1 molar @ 25C (77F))
% Volatiles by volume @ 21C (70F):
0
Boiling Point:
Not applicable.
Melting Point:
60C (140F)
Vapor Density (Air=1):
No information found.
Vapor Pressure (mm Hg):
No information found.
Evaporation Rate (BuAc=1):
No information found.

10. Stability and Reactivity

Stability:
Stable under ordinary conditions of use and storage.
Hazardous Decomposition Products:
Gaseous carbon dioxide.
Hazardous Polymerization:
Will not occur.
Incompatibilities:
Reacts with acids to form carbon dioxide. Dangerous reaction with monoammonium phosphate or a sodium-potassium alloy.
Conditions to Avoid:
Heat, moisture, incompatibles.

11. Toxicological Information

Investigated as a mutagen, reproductive effector. Oral rat LD50: 4220 mg/kg. Irritation data: human,skin, 30mg/3D-I mild, rabbit,eye, 100 mg/30 S, mild.

--------\Cancer Lists\--

Ingredient	---NTP Carcinogen--- Known	Anticipated	IARC Category
Sodium Bicarbonate (144-55-8)	No	No	None

12. Ecological Information

Environmental Fate:
No information found.
Environmental Toxicity:
For Sodium Bicarbonate:
48 hour EC50 Daphnia magna (water flea) : 2350 mg/L.
96 hour LC50 Lepomis macrochirus (bluegill) : > 5000 mg/L.
120 hour EC50 Nitzschia linearis (diatom) : 650 mg/L.

This material is not expected to be toxic to aquatic life.

13. Disposal Considerations

Whatever cannot be saved for recovery or recycling should be managed in an appropriate and approved waste disposal facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

14. Transport Information

Not regulated.

15. Regulatory Information

--------\Chemical Inventory Status - Part 1\---------------------------------

Ingredient	TSCA	EC	Japan	Australia
Sodium Bicarbonate (144-55-8)	Yes	Yes	Yes	Yes

--------\Chemical Inventory Status - Part 2\---------------------------------

Ingredient	Korea	--Canada-- DSL	NDSL	Phil.

Sodium Bicarbonate (144-55-8)	Yes	Yes	No	Yes

--------\Federal, State & International Regulations - Part 1\----------------

Ingredient	-SARA 302- RQ	TPQ	------SARA 313------ List	Chemical Catg.
Sodium Bicarbonate (144-55-8)	No	No	No	No

--------\Federal, State & International Regulations - Part 2\----------------

Ingredient	CERCLA	-RCRA- 261.33	-TSCA- 8(d)
Sodium Bicarbonate (144-55-8)	No	No	No

Chemical Weapons Convention: No TSCA 12(b): No CDTA: No
SARA 311/312: Acute: No Chronic: No Fire: No Pressure: No
Reactivity: No (Pure / Solid)

Australian Hazchem Code: None allocated.
Poison Schedule: None allocated.
WHMIS:
This MSDS has been prepared according to the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

16. Other Information

NFPA Ratings: Health: **1** Flammability: **0** Reactivity: **0**
Label Hazard Warning:
As part of good industrial and personal hygiene and safety procedure, avoid all unnecessary exposure to the chemical substance and ensure prompt removal from skin, eyes and clothing.
Label Precautions:
None.
Label First Aid:
Not applicable.
Product Use:
Laboratory Reagent.
Revision Information:
MSDS Section(s) changed since last revision of document include: 12.
Disclaimer:
****

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Prepared by: Environmental Health & Safety
Phone Number: (314) 654-1600 (U.S.A.)

Appendix D

Site-Specific Supplement to Health and Safety Plan

Appendix D
Site-Specific Supplement to Health and Safety Plan

Final
Remedial Design
LHAAP-35A(58), Shops Area, Group 4
Longhorn Army Ammunition Plant
Karnack, Texas

Prepared for U.S. Army Corps of Engineers – Tulsa District
1645 South 101st East Avenue
Tulsa, Oklahoma 74128

Prepared by Shaw Environmental, Inc.
1401 Enclave Parkway, Suite 250
Houston, Texas 77077

Contract No. W912QR-04-D-0027, Task Order No. DS02
Project No. 117591
Rev 0
September 2011

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Acronyms and Abbreviations

ANSI	American National Standards Institute
CFR	Code of Federal Regulations
DPT	direct-push technology
HSM	Health and Safety Manager
LEL/O_2	lower explosive limit/oxygen
mg/m^3	milligrams per cubic meter
PID	photoionization detector
PPE	personal protective equipment
PVC	polyvinyl chloride
TWA	time-weighted average

Personal Protective Equipment (PPE) Levels

LHAAP-35A(58) – Monitoring Well Sampling/Well Installation or Abandonment/ Direct-Push Technology (DPT) Operations

Level D – Modified PPE:

- Hard hat meeting American National Standards Institute (ANSI) Z89.1 specifications.
- Safety glasses with side shields meeting ANSI Z87.1 specifications.
- Safety-toed work boots meeting ANSI Z41 specifications.
- Nitrile surgical gloves (inner or double layer).
- Disposable Tyvek® coveralls with hoods, elastic wrists, and elastic ankles.
- Chemical resistant boot covers and/or outer boots (polyvinyl chloride/latex/neoprene when there is potential for shoe/boot contact with contaminated soil or water).
- Hearing protection (if necessary or required).
- High visibility vests (ground personnel when working near heavy equipment or vehicular traffic).
- Work gloves, such as leather, cotton, or other material that provides cut/abrasion resistance (as necessary).

LHAAP-35A(58) – Brush Clearing for Access

Level D – Modified PPE:

- Hard hat meeting ANSI Z89.1 specifications.
- Safety glasses with side shields meeting ANSI Z87.1 specifications.
- Safety-toed work boots meeting ANSI Z41 specifications.
- Disposable Tyvek® coveralls with hoods, elastic wrists, and elastic ankles.
- Hearing protection (if necessary or required).
- High visibility vests (ground personnel when working near heavy equipment or vehicular traffic).
- Work gloves, such as leather, cotton, or other material that provides cut/abrasion resistance (as necessary).

Air Monitoring

Particulates

Real-Time Aerosol Monitor

Real-time aerosol monitors (MIE pDR-1000 or equivalent) shall be used to monitor dust emissions during dust generating activities. The only dust generating activity anticipated is clearing brush for well access or during well abandonment. The real-time aerosol monitors will be placed in the work area (near areas where ground personnel are working) and at the downwind site perimeter. The selected placement of these instruments may need to be adjusted throughout the workday to compensate for changes of wind direction.

Real-Time Aerosol Monitoring Action Levels

The real-time aerosol monitors will be set to alarm when the instantaneous aerosol concentration reaches 1.0 milligrams per cubic meter (mg/m^3). The alarm will be used to indicate that additional dust control is necessary.

The real-time aerosol monitors are capable of collecting and integrating the aerosol concentrations throughout the workday into a time-weighted average (TWA). Aerosol monitors shall be visually checked on an hourly basis during dust generating activities to verify that the TWA remains below 1.0 mg/m^3. Aerosol monitors registering time-weighted average aerosol concentrations at or above 2.0 mg/m^3 require that workers upgrade to Level C PPE and indicate that additional dust control measures are necessary. Failure to control workday time-weighted average dust concentrations to below 4.0 mg/m^3 shall necessitate ceasing dust generating activities and contacting the Project Manager and Health and Safety Manager (HSM) for implementing alternate work practices.

The full work-shift time-integrated concentrations will be evaluated at the conclusion of each workday to verify aerosol concentrations are maintained below action levels.

Volatiles/Oxygen

Photoionization detectors (PIDs) and lower explosive limit/oxygen (LEL/O_2) detectors shall be used to monitor emissions during sampling and well abandonment. Measurements will be collected from the work area and breathing zone during sampling or well abandonment activities. The action levels for the area monitoring are provided in the table below:

Direct Reading Air Monitoring Summary for Volatiles/Oxygen

Monitoring Device	Monitoring Location/Personnel	Monitoring Frequency	Action Level [a]	Action
PID/OVA (breathing zone)	DPT operations, groundwater sampling, and well installation	At start-up, minimum four times daily in work area and breathing zone	>5 ppm	Test for vinyl chloride (VC) (colorometric detector tubes)
LEL/O2 meters	DPT operations, groundwater sampling, and well installation	At start-up, minimum four times daily in work area.	>10% LEL	Stop operations; allow vapors to vent and reach <10% before continuing

Notes and Abbreviations:

[a] *Sustained levels above background for 5 minutes in breathing zone*
DPT *direct-push technology*
LEL/O2 *lower explosive limit/oxygen*
ppm *parts per million*
PID/OVA *photo ionization detector/organic vapor analyzer*

Personal Air Sampling (time-integrated)

Time-integrated air sampling may be performed at the discretion of the HSM, if air-monitoring action levels are exceeded.

Medical Surveillance

LHAAP-35A(58)

There are no special medical surveillance requirements in addition to the requirements of 29 Code of Federal Regulations 1910.120(f), which are already in place.

ACTIVITY HAZARD ANALYSIS FOR GROUNDWATER SAMPLING OR DPT OPERATIONS

Task Breakdown	Potential Hazards	Hazard Control Measures	Personal Protective Equipment	Monitoring Devices
Groundwater Sampling or DPT Operations	Inhalation and contact with hazardous substances	• Provide workers proper skin, eye and respiratory protection based on the exposure hazards present • Review hazardous properties of site contaminants with workers before sampling operations begin	Latex inner gloves, Tyvek® coveralls, nitrile gloves	LEL / O_2, PID
	Flammable, explosive atmospheres	• Test well head atmosphere for flammable/toxic vapors • Wear proper level of PPE for the type of atmospheric contaminants • Eliminate sources of ignition from the work area • Prohibit smoking in development area	Tyvek® coveralls, nitrile gloves	LEL / O_2, PID
	Struck by/against flying particles, protruding objects, liquid splash	• Wear hard hats, safety glasses with side shields and steel-toe safety boots at all times • Wear splash shields and safety goggles when sampling, cleaning, decontaminating test equipment	Hard hat, safety glasses	—
	Handling heavy objects	• Observe proper lifting techniques • Obey sensible lifting limits (60 lb maximum per person manual lifting) • Use mechanical lifting equipment (hand carts, trucks) to move large, awkward loads	—	—
	Sharp objects	• Wear cut resistant work gloves when the possibility of lacerations or other injury may be caused by sharp edges or objects • Maintain all tools in a safe condition • Keep guards in place during use	Cut resistant gloves	—
	High / low ambient temperature	• Monitor for heat/cold stress in accordance with Shaw Health & Safety Program, Volumes I & II, HS400 / HS 401 • Provide fluids to prevent worker dehydration	Insulated clothing (subject to ambient temperature)	Meteorological equipment

EQUIPMENT TO BE USED	INSPECTION REQUIREMENTS	TRAINING REQUIREMENTS
Hand tools	Small equipment as specified by operations manual	40 hour Hazardous Waste Training Review HASP Review site-specific AHA with all task personnel. Safe driver's training (HS800)

ACTIVITY HAZARD ANALYSIS FOR BRUSH CLEARING PREPARATION

Principle Steps	Potential Safety/Health Hazards	Hazard Control Measures	Personal Protective Equipment	Monitoring Devices
Clearing Brush	Operations of power clearing tools (brush saws, weed whackers)	• Wear eye, face, hand and hearing protection when operating power clearing equipment • Shut-off / idle power tools walking between work areas • Store flammable liquids in well ventilated areas, away from work areas • Shut off equipment during re-fueling • Allow equipment to cool before re-fueling • Use funnels to avoid fuel spillage • Prohibit smoking while operating clearing equipment • Provide ABC (or equivalent) fire extinguishers for all work areas	Face shield, goggles, cloth gloves, ear plugs, steel toe work boots	—
	Handling heavy objects	• Observe proper lifting techniques • Obey sensible lifting limits (60 lb maximum per person manual lifting) • Use mechanical lifting equipment (hand carts, trucks) to move large, awkward loads	—	—
	Sharp objects	• Wear cut-resistant work gloves when the possibility of lacerations or other injury may be caused by sharp edges or objects • Maintain hand and power tools in a safe condition • Keep guards in place during use	Leather gloves with reinforced palm	—
	Eye injuries	• Wear face shield, goggles when operating powered clearing / grubbing equipment	Face shield, goggles, safety glasses	—
Mobilization/Site Setup and Survey/Layout	Slips, trips, falls	• Clear walkways, work areas of equipment, tools, vegetation, excavated material and debris • Mark, identify, or barricade other obstructions • Ensure footing. Look before you step	—	—
	High noise levels	• Use hearing protection when exposed to excessive noise levels (greater than 85 decibels, A-scale (dBA) over an 8-hour work period)	Ear plugs	—
	High/low ambient temperature	• Monitor for heat/cold stress in accordance with Shaw Health & Safety Program, Volumes I & II, HS400 / HS 401 • Provide fluids to prevent worker dehydration	Insulated clothing (subject to ambient temperature)	Meteorological equipment

EQUIPMENT TO BE USED	INSPECTION REQUIREMENTS	TRAINING REQUIREMENTS
Hand tools	Daily heavy equipment inspections Small equipment as specified by operations manual	Review Site Safety and Health Plan (HASP) Review site-specific Activity Hazard Analysis (AHA) with all task personnel. Review equipment safety operations manual Safe driver's training (HS800)

ACTIVITY HAZARD ANALYSIS FOR MONITORING WELL INSTALLATION OR ABANDONMENT

Task Breakdown	Potential Hazards	Critical Safety Practices	Personal Protective Clothing and Equipment	Monitoring Devices
Monitoring Well Installation or Abandonment	Slips, trips, falls	• Clear walkways, work areas of equipment, debris and excavated materials • Mark, identify, or barricade other obstructions • Halt exterior work in high winds, severe weather	—	—
	Sharp objects	• Wear cut resistant work gloves when the possibility of lacerations or other injury may be caused by sharp edges or objects • Maintain all hand and power tools in a safe condition • Keep guards in place during use	Leather gloves	—
	Handling heavy objects (piping/casings)	• Observe proper lifting techniques • Obey sensible lifting limits (60 lb. maximum per person manual lifting) • Use mechanical lifting equipment (hand carts, trucks) to move large, awkward loads • Move long sections of piping/casing with at least two workers or mechanical equipment • Add tag lines to loads, if necessary, to minimize side-to-side movement • Prohibit workers from standing on top of piping during loading/unloading/transferring pipe or rolling stock • Stand clear of rolling stock/piping; do not attempt to stop rolling piping • Use slip handles to move slips; prohibit kicking slip handles into place	—	—
	Flammable, toxic emissions	• Monitor for flammable/toxic vapors, particulates, and gases • Wear proper level of PPE for the type of atmospheric contaminants	Portable fire extinguishers	PID
	Underground utilities	• Identify all underground utilities around the excavation site before work commences • Cease work immediately if unknown utility markers are uncovered	—	—
	Struck by/against heavy equipment, protruding objects, splashes	• Wear reflective warning vests when exposed to vehicular traffic • Isolate equipment swing areas • Make eye contact with operators before approaching equipment	Warning vest, hard hat safety glasses, steel toe work boots	—

ACTIVITY HAZARD ANALYSIS FOR MONITORING WELL INSTALLATION OR ABANDONMENT

Task Breakdown	Potential Hazards	Critical Safety Practices	Personal Protective Clothing and Equipment	Monitoring Devices
Monitoring well installation or abandonment *(cont.)*	Struck by/against heavy equipment, protruding objects, splashes *(cont.)*	• Wear hard hats, safety glasses with side shields, face shields and goggles, and steel-toe safety boots • Understand and review hand signals • Chock piping/rolling stock stored on trailers/racks/etc to prevent rolling	Warning vest, hard hat safety glasses, steel toe work boots	—
	Equipment failure	• Inspect drilling equipment daily according to manufacturer's specifications • Block and level drilling equipment before use • Ensure equipment not in use is properly stored • Examine fittings, drive rods, hydraulic lines for condition and wear	—	—
	Inhalation and contact with hazardous substances	• Provide workers proper skin, eye and respiratory protection based on the exposure hazards present • Review hazardous properties of site contaminants with workers before operations begin • Monitor breathing zone air to determine levels of contaminants	Tyvek® coveralls, nitrile gloves, latex or neoprene boots	PID
	Insect/ snake bites	• Review injury potential and types of snakes with workers • Avoid insect nests areas, likely habitats of snakes outside work areas • Emphasize The Buddy System where such injury potential exists • Use insect repellant, wear PPE to protect against sting/bite injuries	Tyvek® coveralls, duct tape bottom of coveralls to boots or latex boot covers	—
	Contact dermatitis	• Wear PPE to avoid skin contact with contaminated soil, plants, or other skin irritants • Identify and review poisonous plants with workers • Apply protective cream/lotion to exposed skin to prevent poison ivy or similar reactions	Tyvek® coveralls, duct tape bottom of coveralls to boots or latex boot covers	—
	Caught in/between moving parts	• Identify and understand parts of equipment which may cause crushing, pinching, rotating or similar motions • Assure guards are in place to protect from these parts of equipment during operation • Wear proper work gloves when the possibility of pinching, or other injury may be caused by moving/ handling large or heavy objects • Maintain all equipment in a safe condition • Keep all guards in place during use • De-energize and lock-out machinery before maintenance or service	—	—

ACTIVITY HAZARD ANALYSIS FOR MONITORING WELL INSTALLATION OR ABANDONMENT

Task Breakdown	Potential Hazards	Critical Safety Practices	Personal Protective Clothing and Equipment	Monitoring Devices
Monitoring Well Installation or Abandonment *(cont.)*	High noise levels	• Use hearing protection when exposed to excessive noise levels (greater than 85 dBA over an 8-hour work period) • Assess noise level with sound level meter if possibility exists that level may exceed 85dBA TWA	Ear plugs	Sound level meter
	High/low ambient temperature	• Monitor for heat/cold stress in accordance with Shaw E & I Health and Safety Program, HS400, HS401 • Provide fluids to prevent worker dehydration	Insulated clothing (subject to ambient temperature)	Meteorological equipment

EQUIPMENT TO BE USED	INSPECTION REQUIREMENTS	TRAINING REQUIREMENTS
Drill rig Hand tools	Daily heavy equipment inspections Daily Drill Rig Inspections Small equipment as specified by operations manual	40 hour Hazardous Waste Training Review SSHP Review site-specific AHA with all task personnel. Review equipment safety operations manual Safe driver's training (HS 800)

Appendix E

Contractor Quality Control Plan

Appendix E
Contractor Quality Control Plan

Final
Remedial Design
LHAAP-35A(58), Shops Area, Group 4
Longhorn Army Ammunition Plant
Karnack, Texas

Prepared for U.S. Army Corps of Engineers – Tulsa District
1645 South 101st East Avenue
Tulsa, Oklahoma 74128

Prepared by Shaw Environmental, Inc.
1401 Enclave Parkway, Suite 250
Houston, Texas 77077

Contract No. W912QR-04-D-0027, Task Order No. DS02
Project No. 117591
Rev 0
September 2011

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Acronyms and Abbreviations

CDAP	Chemical Data Acquisition Plan
CQC	contractor quality control
CQCP	Contractor Quality Control Plan
CQCSM	Contractor Quality Control System Manager
DPT	direct-push technology
GPS	Global Positioning System
HASP	Health and Safety Plan
LHAAP	Longhorn Army Ammunition Plant
LUC	land use control
MARC	Multiple Award Remediation Contract
OSHA	Occupational Safety and Health Administration
PPE	personal protective equipment
QAR	quality assurance representative
QC	quality control
Shaw	Shaw Environmental, Inc.
SSO	Site Safety Officer
TO	task order
USACE	U.S. Army Corps of Engineers

1.0 INTRODUCTION

The U.S. Army Corps of Engineers (USACE), Tulsa District, contracted Shaw Environmental, Inc. (Shaw), under the Louisville District's Multiple Award Remediation Contract (MARC) No. W912QR-04-D0027, Task Order (TO) No. DS02, to perform closure of multiple environmental sites at Longhorn Army Ammunition Plant (LHAAP), Karnack, Texas. TO DS02 is being administered by the Tulsa District of USACE.

LHAAP is located in central-east Texas, in Harrison County, between State Highway 43 at Karnack, Texas, and Caddo Lake. Figure 1-1 of the Remedial Design shows the location of LHAAP and surrounding communities.

The objective of this TO is to perform investigations, collect data, perform remediation activities at multiple sites on an expedited basis to achieve site closures, and bring as many sites as possible into the long-term management/long-term operation stage as early as possible. This Contractor Quality Control Plan (CQCP) documents quality control (QC) requirements that will be implemented during remediation at LHAAP-35A(58).

2.0 CONTRACTOR QUALITY CONTROL PLAN PURPOSE AND SCOPE

2.1 Contractor Quality Control Plan Purpose

This CQCP establishes procedures that enable common project field activities to be completed successfully and documents QC requirements for services provided by Shaw and its subcontractors during project activities at LHAAP-35A(58). This plan describes requirements for organizing, planning, performing, reviewing, documenting, and reporting activities that may affect the quality of the work. This CQCP applies the specific requirements of Shaw's Contractor Quality Control (CQC) System to this project by establishing controls for:

- QC staff organization and authority
- Workmanship
- Construction activities for major definable features of work
- Records
- Inspections and tests
- Documentation
- Audits
- Subcontractor performance

This plan references standard field procedures, policies, regulations, and practices required to implement the work. A controlled copy of applicable Field Procedures from Appendix D of the *Final Installation-Wide Work Plan, Longhorn Army Ammunition Plant* (Shaw, 2006) will be available as a reference document.

2.2 Contractor Quality Control Plan Scope

This CQCP is applicable to the work proposed at LHAAP-35A(58), including the major definable features of site work (or major project tasks) identified below:

Task 1 – Mobilization/Site Setup/Site Clearing
Task 2 – Direct Push Technology (DPT) Operations
Task 3 – Monitoring Well Installation
Task 4 – Groundwater Sampling
Task 5 – Waste Management
Task 6 – Monitoring Well Abandonment
Task 7 – Surveying
Task 8 – Site Restoration and Demobilization

2.3 Acceptance of Contractor Quality Control Plan

Work within the scope of this plan will not be started prior to providing this CQCP to USACE, unless otherwise permitted by USACE. Any proposed changes to this CQCP will require notification to USACE in writing. Proposed changes are subject to the approval of USACE.

3.0 ORGANIZATION AND RESPONSIBILITIES

3.1 Personnel and Structure

The Contractor Quality Control System Manager (CQCSM) coordinates implementation of this CQCP with the Project Manager, Remediation Manager, Program QC Manager, and subcontractors.

3.2 Duties and Responsibilities

The duties and responsibilities of personnel with regard to the CQC program are briefly outlined below. Duties and responsibilities of health and safety personnel are presented in Appendix A, Health and Safety Plan (HASP) (Shaw, 2006).

Project Manager: The Project Manager is responsible for all activities on the project, and directs and monitors the Site Superintendent in planning, coordinating, and controlling the work. The Project Manager has overall responsibility for establishing the CQCP and for its implementation, and he has the authority to access the required resources throughout Shaw to ensure compliance with the contract requirements.

Remediation Manager: The Remediation Manager reports to the Project Manager and is responsible for site remediation technical assurance. This individual will oversee the site remediation activities. The Remediation Manager has the following duties and authorities:

- Perform and/or oversee the purging and sampling of monitoring wells
- Perform and/or oversee the preservation, packaging, and shipping of samples to an off-site, fixed laboratory for environmental analyses
- Ensure documentation accuracy, completeness, and consistency among field team members
- Stop work that deviates from the contract documents or is otherwise nonconforming or unsafe.

CQCSM: The CQCSM is responsible for the overall management of the project CQC program during field activities. The CQCSM receives administrative and day-to-day direction from the Remediation Manager. The CQCSM is responsible to the Shaw Program QC Manager for direction on matters that may affect the QC requirements for the project. The CQCSM is assigned the following duties:

- Monitor and verify that the work is performed in accordance with the contract requirements

- Review and verify the disposition of discrepancy and corrective action reports
- Perform QC inspections and surveillance, and report daily on project QC
- Monitor project submittals in accordance with submittal register requirements
- Submit QC reports to the USACE Field Representative/Quality Assurance Representative (QAR) on a daily basis, unless other arrangements are agreed to by the USACE

The CQCSM has the authority to reject materials and workmanship that do not comply with project requirements, and to stop nonconforming work activities (see **Figure 3-1**).

Due to the limited size of the field effort at LHAAP-35A(58), the CQCSM may also serve as the Site Safety Officer (SSO). In this dual role, the CQCSM/SSO is responsible to the Shaw Program Health and Safety Manager for safety-related matters. The SSO duties are discussed in detail in the Installation-Wide CQCP provided as Appendix B of the Installation-Wide Work Plan.

Program QC Manager: The Program QC Manager is responsible to review, monitor, and report the conformance to QC requirements set forth in the CQCP. He may also advise the CQCSM on QC methods and practices. He will maintain a record of his quality monitoring activities and will inform the CQCSM of his monitoring activities. He shall also be responsible for performing periodic internal audits, and reporting his findings to the CQCSM.

Subcontractors: Shaw assumes overall responsibility for conformance to the quality requirements for the subcontracted items and services. Subcontractors are responsible to the Project Manager and Remediation Manager for completing the portion of work assigned to them, and to the CQCSM for CQCP activities. They shall verify that their construction and materials comply with the requirements of the contract plans and specifications. Subcontractors include organizations supplying quality-related items or services to the project.

3.3 Qualification of Personnel

Shaw personnel assigned to the project are qualified to perform the tasks to which they are assigned. The Project Manager and the Remediation Manager will appraise the qualification of professional and/or technical personnel assigned to the project. The appraisal will include the comparison of the requirements of the job assignment with the relevant experience and training of the prospective assignee.

Shaw Environmental, Inc.
1401 Enclave Parkway, Suite 250
Houston, Texas 77077

To:	To Be Determined
From:	John W. Patin, QC Manager
Date:	June 2011
Subject:	Contractor Quality Control System Manager, Letter of Authority U.S. Army Corps of Engineers, Tulsa District MARC Contract No. W912QR-04-D0027, Task Order No. DS02

This letter describes the responsibilities and authority delegated to you in your capacity as the Contractor Quality Control System Manager for Remediation of LHAAP-35A(58) at Longhorn Army Ammunition Plant, Karnack, Texas.

In this position, you are responsible for the implementation and enforcement of the CQCP and site specific addenda. You will use the plan to verify that the quality of materials, workmanship, operations, and safety monitoring conforms to the Remedial Design/Work Plan, its appendices, and addenda.

Your responsibilities include identifying and reporting quality problems, rejecting nonconforming materials, initiating corrective actions, and requesting solutions for nonconforming activities. You have the authority to control or stop project activities until satisfactory disposition and implementation of corrective actions are achieved. Detailed responsibilities and guidelines are given in the Remedial Design, its appendices, and addenda.

Figure 3-1
Letter of Authority

4.0 CONTRACTOR QUALITY CONTROL SYSTEMS

4.1 Control Measures

The CQCP provides measures to verify and document that the work performed complies with the requirements specified in the contract documents. These measures include:

- CQC inspections
- Document control
- Submittals
- Completion inspection
- Records

Procedures for implementing the above measures are included throughout the CQCP. The CQCP may be supplemented by additional guidelines or instructions for implementing the work and/or verifying compliance with the contract requirements.

4.2 Quality Control Monitoring

The project CQC program is monitored to verify that the program is in compliance with the CQCP. Monitoring activities are performed by the Shaw Program QC Manager, or his representative, and include the review of daily QC reporting and instructions, or directions given to the CQCSM on QC matters. If required, an assessment of the project's CQC system is performed. If performed, the assessment includes the following items:

- Subcontractor performance
- Field operation and records
- CQC and health and safety inspections, testing, and records
- Document control
- Training records

4.3 Quality Control Testing

As applicable, the CQCSM monitors the equipment/materials testing firm and/or analytical laboratory activities to verify the following:

- Execution of required tests
- Location of tests
- Timely and accurate reporting of test results
- Correct frequency of tests
- Completeness of documentation

5.0 INSPECTION PLAN

QC inspections include inspection of equipment, materials, testing procedures, documentation/submittals, and workmanship before, during, and after each definable feature of work. QC inspections are performed by the CQCSM in accordance with the Three-Phase CQC system. The CQCSM gives the USACE QAR advance notification (at least 24 hours) of formal inspections.

Definable features of site work (or major work tasks) for which QC inspections will be performed are addressed below.

<u>Definable Features of Site Work</u>:

Task 1 – Mobilization/Site Setup/Site Clearing
Task 2 – DPT Operations Including Injection
Task 3 – Monitoring Well Installation
Task 4 – Groundwater Sampling
Task 5 – Waste Management
Task 6 – Monitoring Well Abandonment
Task 7 – Surveying
Task 8 – Site Restoration and Demobilization

Other site remediation activities that constitute definable features of site work will be defined within site-specific addenda to the work plan. Those addenda will also identify related QC inspection requirements.

5.1 Task 1 – Mobilization and Site Setup

Following approval of the Remedial Design, Shaw will mobilize the necessary personnel and equipment to prepare the site for remedial activities. Using the Three-Phase CQC system, the CQCSM will monitor this task to affirm the following:

- Site personnel have the necessary Occupational Safety and Health Administration (OSHA) training and medical surveillance statements/certifications
- Heavy equipment (e.g., drilling rig) has undergone safety and preventive maintenance checks, and is suitable for the task for which it will be used.
- Measuring and test equipment has undergone calibration and/or calibration checks to assure accuracy and precision.
- The project team understands the investigation/remediation requirements.

- Site personnel have reviewed the HASP provided by the SSO and have acknowledged this review by signing the HASP acknowledgment form.
- Installed government property plan (when applicable) is reviewed and implemented for the equipment to be installed on site.
- Work zones and decontamination facilities are established in accordance with the HASP.
- Material storage areas are kept orderly.
- Site security measures are adequately maintained to prevent unauthorized access.
- Work zones are clearly demarcated using temporary barricading or fencing as required.

Once the site is mobilized and set up, field activities will commence.

5.2 Task 2 – Direct Push Technology Operations Including Injection

The field work involves DPT operations by drilling subcontractors. Using the Three-Phase CQC system, the CQCSM will monitor this task to affirm the following:

- Preparatory meetings are held with work crews to discuss the regulatory requirements for DPT operations.
- Personnel associated with this task have applicable OSHA training and medical surveillance certifications.
- Worker protection is adequate for the associated task hazards.
- DPT operations will employ a well driller licensed in the state of Texas.
- Materials and equipment are suitable and approved for use prior to starting the work.
- Required agency permits and/or notifications are completed prior to starting activities.
- Waste generated during activities is handled and disposed according to the waste management plan.

Injection Activities:

- Injection locations are marked in the field by Shaw personnel or under the direction of Shaw personnel, based on the Remedial Design/Work Plan, and recorded in a logbook.

- Water for DPT injections is transported to the site, combined with amendments, allowed to sit, and verified to be anaerobic.
- Injections for bioremediation are complete, and borings are abandoned.

5.3 Task 3 – Monitoring Well Installation

Well installation is proposed for this site. Using the Three-Phase CQC system, the CQCSM will monitor this task to affirm the following:

- Preparatory meetings are held with work crews to discuss the regulatory requirements for well installation.
- Personnel associated with this task have applicable OSHA training and medical surveillance certifications.
- Worker protection is adequate for the associated task hazards.
- Drilling operations will employ a well driller licensed in the state of Texas.
- Materials and equipment are suitable and approved for use prior to starting the work.
- Required agency permits and/or notifications are completed prior to starting activities.
- Well installation locations are marked in the field by Shaw personnel or under the direction of Shaw personnel, based on the Remedial Design/Work Plan, and recorded in a logbook.
- Waste generated during activities is handled and disposed according to the waste management plan.

5.4 Task 4 – Groundwater Sampling

Following the installation of groundwater monitoring wells, Shaw will collect groundwater samples for laboratory analyses. Using the Three-Phase CQC system, the CQCSM will monitor this task to affirm the following:

- Sampling personnel have reviewed the Chemical Data Acquisition Plan (CDAP) (Appendix C of the Final Installation-Wide Work Plan [Shaw, 2006]) and Work Plan and understand the scope of work.
- The SSO has briefed sampling personnel on task hazards and the appropriate personal protective equipment (PPE) level before sampling begins.
- A sampling equipment checklist is developed for this task and is reviewed with sampling personnel before sampling begins.

- Well depth and depth-to-water measurements are performed consistently from a common location at top-of-well casing (e.g., notch in top of casing or northern lip of casing).
- Well water volume is calculated accurately using well measurements.
- Well is purged of the required quantity of well water and water quality is stabilized as defined by the CDAP prior to sample collection.
- Purged water is contained in drums and managed in accordance with Work Plan waste handling requirements. Field screening procedures are found in Appendix D of the Final Installation-Wide Work Plan, Attachment 1.
- The specified sampling equipment and materials are used for sample collection.
- The sampling team leader (i.e., Remediation Manager) has instructed samplers on the sampling procedures and protocols and has assigned specific duties and responsibilities to each team member.
- Sampling equipment decontamination procedures are performed according to the CDAP.
- Sampling documentation procedures in the CDAP are followed and field documentation is legible, accurate, and complete.
- Quality assurance and QC samples are collected at prescribed frequencies in accordance with CDAP protocols and procedures.
- Sample labels, custody seals, and chain-of-custody forms contain pertinent sampling and analytical information before samples are packaged and shipped off site for laboratory analysis.
- Sampling and analytical records are maintained in the project file (in secured area).
- All field instruments are calibrated at the start of the testing day.

5.5 Task 5 – Waste Management

Using the Three-Phase CQC system, the CQCSM will monitor this task to affirm the following:

- Waste generated during the project activities will be segregated by type (e.g., soil cuttings, used PPE, well development and purging liquids, trash/debris) and stored in approved 55-gallon drums or other containers.

- Waste containers are labeled with a waterproof marker according to the Work Plan, indicating the content, accumulation date, waste code(s) (if known) and pertinent analytical information.
- Waste handling activities are documented in the field logbook and a tracking log is prepared that indicates waste type, point of waste generation (i.e., well number) container size and type, accumulation date, storage location, disposal destination, transporter name, shipping paper/manifest number, and transportation and disposal dates.
- Waste containers are leak proof and stored in a secure storage area.
- Waste storage area is clearly demarcated using barricade tape and/or temporary barricade fencing, as required.
- Waste container and storage area inspections are performed on a weekly basis (at a minimum) and documented in the field logbook and/or in a standard inspection form.

5.6 Task 6 – Monitoring Well Abandonment

Shaw will abandon monitoring wells that were installed during any investigation and remediation activities as needed. Using the Three-Phase CQC system, the CQCSM will monitor this task to affirm the following:

- Preparatory meetings are held with work crews to discuss the regulatory requirements for well abandonment.
- Personnel associated with this task have applicable OSHA training and medical surveillance certifications.
- Worker protection is adequate for the associated task hazards.
- Abandonment activities will employ a well driller licensed in the state of Texas.
- Well abandonment materials and equipment are suitable and approved for use prior to starting the work.
- Well locations and top of casing elevations are verified and recorded in a logbook prior to abandonment.
- Required agency permits and/or notifications are completed prior to starting abandonment activities.
- Waste generated during abandonment activities is handled and disposed according to the waste management plan.

- Quantity and depth measurements are made and recorded accurately the amount of grout used, depth below ground surface of the top of the grout once the grout has settled and hardened, and the amount of cover soil placed and compacted above the top of the grout to re-establish a level ground surface.
- A multi-purpose completion report and/or well abandonment log is accurately completed for each abandoned well and submitted to the State of Texas. Copies are maintained in the project file until submitted to the USACE with the final report.

5.7 Task 7 – Surveying

Using the Three-Phase CQC system, the CQCSM will monitor this task to affirm the following:

- A qualified land surveyor licensed by the State of Texas is employed to perform well surveying and metes and bounds land-use control (LUC) boundary surveys.
- Survey datum (vertical and horizontal) used is consistent with the work plan requirements and/or historical datum.
- Survey team undergoes preparatory meeting to verify their understanding of the scope of work.
- Surveying equipment is operative and properly calibrated.
- Instrument calibration is performed per manufacturer instructions.
- Survey points are clearly marked or labeled (e.g., notch in the top of casing and/or brass surveying marker embedded in surface pad).
- Field documentation is legible, accurate, and complete.
- Worker protection is adequate for the associated task hazards.

For identifying locations of soil samples and limits of excavation, a Global Positioning System (GPS) may be used in lieu of land surveying. Using the Three-Phase CQC system, the CQCSM will monitor this task to affirm the following:

- Survey team undergoes preparatory meeting to verify their understanding of the scope of work.
- Surveying equipment is operative and properly calibrated.
- Instrument calibration is performed per manufacturer instructions.
- Survey points are clearly marked or labeled

- Field documentation is legible, accurate, and complete.
- Worker protection is adequate for the associated task hazards.

5.8 Task 8 – Site Restoration and Demobilization

Shaw will restore the site and demobilize once response complete is attained. Using the Three-Phase CQC system, the CQCSM will affirm the following:

- Equipment installed for the purposes of this project, and not intended to be operated after this project is demobilized.
- Information for remaining equipment or installed materials has been submitted to LHAAP and USACE.

5.9 Other Site Remediation Tasks

Shaw will perform various site remedial activities to include optimizing the existing on-site groundwater treatment plant, soil/groundwater flushing, and instituting bioremedial solutions where applicable. Using the Three-Phase CQC system, the CQCSM will monitor these tasks as appropriate. Specific QC requirements for these tasks will be identified in site-specific addenda to the work plan.

6.0 DOCUMENT CONTROL

6.1 Documentation

The CQCSM maintains current records of QC activities and tests performed, including those of suppliers and subcontractors. The records will be maintained as evidence that required control measures and tests have been performed, and indicate the results of the activities. Photographic documentation is also maintained for this project in accordance with **Section 6.4** of this plan.

6.2 Daily CQC Report

The daily CQC Report is completed and maintained by the CQCSM using a standard form. The form is provided in **Attachment 1**. As applicable, standard forms used to document safety, technical, and operations aspects of daily field activities will be attached to the Daily CQC Report.

6.3 Daily Weather Conditions/Lost Time Report

A Daily Weather Conditions/Lost Time Report is prepared daily by the CQCSM. A report form is provided at the end of this section. Lost time will be logged into the report in increments of 25% (in other words, 0%, 25%, 50%, 75% or 100%). The amount of lost time incurred will be agreed upon and initialed by the CQCSM and the USACE QAR or Technical Manager overseeing the project work. Upon completion of the report for the specified period of time, one copy of the report should be submitted to the QAR/Technical Manager once each month during fieldwork and an extra copy should be maintained by the CQCSM for future reference.

6.4 Photographs

The CQCSM will photograph the project activities. Photographs will be taken on a regular basis during the course of the project to document the work, events, and equipment used. The frequency and number of pictures taken will depend upon the activities occurring and the amount of documentation needed. The Project Manager or Remediation Manager will use judgment to determine the frequency and number of pictures taken; however, a sufficient quantity of pictures will be taken to effectively document the TO.

Pictures will be taken using 35mm film or digital medium (using a digital camera or video camera). Photos will be documented on a project log (see standard form in **Attachment 1**), which includes the photo number, date, time, description of the task depicted, and the view direction (e.g., facing northwest). A copy of the photo log, pictures, slides/videos, and digital media will be maintained in Project Files.

6.5 Review of Vendor Submittals

Vendors and subcontractors are required to expeditiously submit items such as drawings, test data, and specifications to Shaw for review to enable timely submittals to USACE. Shaw technical and CQC personnel review each submittal for compliance with contract documents. If acceptable, the item is stamped or indicated as such, and forwarded to USACE for review and acceptance.

If unacceptable, errors or deficiencies are identified and returned to the vendor or subcontractor for correction. The corrected document is resubmitted to Shaw for review until it meets contract requirements.

6.6 Government Property Accounting and Control

If applicable, Shaw will acquire, manage, and dispose of government property. At the completion of the project, all real property (removed and/or installed) will be listed on a Property Inventory Sheet.

6.7 Submittals

The Project Manager, Remediation Manager, the Program Controls Engineer, and the CQCSM are responsible for project submittals. A submittal register prepared for this project is given in **Figure 6-1**.

SUBMITTAL REGISTER

DACA56-94-D-0020
TO No. 0109

TITLE AND LOCATION: **Longhorn Army Ammunition Plant – LHAAP-35A(58)**

CONTRACTOR: Shaw Environmental Inc.

				TYPE OF SUBMITTAL									CLASSIFICATION			CONTRACTOR SCHEDULE DATES			CONTRACTOR ACTION			GOVT. ACTION		
TRANSMITTAL NO	ITEM NO	SPEC PARA NO	DESCRIPTION OF ITEM SUBMITTED	DATA	DRAWINGS	INSTRUCTIONS	SCHEDULES	STATEMENTS	REPORTS	CERTIFICATES	SAMPLES	RECORDS	INFO ONLY	GOVT. APPROVED	REVIEWER	SUBMIT	APPROVAL NEEDED BY	MAT'L NEEDED BY	CODE	DATE	SUBMIT TO GOVT	CODE	DATE	REMARKS
a.	b.	c.	d.	e.	f.	g.	h.	i.	j.	k.	l.	m.	n.	o.	p.	q.	r.	s.	t.	u.	v.	w.	x.	
			Work Plan (and Appendices)		X	X	X							X		Per Project Schedule								
			Site Personnel OSHA Medical & Training Certificates							X		X	X			Prior to start of work								
			CQC and Safety Reports						X				X			Daily								
			Well Construction Methods/Specifications	X	X								X			Per Work Plan								
			Transporter ID, Insurance Cert							X			X			Prior to subcontract award								
			Manifests/Shipping Papers									X	X			Prior to shipment								
			Disposal Facility ID	X									X			Prior to subcontract award								
			Environmental Inspection Sheets									X	X			Per Work Plan								
			Groundwater Sampling Results	X					X				X			Upon data evaluation								
			Survey Drawings (As-built)		X									X		Upon completion								
			Well Construction Completion Forms									X		X		To State of Texas within 30 days of construction completion								
			Well Abandonment Forms									X		X		To the State of Texas within 30 days of construction completion								
			Drilling Logs & Groundwater Sampling Forms									X				With Daily QC Reports								

Figure 6-1
Submittal Register

7.0 SUBCONTRACTOR QUALITY CONTROL

Subcontractors for this project are responsible for compliance with the QC requirements of their respective subcontract. Subcontractors include organizations supplying quality related items or services to the project. Shaw assumes overall responsibility for conformance to the quality requirements for the subcontracted items and services.

Subcontract documents should include the requirements for personnel qualifications, technical performance levels, QC procedures, acceptability criteria, and documentation. The CQCSM, or his designee, reviews the subcontract procurement documents to verify that the QC requirements are communicated to the subcontractor.

Each subcontractor is required to identify an adequately qualified individual within the organization to perform QC duties. The qualifications of this individual are submitted to the CQCSM for review and approval. The CQCSM coordinates the QC functions with the designated subcontractor QC representative. The Project Manager, or his authorized designee, assists the CQCSM in managing subcontractor QC.

The CQCSM is responsible for the performance of inspections, surveillance, document reviews, audits, and other QC functions to verify compliance with the subcontract requirements. These activities are documented on inspection reports, checklists, audit reports, field logs, or other forms appropriate to the function performed.

For field operations, the CQCSM performs QC inspections before, during, and after the subcontractor activities, to the extent required, to verify that the subcontractor is in compliance with the QC requirements of the contract and the applicable subcontract documents.

Audits of subcontractor activities are conducted by the CQCSM as necessary to verify compliance with the CQCP. Objective evidence of conformance to the subcontract documents is reviewed during the audits.

8.0 REFERENCES

Shaw Environmental, Inc. (Shaw), 2006, *Final Installation-Wide Work Plan, Longhorn Army Ammunition Plant, Karnack, Texas*, Houston, Texas, January.

Attachment 1

Field Forms

- Preparatory Inspection Check List
- Initial/Follow-Up Inspection Form
- Final Inspection Form(s)
- Daily Contractor Quality Control Report
- Daily Weather Conditions/Lost Time Report
- Photo Log Form
- Corrective Action Report

PREPARATORY INSPECTION CHECKLIST

Shaw Environmental, Inc.
1401 Enclave Parkway, Suite 250
Houston, Texas 77077

Project Name:____________________
Project Location:__________________
Project No.:______________________

Plan or Specification Title/Section:__________________ **Drawing Nos.:**____________________

A. Personnel present *(use back of form to list additional personnel)*

Name	Position	Company

B. Submittals involved: *(use back of form to list additional submittals)*

Number and Type	Description	Indicate Contractor of Government Approval

C. Are all materials on hand and in accordance with approvals: ☐ Yes ☐ No
List all deficiencies:

____

____

D. Test required: (list/reference all quality control tests with their required frequencies):

____

____

E. Accident prevention preplanning (list all health and safety items discussed):

____

____

____

CQCSM: ______________________________

INITIAL/FOLLOW-UP INSPECTION FORM

Shaw Environmental, Inc.
1401 Enclave Parkway, Suite 250
Houston, Texas 77077

Project Name:__________________
Project Location:________________
Project No.:____________________

(check one)
INITIAL PHASE CHECK LIST ☐ OR
FOLLOW-UP PHASE CHECK LIST ☐

Plan or Specification Section:______________________________ Drawing Nos.:______________________

A. Personnel present:

Name	Position	Company

B. Materials are in strict conformance with contract specifications: ☐ Yes ☐ No
If no, explain:

C. Work being performed is in strict conformance with contract specifications: ☐ Yes ☐ No
If no, explain:

D. Workmanship is acceptable: ☐ Yes ☐ No
If improvement is needed, explain:

CQCSM: ______________________________

FINAL INSPECTION FORM

Shaw Environmental, Inc.
1401 Enclave Parkway, Suite 250
Houston, Texas 77077

Project Name:________________________
Project Location:______________________
Project No.:__________________________

FINAL INSPECTION FORM

Plan or Specification Title/Section:________________________Drawing Nos.:_______________________

Inspected Work (list feature(s) of work inspected):

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.

Performance Specification by Contract Delivery Order Reference	Status of Inspection

On behalf of Shaw, I certify that the work inspected is complete and meets the performance specifications cited above and that all material and equipment used and work performed was completed in accordance with approved plans and work instructions and meets contract delivery order requirements.

CQCSM ___________________________________ Date______/______/______

Site Manager_______________________________ Date______/______/______

DAILY CONTRACTOR QUALITY CONTROL REPORT

Shaw Environmental, Inc.
1401 Enclave Parkway, Suite 250
Houston, Texas 77077

Project Name:________________________________
Project Location:______________________________
Shaw Report No.:______________________________

WEATHER: ( ) Clear ( ) P. Cloudy ( ) Cloudy
Wind________________________
Temperature: High_______ Low_______
Precipitation: Today________________ Previous Period (i.e., weekend)________________________
Site Conditions:____
Lost Time Due to Inclement Weather: ________________%

PRIME CONTRACTOR/SUBCONTRACTORS AND AREAS OF RESPONSIBILITY/LABOR COUNT:
(Include number, trade, hours, employer, location, and description of work.)

a. ____

b. ____

c. ____

d. ____

e. ____

f. ____

WORK PERFORMED: (Include location and description of work performed including equipment used. Refer to work performed by prime and/or subcontractors as previously designated by letter above. Attached subcontractor daily activity reports when applicable):

____

____

____

MATERIALS AND/OR EQUIPMENT DELIVERED: (Include a description of materials and/or equipment, quantity, date/hours used, date of safety check, and supplier)

____

____

____

Page 1 of 3

DAILY CONTRACTOR QUALITY CONTROL REPORT *(cont.)*

RESULTS OF SURVEILLANCE: (Include satisfactory work completed or deficiencies with action to be taken.)
a. Preparatory Inspection: (Attach Minutes)

b. Initial Inspection: (Attach Minutes)

c. Follow-up Inspection: (List results of inspection compared to specification requirements.)

d. Safety Inspection: (Include safety violations and corrective actions taken.)

OFF-SITE SURVEILLANCE ACTIVITIES: (Include action taken.)

QC TESTS PERFORMED AND RESULTS: (As required by plans and/or specifications.)

VERBAL INSTRUCTIONS RECEIVED OR GIVEN: (List any instructions received from government personnel or given by Shaw on construction deficiencies identified, required retesting, etc., and the corresponding action to be taken.)

CHANGED CONDITIONS/DELAYS/CONFLICTS ENCOUNTERED: (List any conflicts with the delivery order [i.e., Scope of Work and/or drawings], delays to the project attributable to site, and weather conditions, etc.)

Page 2 of 3

DAILY CONTRACTOR QUALITY CONTROL REPORT *(cont.)*

SUBMITTALS REVIEWED: (Include submittal number, specification reference, and name of submitter.)

MEETINGS: (List the meetings, i.e., Health and Safety, Site Operations, Cost/Schedule, etc.)

VISITORS:

REMARKS: (Any additional information pertinent to the project not defined by the previous entries.)

CONTRACTOR'S VERIFICATION: The above report is complete and correct. All material and equipment used and work performed during this reporting period are in compliance with the contract plans and specifications except as noted above.

____________________________________ _____/_____/_____

Shaw CQCSM (or designee) Date

Page 3 of 3

DAILY WEATHER CONDITIONS / LOST TIME REPORT

DAILY WEATHER CONDITIONS/LOST TIME REPORT FOR WEEK/MONTH OF____________

Contract No.:________________________ Delivery Order No.:___________ Project:________________

Contractor:__________________________

DAY	DATE	W/C. L/T	% LOST	ACTIVITY DELAYED	REMARKS	CONCUR	
						CQCR	QAR
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							

Weather Conditions (W/C): R-Precipitation C-Extreme Temperature M-Muddy Site Conditions W-Extreme Winds
Other Lost Time Conditions (L/T): D-Demobilized S-Standby

Representative of the Contractor___________________________

Representative of the Government___________________________

PHOTO LOG FORM

PROJECT PHOTO LOG

Project Name:________________________ Project Location:______________________________________ Project No.:_______________

Photo No.	Date	Time	Task and Description	View Direction

CORRECTIVE ACTION REPORT

Shaw Environmental, Inc.
1401 Enclave Parkway, Suite 250
Houston, Texas 77077

Project Name:________________________________
Project Location:______________________________
Report No.:__________________________________

DESCRIPTION OF PROBLEM:____

____

____

____

____

PERSONNEL RESPONSIBLE FOR INVESTIGATIVE PROCESS:_____________________________________

____

____

____

RECOMMENDED CORRECTIVE ACTIONS:____

____

____

____

PERSONNEL RESPONSIBLE FOR IMPLEMENTATION OF CORRECTIVE ACTIONS:____________________

____

____

____

____

RESULTING ACTIONS AND EFFECTIVENESS OF THOSE ACTIONS:________________________________

____

____

____

PERSONNEL RESPONSIBLE FOR MONITORING EFFECTIVENESS OF CORRECTIVE ACTIONS:________

____

FINAL DISPOSITION APPROVED BY:

Name:____________________________________ Title:____

Date:___________________________

Name:____________________________________ Title:____

Date:___________________________

COPIES TO:

____

____