LONGHORN ARMY AMMUNITION PLANT

KARNACK, TEXAS

ADMINISTRATIVE RECORD

VOLUME 2 of 13

1994

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Prepared for:

Department of the Army
Longhorn Army Ammunition Plant
Marshall, Texas 75671-1059

1995

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J. Title: Final Report - Ultrox Technology (O3, H2O2, & UV Light) Treatability Study
Group(s): Early Interim Action At Burning Ground No. 3
Site(s): LHAAP-18 & LHAAP-24 Burning Ground / Washout Pond & Evaporation Pond
Location: Longhorn Army Ammunition Plant, Marshall, Texas
Company: Ultrox, Division of Zimpro Environmental, Inc.
Author(s): William, S. Himebaugh
Recipient: AWD Technologies, Rockville, Md.
Date: February 8, 1994
Bate Stamp: 007843 - 007869

K. Title: Draft Report - Phase I Interim Remedial Action
Evaluation Of Thermal Treatment Of On-Site Contaminated Soils And Buried Waste
Group(s): Early Interim Action At Burning Ground No. 3
Site(s): LHAAP-18 & LHAAP-24 Burning Ground / Washout Pond & Evaporation Pond
Location: Longhorn Army Ammunition Plant, Marshall, Texas
Company: AWD Technologies, Inc.
Author(s): AWD Technologies, Inc.
Recipient: U.S. Army Corps Of Engineers, Tulsa District
Date: February 9, 1994
Bate Stamp: 007870 - 007896

L. Title: Letter - Subject: Physical, Surveying And Other Field Data
Group(s): Early Interim Action At Burning Ground No. 3
Site(s): LHAAP-18 & LHAAP-24 Burning Ground / Washout Pond & Evaporation Pond
Location: Longhorn Army Ammunition Plant, Marshall, Texas
Company: AWD Technologies, Inc.
Author(s): Amine Bou Onk, P.E. Project Manager
Recipient: Mr. Clif B. Warren, P.E. Resident Officer, U.S. Army Corps Of Engineers
Date: February 17, 1994
Bate Stamp: 007897 - 007985

M. Title: Letter - Subject: Meeting, LHAAP, for Technical Review Committee - March 10, 1994
Attach(s): Meeting Agenda
Group(s): All
Site(s): General
Location: Longhorn Army Ammunition Plant, Marshall, Texas
Agency: Department Of The Army, Longhorn Army Ammunition Plant
Author(s): Lawrence J. Sowa, Lieutenant Colonel, U.S. Army
Recipient: Ms. Lisa M. Price, Environmental Protection Agency
Date: February 22, 1994
Bate Stamp: 007986

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Group(s): 2
Site(s): LHAAP-12 Active Landfill
LHAAP-16 Old Landfill
LHAAP-17 No. 2 Flashing Area / Burning Ground
LHAAP-18 & LHAAP-24 Burning Ground / Washout Pond & Evaporation Pond
LHAAP-29 Former TNT Production Area
LHAAP-32 Formal TNT Waste Disposal Plant
Location: Longhorn Army Ammunition Plant, Marshall, Texas
Agency: Department Of The Army, Longhorn Army Ammunition Plant
Author(s): Lawrence J. Sowa, Lieutenant Colonel, U.S. Army
Recipient: Lisa Marie Price, Environmental Protection Agency
Date: February 22, 1994
Bate Stamp: 007987

O. Title: Final Report - Phase I TerraMet Metals Extraction Treatability Study
Group(s): Early Interim Action At Burning Ground No. 3
Site(s): LHAAP-18 & LHAAP-24 Burning Ground / Washout Pond & Evaporation Pond
Location: Longhorn Army Ammunition Plant, Marshall, Texas
Company: Cognis, Inc.
Author(s): Cognis, Inc.
Recipient: AWD Laboratories, Inc.
Date: February 22, 1994
Bate Stamp: 007988 - 007998

P. Title: Draft Report - Treatability Verification Of Air Stripping On Contaminated Ground Water
Group(s): Early Interim Action At Burning Ground No. 3
Site(s): LHAAP-18 & LHAAP-24 Burning Ground / Washout Pond & Evaporation Pond
Location: Longhorn Army Ammunition Plant, Marshall, Texas
Company: IC Technologies, Inc.
Author(s): John E. Litz
Recipient: AWD Technologies, Inc.
Date: February 24, 1994
Bate Stamp: 007999 - 008022

Q. Title: Letter - Subject: EPA's Request For Extension To Submission Of Comments On Several Documents
Group(s): 2, 3, Early Interim Action At Burning Ground No. 3,
Site(s): LHAAP-12 Active Landfill
LHAAP-16 Old Landfill

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LHAAP-18 & LHAAP-24 Burning Ground / Washout Pond & Evaporation Pond
LHAAP-29 Former TNT Production Area
LHAAP-32 Formal TNT Waste Disposal Plant
LHAAP-35 Process Wastewater Sumps - Various
LHAAP-36 Explosive Waste Pads
Location: Longhorn Army Ammunition Plant, Marshall, Texas
Agency: Environmental Protection Agency
Author(s): Lisa Marie Price, Environmental Protection Agency
Recipient: Lawrence J. Sowa, Lieutenant Colonel, U.S. Army
Lynn Muckelrath, Longhorn Army Ammunition Plant
Date: March 4, 1994
Bate Stamp: 008023 - 008024

R. Title: Meeting Agenda - LHAAP Technical Review Committee Meeting, March 10, 1994
Attach(s): Attendance List
Overhead Slide - IR Accomplishment Since Dec 93
Overhead Slide - IR Activities in the Next 3 Months
Group(s): All
Site(s): General
Location: Longhorn Army Ammunition Plant, Marshall, Texas
Agency: U.S. Army
Author(s): U.S. Army Corps of Engineers, Tulsa District
Recipient: Meeting Participants
Date: March 10, 1994
Bate Stamp: 008025 - 008029

S. Title: Letter - Subject: EPA's Comments On Draft Interim Risk Assessment For Unlined Evaporation Pond / Burning Ground No. 3
Group(s): Early Interim Action At Burning Ground No. 3
Site(s): LHAAP-18 & LHAAP-24 Burning Ground / Washout Pond & Unlined Evaporation Pond
Location: Longhorn Army Ammunition Plant, Marshall, Texas
Agency: Environmental Protection Agency
Author(s): Lisa Marie Price, Environmental Protection Agency
Recipient: Lawrence J. Sowa, Lieutenant Colonel, U.S. Army
Lynn Muckelrath, Longhorn Army Ammunition Plant
Date: March 22, 1994
Bate Stamp: 008030 - 008051

T. Title: Letter - Subject:EPA's Comments On Statistical Methods Used For Calculation Of

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		Background Levels
	Group(s):	**All**
	Site(s):	**General**
	Location:	**Longhorn Army Ammunition Plant, Marshall, Texas**
	Agency:	**Environmental Protection Agency**
	Author(s):	**Ms. Lisa M. Price, Environmental Protection Agency**
	Recipient:	**Mr. David Tolbert, Longhorn Army Ammunition Plant**
	Date:	**April 12, 1994**
	Bate Stamp:	**008052 - 008053**
U.	**Title:**	**Letter - Subject: Draft DERPMIS Resolution Document**
	Group(s):	**All**
	Site(s):	**General**
	Location:	**Longhorn Army Ammunition Plant, Marshall, Texas**
	Agency:	**Department Of The Army, Longhorn Army Ammunition Plant**
	Author(s):	**Lawrence J. Sowa, Lieutenant Colonel, U.S. Army**
	Recipient:	**Ms. Lisa M. Price, Environmental Protection Agency**
	Date:	**April 14, 1994**
	Bate Stamp:	**008054**
V.	**Title:**	**Letter - Subject: EPA's Comments On Draft Phase I Investigation For 125 Waste Rack Sumps And 20 Waste Rack Sum,ps**
	Group(s):	**3**
	Site(s):	**LHAAP-35 Process Wastewater Sumps - Various** **LHAAP-36 Explosive Waste Pads**
	Location:	**Longhorn Army Ammunition Plant, Marshall, Texas**
	Agency:	**Environmental Protection Agency**
	Author(s):	**Lisa Marie Price, Environmental Protection Agency**
	Recipient:	**David Tolbert, Longhorn Army Ammunition Plant**
	Date:	**April 19, 1994**
	Bate Stamp:	**008055 - 008057**
W.	**Title:**	**Letter - Subject: EPS's Comments On Draft Field Investigation Summary For group #2**
	Group(s):	**2**
	Site(s):	**LHAAP-12 Active Landfill** **LHAAP-16 Old Landfill** **LHAAP-17 No. 2 Flashing Area / Burning Ground** **LHAAP-18 & LHAAP-24 Burning Ground / Washout Pond & Evaporation Pond** **LHAAP-29 Former TNT Production Area**

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LHAAP-32 Formal TNT Waste Disposal Plant
Location: Longhorn Army Ammunition Plant, Marshall, Texas
Agency: Department Of The Army, Longhorn Army Ammunition Plant
Author(s): Lisa Marie Price, Environmental Protection Agency
Recipient: David Tolbert, U.S. Army, LHAAP
Date: April 19, 1994
Bate Stamp: 008058 - 008061

X. Title: Memorandum - Subject: EPA's Comments On Interim Risk Assessment For Unlined Evaporation Pond / Burning Ground No. 3
Group(s): Early Interim Action At Burning Ground No. 3
Site(s): LHAAP-18 & LHAAP-24 Burning Ground / Washout Pond & Unlined Evaporation Pond
Location: Longhorn Army Ammunition Plant, Marshall, Texas
Agency: Department Of The Army, Longhorn Army Ammunition Plant
Author(s): Allison Jenkins Toxicologist, Superfund Investigation Section
Recipient: Michael A. Moore, Superfund Investigation Section
Date: April 19, 1994
Bate Stamp: 008062

Y. Title: Letter - Subject: Revised Schedule For Groups #4 IRAs At Unlined Evaporation Pond / Burning Ground #3 And Landfills
Attach(s): Schedule
Group(s): 4, Early Interim Action At Burning Ground # 3
Site(s): LHAAP - 12 Active Landfill
LHAAP - 16 Area 54 Burial Ground
LHAAP - 18 & LHAAP - 24 Burning Ground / Washout Pond & Unlined Evaporation Pond
Location: Longhorn Army Ammunition Plant, Marshall, Texas
Agency: Department Of The Army, Longhorn Army Ammunition Plant
Author(s): Lawrence J. Sowa, Lieutenant Colonel, U.S. Army
Recipient: Ms. Lisa M. Price, Environmental Protection Agency
Date: April 21, 1994
Bate Stamp: 008063 - 008066

Z. Title: Letter - Subject: Revised Schedule For Groups #4 IRAs At Unlined Evaporation Pond / Burning Ground #3 And Landfills
Attach(s): Schedule
Group(s): 1,2,& 3
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LHAAP-27 South Test Area
LHAAP-29 Former TNT Production Area
LHAAP-32 Former TNT Disposal Plant
LHAAP-54 or LHAAP-XX Ground Signal Test Area
Location: Longhorn Army Ammunition Plant, Marshall, Texas
Agency: Department Of The Army, Longhorn Army Ammunition Plant
Author(s): Lawrence J. Sowa, Lieutenant Colonel, U.S. Army
Recipient: Ms. Lisa M. Price, Environmental Protection Agency
Date: April 21, 1994
Bate Stamp: 008067 - 008070

ULTROX

A Division of Zimpro Environmental, Inc.

2435 South Anne Street
Santa Ana, CA 92704-5308
Phone: 714 545-5557
Fax: 714 557-5396

ULTROX DIVISION OF ZIMPRO ENVIRONMENTAL, INC.

LABORATORY TREATABILITY STUDY REPORT

FOR THE

LONGHORN ARMY AMMUNITION PLANT

Submitted by:

William S. Himebaugh
Ultrox Division of Zimpro Environmental, Inc.
February 8, 1994

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1.0 INTRODUCTION

The Burning Ground 3 and Unlined Evaporation Pond (UEP) site located at the Longhorn Army Ammunition Plant (LHAAP) in Karnack, Texas has been used for the treatment, storage, and disposal of solid and liquid explosive, pyrotechnic, and combustible solvent wastes using open burning pits, the UEP, stockpiles of solvent soaked sawdust, and burial trenches.

High concentrations of solvents, primarily trichloroethylene (TCE) and methylene chloride (MEC), and heavy metals such as barium, and traces of semivolatile organics have been detected within the subsurface soils, buried waste and the uppermost water-bearing zone at the site. This contamination is attributed to waste management practices dating back to the early 1950s. Based on previous investigations performed at the site, an Interim Remedial Action (IRA) is planned for the removal and/or control of contaminants sources within the upper groundwater and vadose zone.

The scope of work for the IRA includes the performance of a series of laboratory treatability verifications for the different groundwater remedial technologies. One of these technologies is Ultraviolet (UV) Photolysis for the treatment of volatile organic compounds (VOCs). TCE and MEC were detected in groundwater samples collected in 1992 at concentrations ranging from 0.1 to 200 mg/l and 0.1 to 9,000 mg/l respectively. Traces of metals, mainly barium, lead and chromium; and semivolatile organics were also detected in these samples.

The Ultrox® technology is an Advanced Oxidation Process (AOP) which utilizes ozone (O_3), hydrogen peroxide (H_2O_2), and ultraviolet light (UV) to destroy organic compounds in water. This process has the distinct advantage of on site destruction of organic compounds. This is in contrast to other treatment methods such as granular activated carbon adsorption (GAC) where compounds are captured and transferred to disposal sites or air stripping which merely transforms the problem compounds from the water phase to the vapor phase. Compounds are attacked by the chemical oxidants alone and by free radicals which are produced by combing ozone with hydrogen peroxide and/or with UV. The oxidation strength of these species is detailed in comparison to others in Table 1. The ultimate result of this destruction is carbon dioxide, water, and in the case of chlorinated compounds, salts (see Figure 1). Because different compounds in various groundwaters oxidize with varying efficiencies, (depending upon oxidant dosages, combinations, and UV exposure times) laboratory treatability studies are conducted to optimize these conditions.

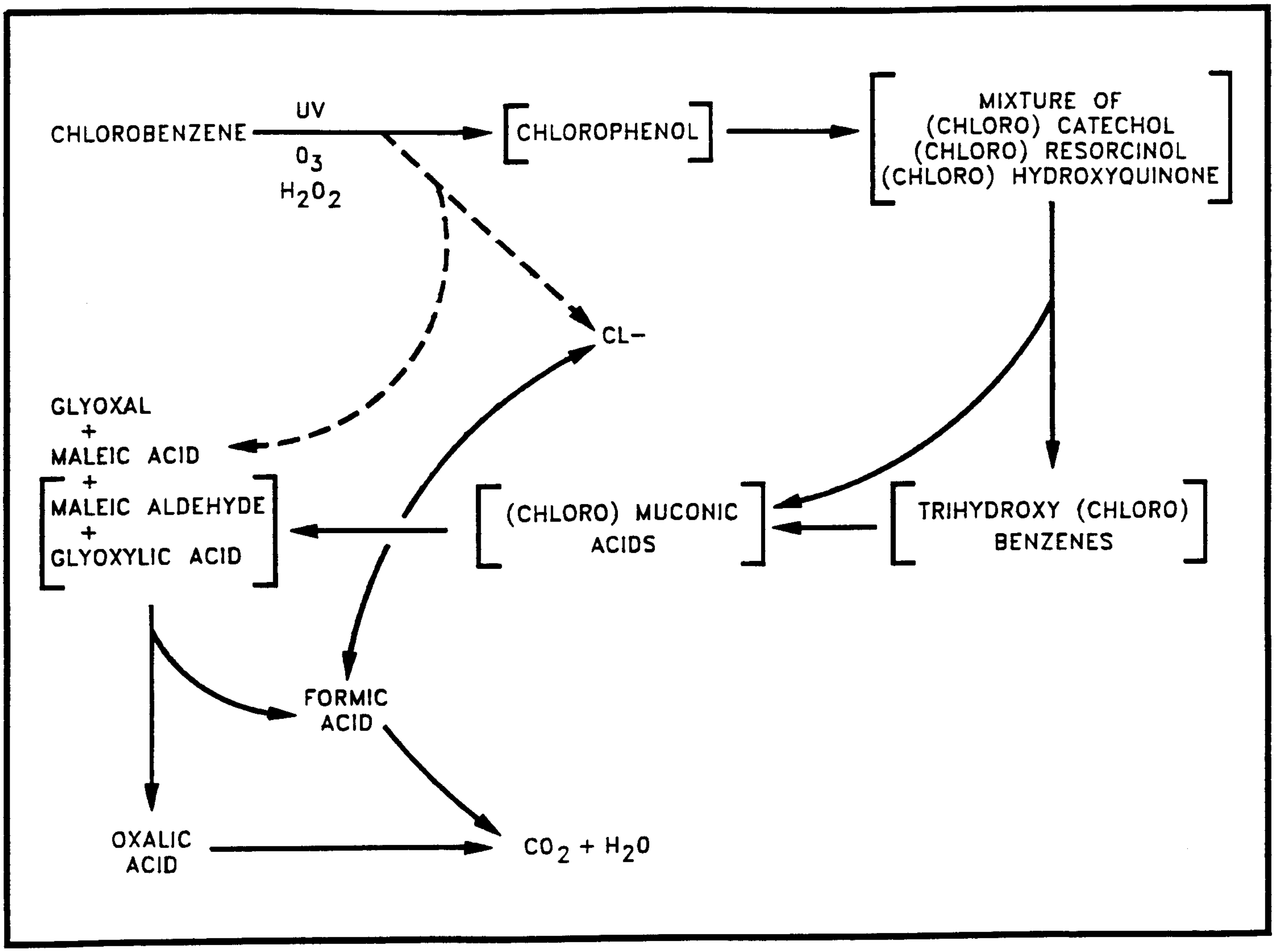
The Ultrox® UV/Oxidation system consists of a UV treatment tank containing highly efficient UV lamps. Hydrogen peroxide is water soluble and is metered into the treatment tank influent line. Ozone is produced on-site from air and diffused into the UV treatment tank through spargers located in the bottom of the tank. Any residual ozone or VOCs which may collect in the vapor area within the UV treatment tank are destroyed by the D-TOX™/Decompozon™ catalytic air treatment unit. The result is water meeting discharge requirements without toxic byproducts or air emissions. What's more, the operating and maintenance costs are typically significantly lower than GAC or other UV/Oxidation technologies which utilize high intensity UV lamps.

TABLE 1

Relative Oxidation Potential (C12 = 1.0)	Species	Oxidation Potential (Volts)
2.23	fluorine	3.03
2.06	hydroxyl radical	2.80
1.78	atomic oxygen (single)	2.42
1.52	ozone	2.07
1.31	hydrogen peroxide	1.78
1.25	perhydroxyl radical	1.70
1.24	permanganate	1.68
1.15	chlorine dioxide	1.57
1.07	hypoiodous acid	1.45
1.00	chlorine	1.36
0.80	bromine	1.09
0.39	iodine	0.54

FIGURE 1 - REACTION PATHWAY

Oxidation of Chlorobenzene



Ultrox Confidential Business Information

2.0 EXECUTIVE SUMMARY

Ultrox division of Zimpro Environmental, Inc. (Ultrox) was contracted by AWD Technologies, Inc. (AWD) on December 14, 1993 to conduct a laboratory treatability study involving the treatment of groundwater from the Longhorn Ammunition Plant located in Karnack, Texas. While Ultrox was contracted to conduct 7 oxidation tests, the concentration of MEC was quite high resulting in a need to conduct six additional tests. Therefore, Ultrox conducted thirteen (13) oxidation tests (at no additional cost to AWD or the U.S. Army Environmental Center).

Groundwater samples were received from wells MW-1 (2 gallons), MW-2 (3 gallons) and EW-1 (2 gallons) on December 16, 1993. Upon receipt, samples were stored in a walk in cooler at 4°C to prevent off-gas of volatile compounds. Two gallons from each well sample were combined to assure feed consistency.

A volume from the combined, untreated sample (feed) was collected and analyzed for total organic carbon (TOC) and inorganic parameters which affect the oxidation process (Table 3). Because iron and manganese concentrations (380 μg/l and 330 μg/l respectively) were less than 5 mg/l (typical cutoff concentration for pretreatment), pretreatment was not required.

A total of 13 batch, advanced oxidation tests were conducted on the combined groundwater samples. The treatment variables to which the sample feed was subjected included O_3, H_2O_2, and UV. Samples were collected after treatment and analyzed for purgeable halogenated hydrocarbons using EPA method 601.

The detected compounds in the untreated groundwater sample included trichloroethylene (TCE) and methylene chloride (MEC) and are listed in Table 2 with their appropriate treatment objective concentrations. An analysis of the untreated sample indicated that the groundwater contained high concentrations of TCE and MEC (85 mg/l and 2,760 mg/l respectively). Analytical results of the treated samples indicate that, Ultrox® UV/Oxidation was successful in reducing the concentrations of methylene chloride and trichloroethyelene to below the treatment objectives of 20 ug/l and 5 μg/l respectively. This was achieved by treatment for a total of four hours with an accumulated ozone dosage of 1,852 mg of ozone and 1,888 mg of H_2O_2 per liter of water. The UV was irradiated during the entire treatment and pH was maintained between 4 and 6 by addition of sodium hydroxide.

A mass balance of the chloride concentration for three of the oxidation tests indicated that most of the MEC and TCE was lost in the off gas during the first 60 minutes of treatment. This volume of offgas can easily be treated for the destruction of the TCE, but the MEC is a saturated compound and is more difficult to treat in the vapor phase at the high concentrations detected.

3.0 LABORATORY TREATABILITY STUDY OBJECTIVES

3.1 The objectives were as follows:

- To provide results which prove the effectiveness of UV/Oxidation as an alternative for achieving the treatment objective for the Longhorn Army Ammunition Plant groundwater. The treatment objective concentrations are listed below in Table 2.

- To obtain information necessary to determine equipment, materials, and utility requirements, and the quantity and nature of treatment residuals for developing full-scale treatment system cost estimates.

TABLE 2

PARAMETER	TREATMENT OBJECTIVE CONCENTRATION ($\mu g/l$)
Methylene Chloride (MEC)	20
Trichloroethylene (TCE)	5

4.0 EXPERIMENTAL PROCEDURES

4.1 Materials.

The bench scale test included the following equipment and materials:

- A Ultrox® bench-scale batch reactor
- A Ultrox® UV radiation lamp
- A 35% solution of H_2O_2
- A 2 lb/day O_3 generator
- Sodium Hydroxide Solution
- Ascorbic acid
- Hydrochloric acid (HCl)

The Ultrox® batch reactor (Figure 2) is a cylindrical, glass vessel with a capacity of 2.4 liters (l). The UV radiation was provided by an Ultrox® UV lamp located inside a quartz sheath which was positioned in the center of the bench-scale reactor.

Two liters of the untreated sample were introduced into the reactor by a peristaltic pump (to limit the loss of volatiles to offgas). A predetermined dosage of H_2O_2 (35% by weight) was added and stirred by a magnetic stirrer. The magnetic stirrer was active throughout the tests to simulate flow dynamics of a full scale system. Ozone was generated by a 2 pound/day Model GL-1 PCI ozone generator. Ozone was introduced as a mixture of 2% ozone in oxygen using a coarse frit gas dispersion tube (sparger) at the bottom of the reactor.

Sodium thiosulfate was added to collected samples to destroy residual H_2O_2 so that samples could not continue to oxidize prior during the time between collection and analysis. The HCl was added to samples prior to analysis for preservation.

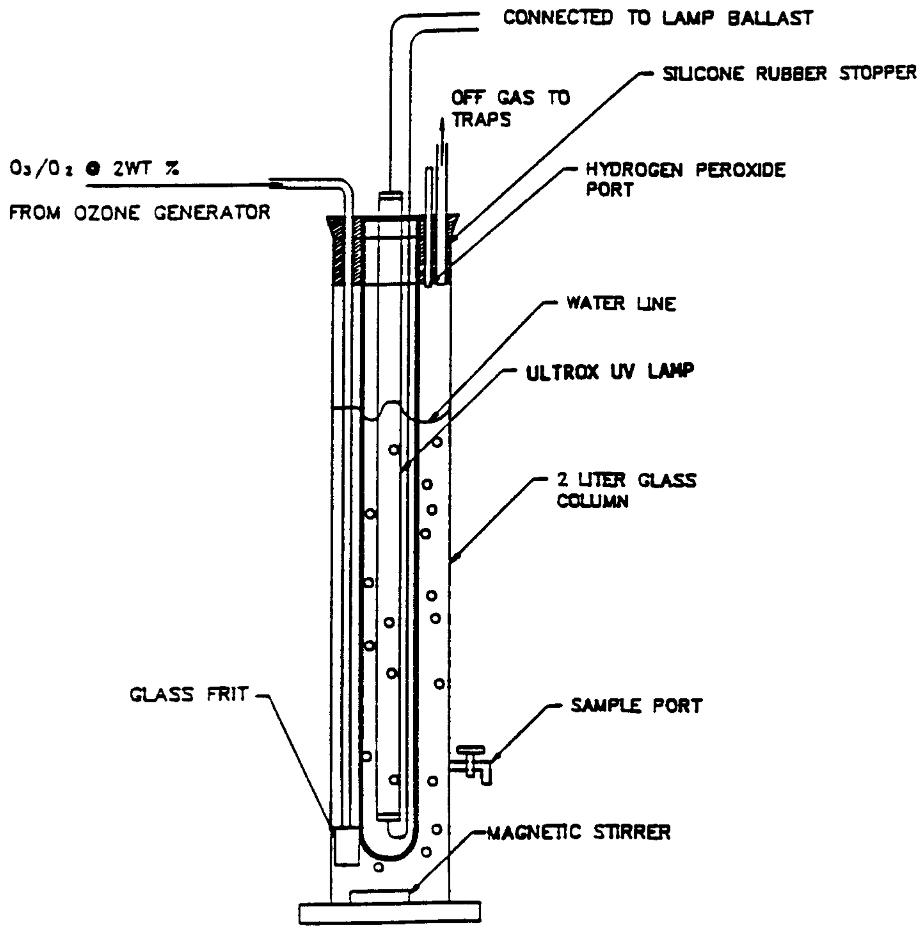


FIGURE 2

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TOLERANCES (EXCEPT AS NOTED)	**ULTROX**	[illegible] SO. [illegible] ST. SANTA ANA, CA. [illegible]
DECIMAL ±	BENCH SCALE UV/OXIDATION TREATMENT ASSEMBLY	
FRACTIONAL ±	DRAWN BY M.OLGUIN	SCALE NONE	MATERIAL
	CHK'D	DATE 12-07-90	DRAWING NO. 3242
ANGULAR ±	1 OF 1	APP'D	

NEXT ASSY	USED ON

4.2 Groundwater Sample Handling

Seven (7) gallons of sample groundwater from the Longhorn Army Ammunition Plant were received at the Ultrox laboratory on December 16, 1993. The samples were examined and found to be intact, contained in ice and with minimal headspace. The seven bottles were from wells MW-2 (3 gallons), EW-1 (2 gallons), and MW-1 (2 gallons). These bottles were contained in three coolers and residual ice was noted in each cooler. The groundwater was contained in seven (7) one-gallon amber glass bottles which had been transported by overnight courier. Upon receipt, the samples were removed from the coolers and transferred to Ultrox's walk in cooler (4° C). Two gallons of water from each well were combined in a seven gallon glass container by a peristaltic pump to assure consistency of sample feed while limiting offgas of volatile compounds. The water samples then were transferred back to the one-gallon amber glass bottles and stored in the walk-in cooler until tested.

4.3 Preparation and Calibration Procedures

Prior to oxidation testing, a sample of the untreated groundwater was analyzed for parameters which can affect the oxidation process. These parameters and analytical methods are listed in Table 3.

At the beginning of each working period, the O_3 output of the ozone generator was determined according to the following procedure:

- The O_3 generator was set at the predetermined power level estimated to produce 2 percent O_3 by weight;
- One liter/minute of the generated O_3 was passed through 300 ml of 2 percent potassium iodide (KI) solution in a 500 ml graduated cylinder for 30 to 60 seconds;
- A 50 ml aliquot of the KI solution was acidified with sulfuric acid then titrated with 0.02 Molar (M) sodium thiosulfate solution to a starch endpoint;

- The O_3 concentration was calculated from the volume of the sodium thiosulfate consumed.

- The calculated concentration of hydrogen peroxide (35% solution) was added by a pipette at predetermined times during each test run.

TABLE 3

PARAMETER	ANALYSIS	METHOD
Alkalinity	Titration	SM 4500
Iron	AAS	EPA 236.1
Manganese	AAS	EPA 244.1
Hardness	Titration	EPA 130.1
Total Suspended Solids (TSS)	Gravimetric	EPA 160.2
Total Dissolved Solids (TDS)	Gravimetric	EPA 160.1
pH	Electrometric	SM 4500H
Chlorides	Titration	EPA 300
Chromium	AAS	EPA 218.1
Total Organic Carbon (TOC)	Combustion-Infrared	EPA 415.1

4.4 Oxidation Test Procedures

All oxidation tests were conducted by pumping the combined groundwater from a one-gallon bottle to the bench scale reactor by a peristaltic pump. This method of transfer was employed to limit the off-gas of the volatile organic compounds associated with pouring.

The first oxidation test was conducted with a total accumulated ozone dosage of 772 mg of ozone per liter of groundwater and 385 mg of hydrogen peroxide per liter of water. The full amount of H_2O_2 was added in the beginning of the test. Ozone was introduced at the continuous rate of 12.8 mg/l/min during

60 minutes of UV irradiation. Samples were collected after 60 minutes of treatment.

The second oxidation test was conducted with a total accumulated ozone dosage of 1,534 mg of ozone per liter of groundwater and 770 mg of hydrogen peroxide per liter of water. The H_2O_2 was added at the rate of 385 mg/l/hr and ozone was introduced at the continuous rate of 12.8 mg/l/min during 120 minutes of UV irradiation. Samples were collected after 120 minutes of treatment.

The third oxidation test was conducted with a total accumulated ozone dosage of 2,315 mg of ozone per liter of groundwater and 1,155 mg of hydrogen peroxide per liter of water. The H_2O_2 was added at the rate of 385 mg/l/hr and ozone was introduced at the continuous rate of 12.8 mg/l/min during 180 minutes of UV irradiation. Samples were collected after 180 minutes of treatment.

The fourth oxidation test was conducted with a total accumulated ozone dosage of 3,086 mg of ozone per liter of groundwater and 1,540 mg of hydrogen peroxide per liter of water. The H_2O_2 was added at the rate of 385 mg/l/hr and ozone was introduced at the continuous rate of 12.8 mg/l/min during 240 minutes of UV irradiation. Samples were collected after 240 minutes of treatment.

The fifth oxidation test was conducted with a total accumulated ozone dosage of 3,858 mg of ozone per liter of groundwater and 1,925 mg of hydrogen peroxide per liter of water. The H_2O_2 was added at the rate of 385 mg/l/hr and ozone was introduced at the continuous rate of 12.8 mg/l/min during 300 minutes of UV irradiation. Samples were collected after 300 minutes of treatment.

To limit the amount of stripping caused by addition of the ozone gas, the remaining tests were conducted with 5% concentration of O_3. This resulted in the same ozone dosage, but with less volume of gas. The flow of the gas was reduced from 0.45 to 0.18 liters of O_2-O_3 per liter of water per minute.

The sixth oxidation test was conducted with a total accumulated ozone dosage of 772 mg of ozone per liter of groundwater and 385 mg of hydrogen peroxide per liter of water. The H_2O_2 was added at the beginning of the test and ozone was introduced at the continuous rate of 12.8 mg/l/min during 60 minutes of UV irradiation. Samples were collected after 60 minutes of treatment.

The seventh oxidation test was conducted with a total accumulated ozone dosage of 1,543 mg of ozone per liter of groundwater and 770 mg of hydrogen peroxide per liter of water. The H_2O_2 was added at the rate of 385 mg/l/hr and ozone was introduced at the continuous rate of 12.8 mg/l/min during 120 minutes of UV irradiation. Samples were collected after 120 minutes of treatment.

The eighth oxidation test was conducted with a total accumulated ozone dosage of 2,315 mg of ozone per liter of groundwater and 1,155 mg of hydrogen peroxide per liter of water. The H_2O_2 was added at the rate of 385 mg/l/hr and ozone was introduced at the continuous rate of 12.8 mg/l/min during 180 minutes of UV irradiation. Samples were collected after 180 minutes of treatment.

The ninth oxidation test was conducted with a total accumulated ozone dosage of 3,218 mg of ozone per liter of groundwater and 1,605 mg of hydrogen peroxide per liter of water. The H_2O_2 was added at the rate of 385 mg/l/hr and ozone was introduced at the continuous rate of 12.8 mg/l/min during 250 minutes of UV irradiation. Samples were collected after 250 minutes of treatment.

Tests 10, 11, 12, and 13 were conducted with a oxidant ratio closer to 1:1. In addition, these tests were conducted with a maintained pH. During oxidation, the pH decreased significantly. For tests 10 - 13, pH was maintained between 4 and 6 by the addition of sodium hydroxide (NaOH).

The tenth oxidation test was conducted with a total accumulated ozone dosage of 463 mg of ozone per liter of groundwater and the hydrogen peroxide dosage was increased to 472 mg of hydrogen peroxide per liter of water. All of the H_2O_2 was added at the beginning of the test and ozone was introduced at the continuous rate of 7.7 mg/l/min during 60 minutes of UV irradiation. Samples were collected after 60 minutes of treatment.

The eleventh oxidation test was conducted with a total accumulated ozone dosage of 926 mg of ozone per liter of groundwater and 944 mg of hydrogen peroxide per liter of water. The H_2O_2 was added at the rate of 472 mg/l/hr and ozone was introduced at the continuous rate of 7.7 mg/l/min during 120 minutes of UV irradiation. Samples were collected after 120 minutes of treatment.

The twelfth oxidation test was conducted with a total accumulated ozone dosage of 1,389 mg of ozone per liter of groundwater and 1,416 mg of hydrogen peroxide per liter of water. The H_2O_2 was added at the rate of 472 mg/l/hr and ozone was introduced at the continuous rate of 7.7 mg/l/min during 180 minutes of UV irradiation. Samples were collected after 180 minutes of treatment.

The thirteenth and final oxidation test was conducted with a total accumulated ozone dosage of 1,852 mg of ozone per liter of groundwater and 1,888 mg of hydrogen peroxide per liter of water. The H_2O_2 was added at the rate of 472 mg/l/hr and ozone was introduced at the continuous rate of 7.7 mg/l/min during 240 minutes of UV irradiation. Samples were collected after 240 minutes of treatment.

4.5 Analytical Procedures

Table 4 lists the Ultrox sample number, run number, interval, analytical method used, and laboratory which performed each test. Ultrox contract laboratory is Applied P & Ch Laboratory (APCL) located at 4066 E. Mission Blvd, Pomona, CA 91766.

All samples were collected, with no headspace, in 40 ml vials containing sodium thiosulfate ($Na_2S_2O_3$) to prevent further oxidation resulting from residual H_2O_2. Samples were preserved after collection by addition of hydrochloric acid (HCl). The samples were then analyzed immediately at Ultrox laboratory by GC-FID (EPA 8015) for VOCs.

TABLE 4

SAMPLE NO.	TEST NO.		METHOD	LABORATORY
9-95.1	Feed	Raw Sample	EPA 601	APCL
9-95.2	1	One hour	EPA 601	Ultrox
9-95.3	2	Two hours	EPA 601	Ultrox
9-95.4	3	three hours	EPA 601	Ultrox
9-95.5	4	four hours	EPA 601	Ultrox
9-95.6	5	five hours	EPA 601	Ultrox
9-95.7	6	One hour	EPA 601	Ultrox
9-95.8	7	two hours	EPA 601	Ultrox
9-95.9	8	three hours	EPA 601	Ultrox
9-95.10	9	four hrs 10 min.	EPA 601	Ultrox
9-97.1	10	one hour	EPA 601	Ultrox
9-97.2	11	two hours	EPA 601	Ultrox
9-97.3	12	three hours	EPA 601	Ultrox
9-97.4	13	four hours	EPA 601	Ultrox

* All intervals expressed in hours represent total accumulated treatment time when sample was collected.

5.0 RESULTS

Analytical results of the parameters which affect oxidation in the untreated groundwater sample from the Longhorn Army Ammunition Plant (Table 6) indicate that the water has a relatively high hardness (507 mg/l as $CaCO_3$) and a significantly high concentration of total dissolved solids (TDS = 1,570 mg/l) comprised of 704 mg/l of chlorides. Total organic carbon (TOC) concentration was 496 mg/l.

Results of the analyses for purgeable halogenated hydrocarbons indicate that the groundwater is characterized primarily by high concentrations of methylene chloride (2,760 mg/l) and trichloroethylene (85 mg/l). Generally, UV/Oxidation is not recommended for treating saturated compounds such as MEC at such high concentrations. However, unsaturated compounds such as TCE are highly susceptible to UV/Oxidation and are generally oxidized prior to stripping or in the vapor phase prior to discharge.

The analytical results of the first five oxidation tests indicate that the treatment objective (less than 20 ug/l) for methylene chloride may have been achieved during the four hours of UV exposure with 1,925 mg of H_2O_2 and 3,086 mg of O_3 per liter of water. A comparison of the first test with subsequent tests indicates that the most significant reduction occurred during the first hour of treatment where a reduction of more than 2,600 mg/l of MEC occurred. To determine the relative volume of halogenated VOCs (such as TCE and MEC) stripped, a chloride analysis was conducted. As halogenated VOCs are oxidized in the water, the chlorides atoms are cleaved off as chloride ions. Resulting increases of chloride ions represent oxidized halogenated VOCs. Because the reductions in TCE and MEC are significantly higher than the increases in chlorides, a significant concentration of the MEC and TCE is likely lost in the off-gas. The results from tests 5, 9, and 13 indicate that low increases in chlorides were detected relative to decreases in TCE and MEC. This supports the hypothesis that much of the MEC and TCE was lost to the offgas. While the concentration of volatiles stripped is not normally significant in treating volatile compounds at lower concentration, the high concentrations of TCE and MEC resulted in improved kinetics resulting in greater concentrations being stripped. Typically, this is not of concern because the D-TOX vapor phase treatment system (an inherent component of the Ultrox® full scale UV/Oxidation system) can reduce the VOCs in the off-gas to below detection limits. However, reductions of high concentrations of MEC in the vapor phase are not expected to be adequate for discharge into the atmosphere with the D-TOX™ system.

To limit the loss of MEC and TCE to the off-gas, subsequent oxidation tests were conducted with an increased ozone concentration. At higher concentrations of ozone, the gas to water ratio is reduced while maintaining the same accumulated ozone dosage. A comparison of the first five tests, where ozone concentration was 2%, to the subsequent tests (5% ozone concentration) indicates that greater reductions of MEC in the groundwater were achieved at lower concentrations. However, a comparison of the increases in chloride concentrations between tests 5, 9 and 13 indicate that more TCE and MEC was destroyed with a higher ozone concentration (assuming same total oxidant dosages and UV exposure times).

The pH of the untreated water was slightly acidic (pH = 6.1 - 6.2). The pH dropped significantly after the first hour of oxidation. It is hypothesized that the pH reduction was caused by hydrochloric acid (HCl) formed by the cleaved chloride ions (from the TCE and MEC) and hydrogen in the treated water. Such a significant drop in pH is not typical of lower concentrations of halogenated VOCs where the concentration of chlorides is lower.

In Tests 10 - 13, the pH of groundwater was maintained between 4 and 6 by adding dropwise 50% sodium hydroxide solution during the oxidation. The results indicate that at a lower total accumulated oxidant dosage, greater reduction in MEC was achieved at the maintained pH of 4-6. However, the increase in chloride concentration in Test 13 was lower than the increase detected in Test 9 (1,047 mg/l vs. 1,104).

TABLE 6

PARAMETERS AFFECTING OXIDATION

Component Analyzed	Unit	PQL[1]	Concentration 9-93.1 93-5253-1
Total Suspended Solids (TSS)	mg/L	4	10
Hardness (Ca and Mg) by Titration	$mgCaCO_3/L$	1	507
Turbidity	NTU	0.1	7.3
Chloride Cl^-	mg/L	1	704
Alkalinity	mg/L	1	106
Total Dissolved Solids (TDS)	mg/L	10	1,570
Chromium, Total	mg/L	0.2	ND[2]
Iron, Fe (total)	mg/L	0.05	0.38
Manganese, by AAS	mg/L	0.04	0.33

[1] PQL: Practical Quantitation Limit
[2] ND: Not Detected or less than the quantitation limit

6.0 CONCLUSIONS

It can be concluded that the Ultrox® UV/Oxidation system can reduce the purgeable halocarbons detected in the Longhorn Army Ammunition Plant groundwater. Results indicate that reduction of methylene chloride to below 20 ug/l is possible after four hours of UV/O_3 (1,852 mg/l) and H_2O_2 (1,888 mg/l) treatment at the maintained pH in the range of 4-6. However, it is highly probable that the majority of the MEC was stripped during the oxidation process by the ozone introduced into the groundwater. While the stripping phenomena is not expected to be significant in lower concentrations, the MEC and TCE concentrations were substantialy high resulting in a greater propensity to volatilize. Therefore, it is recommended that a solvent recovery system approach be investigated to reduce the concentration of MEC. UV/Oxidation would be more applicable to treating concentration of MEC below 10 mg/l.

7.0 COMMERCIAL

The following estimated capital and operating costs are for an Ultrox® oxidation system design based upon the treatment conditions represented in the thirteenth oxidation test of this study. Performance does not take into account the loss of TCE and MEC due to stripping and are based upon an O_3 concentration of 5%, a maintained pH of 4-6 and the chemical characteristics as indicated in the untreated sample analysis. Assuming a flow rate of 10 gpm, an accumulated ozone dosage of 248 mg/l, and a H_2O_2 dosage of 1,888, we submit the following cost estimates:

7.1 Design Assumptions

• Flow Rate	10 gpm
• Ozone Dosage	1,852 mg/l
• Hydrogen Peroxide Dosage	1,888 mg/l
• Retention Time*	312 minutes
• UV Lamp Life	9,000 hours

* Full scale retention time is increased by 30% over the laboratory retention time to account for flow through characteristics of a full scale system (as opposed to the batch treatment conducted in the laboratory).

7.2 Cost Assumptions

• Power Cost	$0.06/kwh
• H_2O_2 Cost	$0.70/lb
• UV Lamp Cost	$60/lamp

7.3 System Equipment

The proposed Ultrox oxidation system consist of the following major components:

- Ultrox® F-3900 Oxidation Treatment Tank
- 230 lb/day ozone generator
- Compressor
- Air Preparation System consisting of:
    - Air Filter
    - Air Dryer
- D-Tox/Decompozon Air Treatment System
- Hydrogen Peroxide Feed System
- pH Control System
- Programmable Logic Control Panel

7.4 Estimated System Capital Cost

The estimated capital cost for the Ultrox® UV/Oxidation system described in Section 7.3 is **$538,000**. Estimated cost is F.O.B. Santa Ana, California and does not include any applicable federal, state or local taxes.

7.5 Estimated Operating Costs

• Electrical Costs for O_3 Production	$10.20/1000 gal
• Electrical Costs for UV	$2.81/1000 gal
• H_2O_2 Cost	$11.03/1000 gal
Total Operating Costs	**$24.04/1000 gal**

7.6 Estimated Maintenance Costs

• Annual UV replacement (amortized)	$4.93/1000 gal
• Air Filter Cartridge replacement	$0.01/1000 gal
Total Maintenance Costs	**$4.94/1000 gal**

(Ultrox SS-11/1/93)

ULTROX DIVISION
ZIMPRO ENVIRONMENTAL, INC.
TERMS AND CONDITIONS FOR SUPPLIES AND SERVICES

1. **STATEMENT OF WORK - SCHEDULE - COMPLETE AGREEMENT:** This instrument contains the complete statement of terms of agreement between the ULTROX DIVISION of Zimpro Environmental, Inc. (ULTROX) and the party named in this Agreement (Buyer) for supplies and services provided by ULTROX to Buyer, as set forth in the Statement of Work and Schedule agreed upon by the parties, copies of which are attached and incorporated herein by this reference. This Agreement supersedes and merges any prior or contemporaneous, written or oral agreements, commitments, or understandings with respect to the subject matter of this Agreement. The provisions of this Agreement shall prevail between ULTROX and Buyer notwithstanding additional or modified provisions submitted by Buyer to ULTROX hereunder. This Agreement may not be changed, amended, or modified except by a written instrument executed by both parties.

2. **PERIOD OF PERFORMANCE:**

(a) ULTROX shall accomplish the Statement of Work in accordance with the Schedule set forth herein.

(b) ULTROX shall not be responsible for damages due to any delay or failure to perform services arising out of causes beyond the reasonable control, or which are not occasioned by the fault or negligence of ULTROX (including failure of ULTROX subcontractors, where substitute subcontractors cannot be reasonably made available to ULTROX). If the performance hereunder is delayed or interrupted, the Statement of Work, Schedule and other provisions of this Agreement shall be equitably adjusted to reflect the effects of such delay or interruption.

(c) The Services performed by ULTROX shall be deemed complete and accepted at the earlier of: (1) the date when submissions have been accepted by Buyer, or (2) thirty (30) days after the date when such submissions are delivered to Buyer for final acceptance.

3. **PAYMENT:**

(a) Buyer shall pay ULTROX for supplies and services in the amount(s) agreed upon by the parties in writing, attached and incorporated herein by reference.

(b) ULTROX shall be reimbursed for any federal, state, local or foreign sales, use, excise, duties or other taxes which Buyer does not directly pay and are applicable to the sale of the services provided by this Agreement.

(c) Unless otherwise agreed in a payment schedule, ULTROX shall be entitled to invoice Buyer monthly for all supplies and services provided during the preceding month. Terms are net cash, without discount, payable within thirty (30) calendar days after date of invoice in U.S. dollars.

(d) If a total estimated cost has been set forth in this Agreement, such estimate shall not be deemed to establish a fixed price for performance hereunder; provided, however, Buyer shall not be obligated to reimburse ULTROX for amounts in excess of the total estimated cost nor shall ULTROX be obligated to continue performance or otherwise incur costs in excess of the total estimated cost, unless the Buyer has by express written authorization directed ULTROX to continue with work in excess of the estimate.

4. **BUYER RESPONSIBILITIES:** Buyer shall:

(a) Provide full information as to Buyer requirements for any order.

(b) Assist ULTROX by making available or delivering to ULTROX all information in Buyer possession or under Buyer control pertinent to the services herein including (1) previous reports; (2) reports of other consultants, as required; and (3) any other data pertaining to this Agreement, all of which ULTROX may rely upon in performing services hereunder.

(c) Guarantee access to and make all provisions for ULTROX to enter upon public and private property as required for ULTROX to perform services hereunder.

(d) Provide such accounting, independent cost estimating, auditing, legal and insurance counseling services as may be required for this Agreement.

(e) Designate in writing a person to act as Buyer representative with respect to the work to be performed for this Agreement. Such person shall have complete authority to transmit instructions, receive information, interpret and define policies and decisions with respect to materials, equipment, elements, and systems pertinent to ULTROX supplies and services.

(f) Promptly examine all preliminary and final documents presented by ULTROX.

(g) Furnish approvals and permits from all governmental authorities having jurisdiction for ULTROX services performed and such approvals and consents from others as may be necessary for completion of ULTROX services.

(h) Bear all costs incident to compliance with the requirements of this Paragraph 4.

5. **DELIVERY AND ACCEPTANCE:** Unless otherwise provided in writing by the parties hereto, delivery will be F.O.B. point of shipment, and title and liability for loss or damage to goods tendered shall pass to Buyer upon delivery to carrier for shipment and all claims filed against carrier shall be the responsibility of buyer with acceptance of goods accomplished by buyer at point of manufacture.

6. **CHEMICAL SUBSTANCES IDENTIFICATION:** Buyer shall properly label all chemical substances, hazardous materials, hazardous substances, and/or hazardous wastes provided to ULTROX, and shall provide proper information regarding such materials as required pursuant to any applicable Federal, state or local legislation. Such legislation includes, but is not limited to the Occupational Safety and Health Act (OSHA), the Resources Conservation and Recovery Act (RCRA), the Toxic Substances Control Act (TSCA), and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and Superfund Amendment and Reauthorization Act (SARA).

7. **CANCELLATION OR TERMINATION:** Either party may terminate this Agreement in its entirety at any time by giving written notice of termination to the other. Such termination may be based on the convenience of the party terminating and shall be effective five (5) days after receipt of notice thereof by the addressee, unless a later date is agreed to in writing by the parties. In the event of termination, Buyer shall remain responsible for all charges for services performed and expenses incurred by ULTROX in accordance with this Agreement up to and including the effective date of termination.

8. **CHANGES:** Buyer may at any time by written order make changes in drawings and specifications, require additional work or direct the omission of work set forth in this Agreement. If such changes cause and increase or decrease in the amount of work hereunder or in the time required for performance, an equitable adjustment shall be made and this Agreement shall be modified in writing.

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DRAFT

INTERIM REMEDIAL ACTION - PHASE I
BURNING GROUND NO. 3 AND
UNLINED EVAPORATION POND
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

EVALUATION OF THERMAL TREATMENT OF ON-SITE CONTAMINATED SOILS AND BURIED WASTE

PREPARED FOR

UNITED STATES ARMY CORPS OF ENGINEERS
TULSA DISTRICT

PREPARED BY

AWD TECHNOLOGIES, INC.
ROCKVILLE, MARYLAND

FEBRUARY 9,1994
USACE CONTRACT NUMBER DACA56-93-D-0016
DELIVERY ORDER 0002
MODIFICATION 000202
AWD PROJECT NO. 2379

DRAFT

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SECTION **Page No.**

ATTACHMENT 1

TEXAS NATURAL RESOURCES and CONSERVATION COMMISSION (TNRCC) CHAPTER 335

007872

DRAFT

1.0 INTRODUCTION

This report summarizes AWD Technologies, Inc. (AWD) review of existing soil information and evaluation of thermal treatment of contaminated soils and buried waste at the Burning Ground 3 and Unlined Evaporation Pond (UEP) at Longhorn Army Ammunition Plant (LHAAP) in Karnack, Texas. It is submitted in partial fulfillment of the requirements of Contract No. DACA56-93-D-0016, Delivery Order No. 0002 and Mod. No. 000202, for the U.S. Army Corps of Engineers (USACE), Tulsa District.

The data sources for this evaluation include:

- Longhorn Army Ammunition Plant, Data Summary Report of Investigation Results from 1976 Through 1992, For Burning Ground 3 & The Unlined Evaporation Pond, U.S. Army Corps of Engineers, May 1993.
- Summary Report, Review of Existing Data, Burning Ground No. 3 and Unlined Evaporation Pond, Longhorn Army Ammunition Plant, Karnack, Texas, AWD Technologies, Inc., October 1993.
- Results of analytical testing conducted by Inchcape Testing Services, NDRC Laboratories on soil samples collected by AWD during Phase I field work. These results were submitted to the USACE Tulsa District previously and are not included with this report.

This report presents the data in a statistical format. It uses boiling points of contaminants of concern, molecular weights, EPA waste code information, and chemical abstract numbers (CAS No) to evaluate potential thermal treatment. The report provides recommendations regarding Low Temperature Thermal Desorbtion (LTTD), as well as High Temperature Incineration, as they relate to the remediation of the soil matrix.

2.0 BACKGROUND

Soil sampling for metal analysis was conducted in March, April, May, and July of 1988 as well as July, August, and September of 1989. Soil sampling for volatile organic compounds (VOCs) analysis was conducted in March, April, May, and August of 1988, and in July, August and September of 1989. Soil sampling for semi-volatiles analysis was conducted in July and August of 1989. A second and more recent set of six samples was taken by AWD in November of 1993. All six samples were analyzed for volatiles, semi-volatiles, metals, BTU content, and moisture content. Two of the six samples were also analyzed for ash content, chlorinated pesticides and PCBs, organophosphorus pesticides, chlorinated herbicides, and dioxins and furans.

Based on the data collected from the historical testing programs for the on-site soils, AWD gathered, as applicable for contaminants of concern, the following information:

- Boiling points
- Molecular weight
- EPA waste code information
- CAS number
- EPA listings

Calculations were then made regarding the contaminants' concentrations, maximum (or highest concentration in the sample set), average, and minimum concentrations. Calculations were also made regarding the contaminants' median and standard deviations. These calculations used all of the data in the above mentioned references. In this evaluation, AWD has assumed that the volatile organic materials detected in on-site soils were handled as solvents in the processing of products at LHAAP. Discussions and conclusions in relation to the impact of future operations in either, the LTTD operation, or incineration are included in Sections 3.1 through 3.4 for the metals, VOCs, semi-volatiles, and the dioxins and furans, respectively. Pesticides, PCBs, and herbicides (EPA Methods 8080, 8140, and 8150) were not detected above the detection limits in the tested samples and are not considered contaminants of concern in this study. Sections 3.5 and 3.6 address material handling and physical characteristics of soils, and handling of volatilized compounds, respectively.

3.0 DISCUSSIONS AND CONCLUSIONS

3.1 Metals

Metals detected during the historical testing programs include: Arsenic, Lead, Cadmium, Barium, Chromium, Zinc, and Nickel, Potassium, Magnesium, Vanadium Sodium, Iron, Aluminum, Calcium, Cobalt, and Copper. Table 3.1 lists the metals, their maximum, average, minimum, and median concentrations (in ppm), as well as the "count" (the number of samples in which the analysis showed the material tested for to be above the detection limit), and the standard deviation of the sample set. In addition to the data, Table 3.1 shows the RCRA waste code, as well as the action or cleanup level for the material according the waste indicated.

Table 3.1
Metals Detected in On-Site Soils
Concentrations and Waste Codes by Component

COMPONENT	Arsenic	Lead	Cadmium	Barium	Chromium	Zinc
MAXIMUM	26.5	200	11.3	1500	130	160
AVERAGE	1.98	15.10	3.46	101.20	12.28	26.21
MINIMUM	0.01	0.06	0.01	0.06	0.02	2.8
MEDIAN	1.43	10	2.74	64.5	9.4	18
COUNT	63	115	73	122	75	115
STD DEV	3.21	26.78	2.57	171.22	19.28	25.20
WASTE CODE/REG. LEVEL BY WAY OF 261.24	D004/5.0	D008/5.0	D006/1.0	D005/100.0	D007/5.0	NONE LISTED
Boiling Point	358° C decomposes	1750° C	764.9° C	1638° C	2642° C	907° C decomposes

Table 3.1 (Cont.)
Metals Detected in On-Site Soils
Concentrations and Waste Codes by Component

COMPONENT	Nickel	Potassium	Magnesium	Manganese	Vanadium	Sodium
MAXIMUM	45	485	1270	339	10.6	209
AVERAGE	7.57	356.5	998.83	97.32	8.3	209
MINIMUM	1	294	576	19.8	5.4	209
MEDIAN	5.5	328.5	1059.5	56.2	8.4	209
COUNT	107	6	6	6	6	1
STD DEV	6.88	73.70	260.64	119.46	2.08	
WASTE CODE/REG. LEVEL BY WAY OF 261.24	NONE LISTED	NONE LISTED	NONE LISTED	NONE LISTED	NONE LISTED	NONE LISTED
Boiling Point	2835° C	757° C	1117° C	2040° C	3375° C	889° C

COMPONENT	Iron	Aluminum	Calcium	Cobalt	Copper
MAXIMUM	10700	7540	825	11.4	7
AVERAGE	8221.67	5128.33	619.33	9.3	5.45
MINIMUM	3080	3070	396	7.2	3.1
MEDIAN	8560	4730	625	9.3	5.6
COUNT	6	6	6	2	6
STD DEV	2735.30	1947.09	143.72	2.97	1.28
WASTE CODE/REG. LEVEL BY WAY OF 261.24	NONE LISTED	NONE LISTED	NONE LISTED	NONE LISTED	NONE LISTED
Boiling Point	2885° C	2450° C	1490° C	2880° C	2582° C

The lowest volatility listed in the table above is that of Arsenic (358°C). Low Temperature Thermal Desorbtion (LTTD) which operates in the range of 104°C to 287°C will not volatilize these materials (if maintained below 250°C), and therefore will discharge them "in tact" with the sterilized soil. For this reason, the discharged soil may require stabilization, due to the nature of the metals and the concentrations involved. Of particular concern are Arsenic, Lead, Cadmium, Barium, and Chromium (as indicated by the action levels in the table above). However, based on the metal extraction and metal stabilization treatability verifications that have been conducted on- site soils by subcontractors under contract with AWD, the Barium (which exhibited the highest maximum concentration of the regulated metals) and other metals were shown to be non and/or slightly leachable, well below TCLP limits. If similar results of TCLP testing on the LTTD discharged soils are obtained, then metal stabilization would not be necessary.

3.2 Volatile Organics

The data summary report prepared by the USACE Tulsa District indicates that the following parameters were detected in the on-site soils as a result previous studies: Methylene chloride, Trichloroethene, Vinyl chloride, 1,1 Dichloroethene, 1,2 Dichloroethene, 1,2 Dichloroethane, 1,1 Dichloroethane, Tetrachloroethene, Toluene, Ethyl benzene, Xylene, Acetone, Chloroform, Styrene, Benzene, 1,1,1 Trichloroethane, and Trichlorofluoromethane. For the samples collected by AWD during the Phase I field work, only Trichloroethene was found above the detection limit stated by the laboratory.

Table 3.2 lists the detected VOCs, their maximum, average, minimum, and median concentrations (in ppb), as well as the "count" (the number of samples in which the analysis showed the material tested for to be above the detection limit), and the standard deviation of the sample set. In addition to the data, Table 3.2 shows the RCRA waste code, as well as the action or cleanup level for the material according the waste indicated.

The materials in order of highest concentration are as follows; Methylene chloride, Trichloroethene, 1,2 Dichloroethene, Styrene, Toluene, Acetone, Ethylbenzene, 1,2 Dichloroethane, Tetrachloroethene, Xylene, Vinyl chloride, 1,1 Dichloroethane, 1,1 Dichloroethene, Chloroform, Benzene, Trichlorofloromenthane, and 1,1,1-Trichloroethane.

It should be noted that many of these compounds are present in very high quantity and handling (Health and Safety) will be of prime concern. As far as thermal desorbtion and incineration, the boiling points of these volatile compounds are well within the range of LTTD treatment (standard operating range proposed approximately 150°- 250°C), as well as incineration (standard operating range proposed approximately 490°- 1050°C).

Table 3.2
Volatile Organic Compounds Detected in On-Site Soils
Concentrations and Waste Codes by Component

COMPONENT	MEC	TCE	VC	1,2 DCE	1,2 DCA	1,1 DCA
MAXIMUM	6,000,000	1,000,000	2,279	350,880	4,600	2,539
AVERAGE	120,479	26,847	792	22,646	1,163	464
MINIMUM	5	3	51	8	130	19
MEDIAN	200	185	418	1,050	340	43
COUNT	58	82	4	27	5	6
STD DEV	792,000	124,300	1,050	72,000	1,900	1,010
WASTE CODE/REG. LEVEL BY WAY OF 261.30-33	F002/0.96 mg./l	F002/0.091 mg./l	U043/33.0 mg./kg	U079/33.0 mg./kg	U077/7.2 mg./kg	U076/7.2 mg./kg
Boiling Point	40° to 42° C	86.7° C	-13.9° C	60° to 48° C	83.5° C	57.3° C

COMPONENT	PEC	TOL	EBZ	XYL	ACETONE	CHLORO-FORM
MAXIMUM	4,500	3,400	10,665	3,000	33,000	340
AVERAGE	1,168	4,638	2,307	1,062	2,132	177
MINIMUM	8	8	12	59	5	14
MEDIAN	580	690	1,000	830	39	177
COUNT	10	11	12	9	39	2
STD DEV	1,500	10,200	3,400	1,030	6,400	231
WASTE CODE/REG. LEVEL BY WAY OF 261.30-33	F002/0.05 mg./l	F005/0.33 mg./l	F003/0.053 mg./l	F003/0.15 mg./l	F003/0.59 mg./l	U044/5.60 mg./kg
Boiling Point	121.4° C	110.8° C	136.2° C	138° to 144° C	56.2° C	62° C

Table 3.2 (Cont.)
Volatile Organic Compounds Detected in On-Site Soils
Concentrations and Waste Codes by Component

COMPONENT	1,1 DCE	STYRENE	BENZENE	1,1,1, TCA	TCF
MAXIMUM	750	35,000	1,200	31	160
AVERAGE	442	17,226	1,200	31	106
MINIMUM	133	17	1,200	31	27
MEDIAN	442	16,660	1,200	31	130
COUNT	2	3	1	1	3
STD DEV	436	17,500			
WASTE CODE/REG. LEVEL BY WAY OF 261.30-33	U078/33.0 mg./kg	NONE LISTED	NONE LISTED	F002/0.41 mg./l	F002/0.96 mg./l
Boiling Point	31.9° C	145.2° C	80.1° C	17/81° C	47.6° C

3.3 Semi-volatile Organics

Detected semi-volatile organics are listed in Table 3.3. Also listed in this table are the parameters maximum, average, minimum, and median detected concentrations (in ppb), as well as the "count" (the number of samples that analyzed above the detection limit), and standard deviation.

It should be noted that the semi-volatiles may not be completely volatilized by LTTD. This incomplete volatilization is due to the matrix and mixing of all of the components and due to the high boiling point of these parameters which is near the upper range of the LTTD standard operating temperature of 250° C or higher. These materials would, therefore, pass through the rotary section (for the most part) and reside with the soil. These materials would, however, be totally incinerated at the higher proposed temperatures of incineration equipment (see the "Conclusions for Volatiles" section for temperature ranges for LTTD and incineration).

Action levels for two of the compounds (2-Methanaphthalene and Fluorene) could not be found in the sections of 40 CFR reviewed, and only two action levels were found as a part of an action level associated with Creosote (U051, which only applies if the material was disposed of as Creosote, which is not the case in this instance). Therefore, the remediation of the semi-volatiles may be a non-issue. This appears to be the case in that the action levels listed for U165 are considerably higher than the sample analysis indicates, and the action level for bis (2-

ETHYL-HEXYL) PHTHALATE (DEPH) applies only if the material was disposed of as bis (2-ETHYL-HEXYL) PHTHALATE (which there is no evidence to substantiate). Therefore, it must be determined whether or not the remaining compounds (2-Methnaphthalene and Fluorene) have action levels or not. If no action levels are proposed for these compounds, then LTTD can be utilized as a treatment alternative. If action levels exist for the two compounds, then full incineration would have to be used for thermal treatment of the subject soils. Incineration could destroy all of the compounds of concern.

Table 3.3
Semi-Volatile Organic Compounds Detected in On-Site Soils
Concentrations and Waste Codes by Component

CONCENTRATION IN PPB	NAPHTHALENE	2-METHNAPHTHALENE	FLUORENE	PHENANTHRENE	PYRENE	bis(2ETHYL-HEXYL) PHTHALATE (DEPH)
	620	3200	460	660	37	89
	440	1100				
MAXIMUM	620	3200	460	660	37	89
AVERAGE	530	2150	460	660	37	89
MINIMUM	440	1100	460	660	37	89
MEDIAN	530	2150	460	660	37	89
COUNT	2	2	1	1	1	1
STD DEV	127.3	1484.9				
WASTE CODE/REG. LEVEL BY WAY OF 261.30-33	U165/3.1 mg./kg	NONE LISTED	NONE LISTED	LISTED ONLY UNDER CREOSOTE UO51	U028/28.0 mg./kg.	
Boiling Point	217.9° C	241° to 242° C	294° C	340° C	393° C	298° C

3.4 Dioxins and Furans

The PCDD and PCDF tests conducted by Inchcape/NDRC (reference 3), on two soil samples collected by AWD, indicated that the only "dioxin" found in the soil was OCDD. In light of the rules set forth by the Texas Water Commission (now part of the TNRCC) in Rule 335-141, Appendix 1 , Table 1 "Constituents of Concern and Their Maximum Leachable Concentrations"

(Attachment 1), the OCDD detected is not regulated (only TCDD, PeCDD, and 8-HxCDD are listed). Therefore, the site can be remediated outside of TSCA regulations as they pertain to dioxins and furans.

3.5 Material Handling and Physical Characteristics of Soils

In regards to handling the material/material flow, it should be noted that the characteristics of the soil as it pertains to silt, clay, sand, show that the material is heavily weighted in silt (average 45.79%), and sand (average 31.24%) with clay close behind (average 22.98%). Whether or not LTTD or full incineration can remediate the site, given the timing involved for the remediation, depends greatly on these characteristics and how the matrix is subdivided.

Moisture content, solids content, and BTU analyses conducted on samples taken by AWD during the Phase I field work indicate that the average moisture is 17.58%, average ash/solids content is 80.95%, and the average BTU content is 148 BTU per pound. This data suggests a high likelihood for small particulates and thus, a high load factor for any air pollution control equipment involved, as well as a high supplemental BTU load to either volatilize, or incinerate the matrix.

3.6 Handling of Volatilized Compounds

For either LTTD or full incineration an off gas scrubber system with a recycle will be required to handle the volatilized compounds. This system should consist of an alkaline scrubbing media and a particulate suppression system (as dictated by the soil characteristics mentioned in the previous paragraphs). The waste water exiting the scrubber and particulate suppression systems will require treatment. This treatment could be conducted at an on-site waste water treatment plant or disposed off-site at an approved disposal facility.

4.0 COST SUMMARY

Based on the analytical test results and the assumed treatment goals, the processes proposed (thermal desorbtion or incineration) will generate an approximate cost of $150.00/Ton for LTTD and $325.00/Ton for incineration.

5.0 SUMMARY CONCLUSION AND RECOMMENDATION

Based on the information reviewed by AWD LTTD can remediate the on-site soils assuming that there are no action levels for the semi-volatile compounds discussed in Section 3.4. If action levels for these compounds are identified, incineration would be the applicable thermal treatment option.

The above conclusions and recommendations are based on technical and operational experience. It is recommended that they are confirmed by conducting a pilot test using the on-site soils. An LTTD unit could be brought to LHAAP and used to conduct a pilot test on-site. However, for full incineration an on-site pilot test would not be possible. Such a test would have to be done as a bench scale study in an off-site facility. The need for metal stabilization should be part of any pilot test.

6.0 REFERENCES

1. Longhorn Army Ammunition Plant, Data Summary Report of Investigation Results from 1976 Through 1992, For Burning Ground 3 & The Unlined Evaporation Pond, U.S. Army Corps of Engineers, May 1993.

2. Summary Report, Review of Existing Data, Burning Ground No. 3 and Unlined Evaporation Pond, Longhorn Army Ammunition Plant, Karnack, Texas, AWD Technologies, Inc., October 1993.

3. Analytical Results, Phase I Program, Inchcape Testing Services, November 1993.

DRAFT

ATTACHMENT 1
TEXAS NATURAL RESOURCES AND CONSERVATION COMMISSION (TNRCC)
(Formerly Texas Water Commission)
CHAPTER 335

CHAPTER 335

SUBCHAPTER R
WASTE CLASSIFICATION

Sections 335.501-335.515

Section 335.501. Purpose, Scope and Applicability. Person who generates industrial solid waste or municipal hazardous waste shall comply with the provisions of this subchapter. Persons who generate wastes in Texas shall classify their own waste according to the standards set forth in this subchapter and may do so without any prior approval or communication with the Commission other than notification of waste generation activities pursuant to Section 335.6 of this title (relating to Notification Requirements) and submittal of required documentation pursuant to Section 335.513 of this title (relating to Documentation Required). This subchapter will:

(1) Provide a procedure and time schedule for implementation of a new Texas waste notification system; and,

(2) Establish standards for classification of industrial solid waste and municipal hazardous waste managed in Texas.

Section 335.502. Conversion to New Waste Notification and Classification System.

(a) These rules relating to waste classification are effective as outlined below. The rules shall be implemented as defined in Subsections (b)-(g) of this section, which are summarized as follows:

(1) Effective date of rules adoption--after this date all waste classifications involving new waste streams and existing unclassified waste streams shall be classified according to the requirements of this subchapter;

(2) January 1, 1993--On and after this date all waste classifications involving new waste streams and existing unclassified waste streams shall be classified according to the requirements of this subchapter.

(3) July 1, 1994--This is the completion deadline for updating all hazardous and nonhazardous waste stream notifications.

(4) October 1, 1994--This date is the deadline for the Commission to provide notice in *Texas Register* concerning final implementation of rules.

(5) January 1, 1995--The rules shall be fully implemented on or before the date. All waste must be managed according to the classification assigned under this subchapter.

(b) Waste notification information as required under Section 335.6 of this title (relating to Notification Requirements) and waste codes required under Section 335.10(b) of this title (relating to Shipping and Reporting Procedures Applicable to Generators of Hazardous Waste or Class I Waste and Primary Exporters of Hazardous Waste) shall be assigned by the generator and provided to the Commission as provided by this chapter and all other applicable laws.

(1) All waste notification information provided to the Commission after the effective date of this subchapter shall be provided in a format defined by the Commission.

(2) All existing waste notification information on file with the Commission shall be updated to the new format by the generator no later than July 1, 1994.

(3) All waste notification information may be submitted on paper or by electronic data transmission.

(4) Forms and format information for submitting notice of registration information on paper or by electronic means may be obtained by contacting the Commission at the address listed in Appendix 2 of this subchapter.

(c) All industrial solid waste and municipal hazardous waste managed in the state shall be classified by the generator according to the provisions of this subchapter.

(1) After the effective date of this subchapter, all new waste streams not previously classified shall be classified and managed pursuant to the provisions of this subchapter.

(2) All generators that have existing waste streams classified as Class 1, Class 2 or Class 3 under any previous system are required to reevaluate the waste under the provisions of this subchapter and to submit the updated information to the Commission pursuant to Subsection (b) of this section. However, generators of waste classified under a previous waste classification system may continue to manage and dispose of that waste under the existing classification until the effective management date provided in Subsection (d) of this section. If a generator chooses to continue to manage waste under a previous waste classification system the existing waste code shall be used when shipping, storing, disposing or otherwise managing the waste. The generator shall use the new waste code when the waste is to be managed under the new classification designation. Once a waste is reclassification and using the new waste code, the generator may not return to managing the waste under the old classification system.

(d) The effective date for management of wastes under these rules is January 1, 1995. On and after this date, all solid waste generated or otherwise handled in the state shall be classified and accordingly managed pursuant to this subchapter. This effective date may be revised by Subsection (e) of this section.

(e) Not later than October 1, 1994, the Commission shall assess the impact of the implementation of these rules. The Commission shall evaluate waste capacity issues, costs to the regulated community and the state, personnel and staffing levels of the Commission, and review the applicability of the rules themselves. The Commission may use information from any source necessary to assess the impact. Based on this evaluation, by October 1, 1994, the Commission shall give public notice in the *Texas Register* that either:

(1) these waste classification requirements take full force and effect on January 1, 1995; or,

(2) implementation of these waste classification requirements shall be delayed. If implementation is delayed the Commission shall provide a revised implementation date and give additional information as necessary to guide the regulated community until the revised effective date.

(f) If the Commission fails to give public notice in the *Texas Register* as required in Subsection (e) of this section, these rules take full force and effect on January 1, 1995.

(g) After the effective management date of these rules as provided in Subsection (d) of this section, future reclassification of a waste may be required because of changes in classification criteria. A generator whose waste stream is reclassified to a more stringent waste classification after the effective management date of this subchapter as provided in Subsection (d) of this section must reclassify the waste and begin managing the waste according to the more stringent classification requirements according to the following schedule:

(1) if mandated by a federal or state law, as specified in that law;

(2) if a date is provided in the adoption of the amendment, as required in that rule adoption;

(3) if not otherwise specified, within 180 days of the effective date of the rule amendment adopting the new classification criteria;

(4) in situations where a compliance date creates an unusual hardship a generator may request a different implementation time under the variance provisions of Section 335.514 of this title (relating to Variance from Waste Classification Provisions).

Section 335.503. Waste Classification and Waste Coding Required.

(a) All industrial solid and municipal hazardous waste generated, stored, processed, transported or disposed of in the state shall be classified according to the provisions of this subchapter.

(1) All solid waste shall be classified at the point of generation of the waste. A generator may not dilute a waste to avoid a Class 1 classification; however, combining waste streams for subsequent legitimate processing, storage,

or disposal does not constitute dilution and is acceptable. Wastes shall be classified prior to, and following any type of processing or mixing of the waste.

(2) All industrial solid and municipal hazardous waste shall be classified as either:

(A) Hazardous
(B) Class 1;
(C) Class 2; or
(D) Class 3.

(3) A person who generates a solid waste shall first determine if that waste is hazardous pursuant to Section 335.504 of this title (relating to Hazardous Waste Determination).

(4) After making the hazardous waste determination as required in Paragraph (3) of this subsection, if the waste is determined to be nonhazardous, the generator shall then classify the waste as Class 1, Class 2, or Class 3, pursuant to Sections 335.505-335.507 of this title (relating to Class 1 Waste Determination, Class 2 Waste Determination, and Class 3 Waste Determination) using one or more of the following methods:

(A) Use the criteria for waste classification as provided in Sections 335.505-335.507 of this title (relating to Waste Classification);

(B) Use process knowledge as provided in Section 335.511 of this title (relating to Use of Process Knowledge);

(C) Classify the waste as directed under Section 335.508 of this title (relating to Classification of Specific Industrial Wastes); or

(D) Choose to classify a nonhazardous waste as Class 1 without any analysis to support that classification. However, documentation (analytical data and/or process knowledge) is necessary to classify a waste as Class 2 or Class 3, pursuant to Section 335.513 of this title (relating to Documentation Required).

(b) As required under the schedule provided in Section 335.502 (relating to Conversion to New Waste Notification and Classification System), all industrial solid waste and municipal hazardous waste generated, stored, processed, transported or disposed of in the state shall be coded with an eight (8) digit waste code number which shall include a four-digit waste sequence number, a three-digit form code, and a one-character classification (either H, 1, 2, or 3). Form codes are provided in Appendix 3 of this subchapter. Procedures for assigning waste code numbers and sequence numbers are outlined below and available from the Commission at the address listed in Appendix 2 of this subchapter.

(1) A waste code is represented by the following 8-digit character string: sequence number + form code + classification code (H, 1, 2, or 3).

(2) In-state generators will assign a unique 4 digit sequence number to each individual waste. These sequence numbers will range from 0001 to 9999. They need not be assigned in sequential order. An in-state registered generator may choose to request the Commission assign a sequence number to a specific waste which is not regularly generated by a facility and is being shipped as a one-time shipment rather than adding that waste to the regular sequence numbers on a notice of registration. Sequence numbers provided by the Commission may be a combination of alpha and numeric characters.

(3) In-state unregistered generators will be provided a 4-digit sequence number by the Commission for each regulated waste it generates. Sequence numbers provided by the Commission may be a combination of alpha and numeric characters.

(4) Generators of wastes resulting from a spill must obtain a sequence number for the spill related wastes from the Commission's Emergency Response Section.

(5) Out-of-state generators will use the sequence code "OUTS" in the first 4 digits of the waste code.

(6) Municipal Conditionally Exempt Small Quantity Generators will use "CESQ" in the first 4 digits of the waste code.

(7) A facility which receives a waste and consolidates that waste with other like waste (thus not changing the form code of the waste stream or its

composition), or stores a waste without treating or changing the form or composition of that waste may ship that waste to a storage, treatment or disposal facility using "TSDF" in the first 4 digits sequence position of the waste code. This does not pertain to wastes which are treated or altered. This "TSDF" designation is only to be used by facilities that store and/or accumulate a quantity of wastes from more than one site for subsequent shipment to a treatment or disposal facility.

Section 335.504. Hazardous Waste Determination. A person who generates a solid waste must determine if that waste is hazardous using the following method:

(1) First determine if the waste is listed as a hazardous waste in 40 Code of Federal Regulations Part 261, Subpart D.

(2) If the waste is not listed as a hazardous waste in 40 Code of Federal Regulations Part 261, Subpart D, the person must then determine whether the waste exhibits a characteristic of a hazardous waste as identified in 40 Code of Federal Regulations Part 261, Subpart C, by either:

(A) testing the waste according to methods set forth in 40 Code of Federal Regulations Part 261, Subpart C, or according to an equivalent method approved by the administrator under 40 Code of Federal Regulations Section 260.21; or

(B) applying knowledge of the hazardous characteristic of the waste in light of the materials or process used, pursuant to Section 335.511 of this title (relating to Use of Process Knowledge).

Section 335.505. Class 1 Waste Determination. A nonhazardous industrial solid waste is a Class 1 waste if:

(1) it contains specific constituents which equal or exceed the level listed in Table 1 of Appendix 1 of this subchapter as determined by the methods outlined in this section. A nonhazardous waste is a Class 1 waste if using the test methods described in 40 Code of Federal Regulations Part 261, Appendix II, or equivalent methods approved by the executive director under the procedures set forth in Section 335.509 of this title (relating to Waste Analysis), the extract from a representative sample of the waste contains any of the contaminants listed in Appendix 1 at a concentration equal to or greater than the Maximum Concentration given in that table. Information on representative samples is set forth in Section 335.509 of this title (relating to Waste Analysis). Where matrix interferences of the waste cause the Practical Quantitation Limit (PQL) of the specific analysis to be greater than the Maximum Concentration listed in Appendix 1, then the achievable PQL becomes the Maximum Concentration, provided that the generator maintains documentation which would satisfactorily demonstrate to the executive director that lower levels of quantitation of a sample are not possible. A satisfactory demonstration includes the results from the analysis of the waste for that specific analyses by a laboratory utilizing an appropriate EPA SW-846, EPA-600, "Standard Methods for the Examination of Water and Wastewater", or ASTM Standard Methods, or an equivalent method approved by the executive director under procedures set forth in Section 335.509 of this title (relating to Waste Analysis);

(2) it is Class 1 ignitable. A nonhazardous waste is Class 1 ignitable if a representative sample of the waste has any of the following properties:

(A) it is liquid and has a flash point less than 65.6°C (150°F), as determined by a Pensky-Martens Closed Cup Tester, using the test method specified in ASTM Standard D-93-79 or D-93-80, or a Setaflash Closed Cup Tester, using the test method specified in ASTM Standard D-3278-78 or as determined by an equivalent test method approved by the executive director under procedures set forth in Section 335.509 of this title (relating to Waste Analysis); or,

(B) it is a physical solid or semi-solid under which conditions normally incident to storage, transportation, and disposal is liable to cause fires through friction, retained heat from manufacturing or processing, or which can be ignit readily, and when ignited burns so vigorously and persistently as to create a serious hazard. Included in this class are spontaneously combustible and water-reactive materials, including but not necessarily limited to the substances listed in Table 2 of Appendix 1;

(3) it is Class 1 corrosive. A nonhazardous waste is Class 1 corrosive if a representative sample of the waste is a semi-solid or solid which, when mixed with an equivalent weight of ASTM Type II laboratory distilled or deionized water, produces a solution having a pH less than or equal to 2 or greater than or equal to 12.5. Solidified, stabilized, encapsulated, or otherwise chemically-bound wastes are not subject to this requirement provided the waste is solidified such that when a representative sample of the waste is subjected to the Paint Filter Test (SW-846 Method 9095) it exhibits no free liquids. An equivalent method approved by the executive director under procedure set forth in Section 335.509 of this title (relating to Waste Analysis) may be utilized;

(4) there is an absence of analytical data and/or documented process knowledge which proves a waste is Class 2 or Class 3;

(5) it is identified as a Class 1 waste in Section 335.508 of this title (relating to Classification of Specific Industrial Solid Wastes); or,

(6) it is not a hazardous waste pursuant to Section 335.504 of this title (relating to Hazardous Waste Determination) and a generator chooses to classify the waste as Class 1.

Section 335.506. Class 2 Determination.

(a) An industrial solid waste is a Class 2 waste if:

(1) it is not a hazardous waste pursuant to Section 335.504 of this title (relating to Hazardous Waste Determination);

(2) it is not a Class 1 waste pursuant to Section 335.505 of this title (relating to Class 1 Waste Determination); and

(3) it is not a Class 3 waste because:

(i) it cannot qualify as a Class 3 waste pursuant to Section 335.507 (relating to Class 3 Waste Determination); or,

(ii) a generator chooses not to classify the waste as a Class 3 waste.

(b) Any waste designated as a Class 2 waste under Section 335.508 of this title (relating to Classification of Specific Industrial Solid Wastes) is a Class 2 waste.

Section 335.507. Class 3 Waste Determination. An industrial solid waste is a Class 3 waste if it is inert and essentially insoluble, and poses no threat to human health and/or the environment. Class 3 wastes include, but are not limited to, materials such as rock, brick, glass, dirt, and certain plastics and rubber, which are not readily decomposable. An industrial solid waste is a Class 3 waste if it:

(1) is not a hazardous waste pursuant to Section 335.504 of this title (relating to Hazardous Waste Determination);

(2) does not meet any of the Class 1 waste criteria set forth in Section 335.505 of this title (relating to Class 1 Waste Determination);

(3) is inert. Inertness refers to chemical inactivity of an element, compound, or a waste. Ingredients added to mixtures chiefly for bulk and/or weight purposes are normally considered inert; and

(4) is essentially insoluble.

(A) Essential insolubility is established:

(i) when, using the test methods specified in Appendix 4 (7-Day Distilled Water Leachate Test), the extract from a representative sample of the waste does not leach greater than the Maximum Contaminant Levels listed in Table 3 of Appendix 1 of this subchapter;

(ii) using the test methods described in 40 Code of Federal Regulations Part 261, Appendix II, or equivalent methods approved by the executive director under the procedures set forth in Section 335.509 of this title (relating to Waste Analysis), the extract from a representative sample does not exhibit detectable levels of constituents found in Table 1. This excludes the constituents listed in 40 Code of Federal Regulations Part 141, Subparts B and G, which were addressed in Subparagraph (i) of this paragraph;

(iii) when using an appropriate test method, a representative sample of the waste does not exhibit detectable levels of total petroleum hydrocarbon (TPH). Petroleum substance wastes as defined in 31 TAC Section 334.481 of this title (relating to Definitions) are not subject to this subsection; and,

(iv) when using an appropriate test method, a representative sample of the waste does not exhibit detectable levels of polychlorinated biphenyls (PCB's).

(B) Subparagraph (A) of this paragraph does not apply to naturally occurring material, i.e., soil, rock, etc., if the generator can demonstrate that the levels present in the waste are naturally occurring in the background of that particular material.

(C) If the detection level submitted by the generator is challenged by the Commission, and for other enforcement purposes, the burden is on the generator to demonstrate that the detection level was reasonable for the material in question and for the technology in use at the time the waste was classified.

Section 335.508. Classification of Specific Industrial Solid Wastes. The following nonhazardous industrial solid wastes shall be classified no less stringently than according to the provisions of this subsection:

(1) Industrial solid waste containing asbestos material identified as Regulated Asbestos Containing Material (RACM), as defined in 40 Code of Federal Regulations Part 61, shall be classified as a Class 1 waste.

(2) Empty containers that are a solid waste as defined in Section 335.1 (relating to Definitions) shall be subject to the following criteria:

(A) A container which has held a Hazardous Substance as defined in 40 CFR Part 302, a Hazardous waste, a Class 1 waste, or a material which would be classified as a Hazardous or Class 1 waste if disposed, and is empty per Section 335.41(f)(2) of this title (relating to Purpose, Scope and Applicability concerning empty containers):

(i) shall be classified as a Class 1 waste;

(ii) may be classified as a Class 2 waste if the container has a capacity less than 5 gallons and has held a nonhazardous waste; or

(iii) may be classified as a Class 2 waste if the container has a capacity of 5 gallons or more and:

(I) the residue has been completely removed either by triple rinsing with a solvent capable of removing any waste, by hydroblasting or by other methods which adequately remove the residue; and,

(II) the container has been crushed, punctured, or subjected to other mechanical treatment which renders the container unusable.

(B) A container which has held a Class 2 waste shall be classified as a Class 2 waste.

(C) Aerosol cans that have been depleted of their contents, such that the inner pressure of the can equals atmospheric pressure and minimal residues remain in the can, may be classified as a Class 2 waste.

(3) Paper, cardboard, food wastes, and general plant trash shall be subject to the following classification criteria:

(A) Paper, cardboard, linings, wrappings, paper packaging materials, or absorbants shall be subjected to Section 335.504 (relating to Hazardous Waste Determination), and if nonhazardous, to the criteria listed in Section 335.505 of this title (relating to Class 1 Waste Determination). Paper or cardboard containers may be classified as Class 1 or 2 under the provisions of Paragraph (2) of this section.

(B) Paper, cardboard linings, wrappings, paper packaging mater als, food wastes, glass, aluminum foil, plastics, styrofoam and food packaging, that are produced as a result of plant production, manufacturing or laboratory operations and that are classified as Class 2 waste shall be designated "plant production refuse". Plant production refuse shall not include oils, lubricants of any type, oil filters, contaminated soils, sludges, or wastewaters.

(C) Paper, cardboard, linings, wrappings, paper or wood packaging materials, food wastes, glass, aluminum foil, plastics, styrofoam and food packaging, that come from general office, cafeteria, or food service operations, that are classified as Class 2 wastes, shall be designated "plant office refuse".

(D) Any Class 2 Waste from production, manufacturing, or laboratory operations can be designated as "supplemental plant production refuse" as long as the total amount of the supplemental plant production refuse does not exceed twenty percent of the total plant production refuse volume or weight, whichever is less. Individual wastes which have been designated supplemental plant production refuse may be designated by the generator at a later time as a separate waste in order to maintain the supplemental plant production refuse at a level below 20 percent of the appropriate plant production refuse amount. For any waste stream redesignated, the generator must provide the notification information required pursuant to this subchapter.

(E) Wastes associated with first aid station, medical emergencies, or other nonsurgical medical treatment shall be designated as Class 2 wastes and are subject to the provisions of 31 TAC Sections 330-1004-1009.

(4) Media contaminated by a material containing greater than or equal to 50 parts per million total polychlorinated biphenyls (PCBs) and wastes containing greater than or equal to 50 ppm PCBs shall be classified as Class 1.

(5) Waste containing petroleum hydrocarbon concentration greater than 1500 parts per million total petroleum hydrocarbon (TPH) shall be classified as Class 1. Wastes resulting from the cleanup of leaking underground storage tanks (USTs) which are regulated under 31 TAC Section 334 Subchapter K (relating to Petroleum Substance Waste) are not subject to the classification under this subchapter.

(6) Wastes generated by the mechanical shredding of automobiles, appliances, or other items of scrap, used or obsolete metals shall be handled according to the provisions set forth in Texas Solid Waste Disposal Act, Health and Safety Code, Section 361.019 (Vernon Pamphlet 1992), until the Commission develops specific standards for the classification of this waste and assures adequate disposal capacity.

(7) If a nonhazardous industrial solid waste is generated as a result of commercial production of a "new chemical substance" as defined by the federal Toxic Substances Control Act, 15 U.S.C.A. Section 2602(9), the generator shall notify the Commission prior to the processing or disposal of the waste and shall submit documentation requested under Section 335.513(b) and (c) of this title (relating to Documentation Required) for Commission review. The waste shall be managed as a Class 1 waste, unless the generator can provide appropriate analytical data and/or process knowledge which demonstrates that the waste is Class 2 or Class 3, and the Commission concurs. If the generator has not received concurrence from the Commission within 120 days from the date of the request for review, the generator may manage the waste according to the requested classification, but not prior to giving 10 working days written notice to the Commission.

(8) All nonhazardous industrial solid waste generated outside the state of Texas and transported into or through Texas for processing, storage, or disposal shall be classified as:

(A) Class 1; or,

(B) May be classified as a Class 2 or Class 3 waste if:

(i) the material satisfies the Class 2 or Class 3 criteria as defined in Section 335.506, Section

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335.507 or Section 335.508 (relating to Class 2 Waste Determination and Class 3 Waste Determination); and

(ii) a request for Class 2 or Class 3 waste determination is submitted to the Commission accompanied by all supporting analytical data. Waste generated out-of-state may be assigned a Class 2 or Class 3 classification only after approval by the Commission.

Section 335.509. Waste Analysis.

(a) Generators who use analytical methods to classify their waste must use methods described in "Test Methods for the Evaluation of Solid Waste, Physical/Chemical Methods," SW-846, "Methods for Chemical Analysis of Water and Wastes," EPA-600, "Standard Methods for the Examination of Water and Wastewater," or American Society for Testing and Materials (ASTM) Standard Methods, or may request in writing that the Commission review and approve an alternate method. The generator must also choose representative sample(s) of their waste, as described in Chapter 9 of SW-846. A generator who proposes to use an alternate method must validate the alternate method by demonstrating that the method is equal to or superior in accuracy, precision, and sensitivity to the corresponding SW-846, EPA-600, Standard Method or ASTM method.

(b) The generator proposing an alternate method shall provide the Commission with the following information:

(1) a full description of the proposed method including all equipment used;

(2) a description of the types of wastes and waste matrices analyzed;

(3) comparative results of the proposed method and the corresponding SW-846 method;

(4) a complete assessment of any factors which may interfere with the method; and

(5) a description of the Quality Control procedures necessary to ensure the sensitivity, accuracy, and precision of the proposed method.

(c) Upon request of the executive director, generator shall provide additional information as necessary to enable the executive director to adequately review the alternate methods proposed by the generator.

Section 335.510. Sampling Documentation.

(a) Generators who use analytical data to classify their Class 2 or Class 3 wastes pursuant to Section 335.509 of this title (relating to Waste Analysis) must maintain documentation of their sampling procedures.

(b) The sampling documentation must, at a minimum, include the following:

(1) Dates samples were collected;

(2) A description of the site or unit from which the sample is taken and sampling location(s) at the site unit;

(3) Methods and equipment utilized; and

(4) Description of sample handling techniques, including containerization, preservation, and chain of custody.

(c) Generators shall document all the information listed in Subsection (b) of this section, and retain copies on-site for a minimum of five years after waste is no longer generated or upon site closure, pursuant to Section 335.513 of this title (relating to Documentation Required).

(d) Generators who have existing sampling documentation, which includes the information listed in Subsection (b) of this section, do not need to prepare any new documentation specifically for this section.

Section 335.511. Use of Process Knowledge.

(a) Generators may use their existing knowledge about the process to classify or assist in classifying a waste as Hazardous, Class 1, Class 2 or Class 3. Process knowledge must be documented and maintained on site pursuant to Section 335.513 of this title (relating to Documentation Required). Material Safety Data Sheets, manufacturers' literature, and other documentation generated in conjunction with a particular process may be used to classify a waste provided that the literature provides sufficient information about waste and addresses the Class 1 criteria set forth in Section 335.505 of this title (relating to Class 1 Waste Determination). A generator must be able to demonstrate requisite knowledge of his or her process by satisfying all of the following:

(1) The generator must have a full description of the process, including a list of chemical constituents that enter the process. Constituents listed in Appendix 1 of this subchapter must be addressed in this description;

(2) The generator must have a full description of the waste, including a list of chemical constituents likely to be in the waste. This list should be based on Paragraph (1) of this subsection;

(3) The generator may develop a subset of Appendix 1 constituents by which to evaluate the waste utilizing the information from Paragraphs (1) and (2) of this subsection; and

(4) Documentation of the waste classification must be maintained, and provided to the Commission if required, pursuant to Section 335.513 of this title (relating to Documentation Required).

(b) If a total analysis of the constituents the generator chooses to evaluate demonstrates that individual analytes are not present in the waste, or that they are present but at such low concentrations that the appropriate Maximum Leachable Concentrations could not possibly be exceeded, the TCLP extraction procedure discussed in Section 335.505(1) of this title (relating to Class 1 Waste Determination) need not be run. If an analysis of any one of the liquid fractions of the TCLP extract indicates that a regulated constituent is present at such high concentrations that, even after accounting for dilution from the other fractions of the extract, the concentration would be equal to or greater than the Maximum Leachable Concentration for that constituent, then the waste is Class 1, and it is not necessary to analyze the remaining fractions of the extract.

Section 335.512. Executive Director Review.

(a) The executive director may review the generator's classification of any waste to determine if it is appropriately classified. If the executive director determines that a waste has been classified incorrectly according to the standards set forth in this subchapter, or if the executive director determines that extenuating circumstances that may result in threat of harm to human health or the environment warrant an upgrading of the classification, the executive director may reclassify the waste to the more stringently regulated classification. The executive director shall provide the generator with written notice of his determination and reclassification.

(b) A person who believes that the Commission staff has inappropriately classified a waste pursuant to this section may appeal that decision. Such appeal must be filed within 30 days of the date of the receipt of the executive director's determination. The person shall file an appeal directly with the executive director requesting a review of the waste classification. If the person is not satisfied with the decision of the executive director on the appeal, the person may request an evidentiary hearing to determine the appropriateness of the classification by filing a request for hearing with the Commission.

Section 335.513. Documentation Required.

(a) Documentation on each waste stream is required to be maintained by the generator in accordance with the requirements of this subchapter and in accordance with Section 335.9 of this title (relating to Recordkeeping and Annual Reporting Procedures Applicable to Generators).

(b) The following documentation shall be submitted by the generator to the Commission prior to waste shipment or disposal and not later than 90 days of initial waste generation:

(1) Description of waste;

(2) Date of initial waste generation;

(3) Description of process that generated the waste;

(4) Hazardous waste determination;

(5) All analytical data and/or process knowledge allowed under Section 335.511 of this title (relating to Use of Process Knowledge) used to characterize Class 3 wastes, including Quality Control data; and

(6) Waste classification determination.

(c) The following documentation shall be maintained by the generator on site immediately upon waste generation and for a minimum of five years after the waste is no longer generated or stored or until site closure:

(1) All information required under Subsection (b) of this section;

(2) All analytical data and/or process knowledge allowed under Section 335.511 of this title (relating to Use of Process Knowledge) used to characterize Hazardous, Class 2 and Class 3 wastes, including Quality Control data.

(d) The executive director may request that a generator submit all documentation listed in Subsections (b) and (c) of this section for auditing the classification assigned. Documentation requested under this section shall be submitted within ten (10) working days of receipt of the request.

(e) Any changes to the information required in Sections (b) and (c) of this subsection shall be maintained or submitted according to the timing requirements of this section.

Section 335.514. Variance from Waste Classification Provisions.

(a) The executive director may determine on a case-by-case basis the merits of the following types of variances:

(1) Compliance with timing requirements under Section 335.502 of this title (relating to Conversion to New Waste Notification and Classification System);

(2) Appropriateness of a particular waste classification resulting from application of the classification criteria; and

(3) Other matters requiring special attention by the Commission.

(b) Factors to be considered in determining whether a variance should be granted include, but are not limited to, circumstances which are reasonably unforeseeable and beyond the reasonable control of the generator, or the use of alternating classification criteria or procedures which meet or exceed the requirements and intent of these rules. The burden of justifying the need for a variance is on the requestor, and the requestor must submit information sufficient to clearly indicate the issues involved, the reason(s) for the request, and both positive and negative impacts that may result from the granting of the variance. Prior approval for the variance must be obtained before any change is authorized.

(c) A person who feels that the executive director has inappropriately denied a request for variance may appeal that decision. The person shall file an appeal directly with the executive director requesting a review of the variance. If the person is not satisfied with the decision of the executive director he or she may request an evidentiary hearing to determine the appropriateness of the variance, by filing a request for hearing with the chief hearings examiner of the Texas Water Commission.

Section 335.515. Enforcement.

(a) It is a violation of Commission rules if a waste is not properly classified according to the provisions of this subchapter.

(b) Where violations of this subchapter occur, the executive director may initiate formal enforcement action and may seek administrative penalties and order corrective actions, as prescribed under Chapter 337 of this title (relating to Enforcement), or pursue any other remedy available at law.

(c) When establishing corrective actions and penalty amounts involving violations of this subchapter, the executive director should consider circumstances which mitigate the nature or extent of the violations in accordance with applicable rules and statues.

Appendix 1

Table 1.

Constituents of Concern and Their Maximum Leachable Concentrations.

Values are based on information contained in Federal Registers Vol. 55 / Friday, July 27, 1990; Vol. 56 / June 7, 1991; and Integrated Risk Information Systems, Environmental Protection Agency, and 40 CFR 264 Appendix 9.

Compound	CAS No.	Concentration (mg/l)
Acetone	67-64-1	400
Acetonitrile	75-05-8	20
Acetophenone	98-86-2	400
Acrylamide	79-06-1	0.08
Acrylonitrile	107-13-1	0.6
Aniline	62-53-3	60
Antimony	7440-36-0	1
Arsenic	7440-38-2	1.8
Barium	7440-39-3	100.0
Benzene	71-43-2	0.50
Benzidine	92-87-5	0.002
Beryllium	7440-41-7	0.08
Bis(2-chloroethyl)ether	111-44-4	0.3
Bis(2-ethylhexyl)	117-81-7	30
phthalate	--	--
Bromodichloromethane	75-27-4	0.3

Bromomethane	74-83-9	5
Butylbenzyl phthalate	85-68-7	700
Cadmium	7440-43-9	0.5
Carbon disulfide	75-15-0	400
Carbon tetrachloride	56-23-5	0.50
Chlordane	57-74-9	0.03
Chlorobenzene	108-90-7	70
Chloroform	67-66-3	6.0
2-Chlorophenol	95-57-8	20
Chromium	7440-47-3	5.0
m-Cresol	108-39-4	200.0*
o-Cresol	95-48-7	200.0*
p-Cresol	106-44-5	200.0*
Cyanide	57-12-5	70
DDD	72-54-8	1
DDE	72-55-9	1
DDT	50-29-3	1
Dibutyl phthalate	84-74-2	400
1,4-Dichlorobenzene	106-46-7	7.5
3,3-Dichlorobenzidine	91-94-1	0.8
1,2-Dichloroethane	107-06-2	0.50
Dichlorodifluoromethane	75-71-8	700
1,1-Dichloroethylene	75-35-4	0.6
1,3-Dichloropropene	542-75-6	
2,4-Dichlorophenol	120-83-2	

2,4-Dichlorophenoxy-	94-75-7	10.0
acetic acid (2,4-D)	--	--
Dieldrin	60-57-1	0.02
Diethyl phthalate	84-66-2	3000
Dimethoate	60-51-5	70
m-Dinitrobenzene	99-65-0	0.4
2,4-Dinitrophenol	51-28-5	7
2,4 -Dinitrotoluene	602-01-7	0.13
(and 2,6-, mixture)	--	--
1,4-Dioxane	123-91-1	30
Dioxins (Poly chlorinated dibenzo-p-dioxins)		
2,3,7,8-TCDD	1746-01-6	0.005
1,2,3,7,8-PeCDD	40321-76-4	0.010
1,2,3,4,7,8-HxCDD	57653-85-7	0.050
1,2,3,6,7,8-HxCDD	34465-46-8	0.050
1,2,3,7,8,9-HxCDD		0.050
Diphenylamine	122-39-4	90
1,2-Diphenylhydrazine	122-66-7	0.4
Disulfoton	298-04-4	0.1
Endosulfan	959-98-8	0.2
Endrin	72-20-8	.02
Epichlorohydrin	106-89-8	40
Ethylbenzene	100-41-4	400
Ethylene dibromide	106-93-4	0.004
Furans (Polychlor[illegible]nzo furans)		
2,3,7,8[illegible]	[illegible]-9	0.050

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ABO-94-LHAAP-0033
February 17, 1994

18

Mr. Clif B. Warren, P.E.
HTRW Cost Plus Contract
Resident Office
U.S. Army Corps of Engineers
Tulsa District
1645 S. 101st East Avenue
Tulsa, Oklahoma 74128

Reference: **Contract No. DACA56-93-D-0016**
Interim Remedial Action - Phase I
Burning Ground 3 and Unlined Evaporation Pond LHAAP 18 and 24
Longhorn Army Ammunition Plant, Karnack, Texas

Subject: **Physical, Surveying and other Field Data**
Delivery Order No. 0002, Mod. No. 000202

Dear Mr. Warren:

Per our discussion during the project meeting in Tulsa on February 16, 1994, I am enclosing a copy of the following data which had been previously submitted in stages:

- Drilling Logs for the extraction well and four monitoring wells;
- Well completion forms;
- State of Texas Well Reports, prepared and submitted by the driller;
- Drilling Logs for the soil borings;
- Survey data for the wells and soil borings;
- Field parameters collected during well purging and sampling activities;
- Calculated well volumes and purging data;
- Slug test data and evaluation reports for the four monitoring wells;
- Geotechnical test results; and
- Test Pit logs; these test pits were excavated for collection of treatability samples.

AWD Technologies, Inc.
15204 Omega Drive Suite 200 Rockville Maryland 20850 Telephone 301 948 0040 Fax 301 948 6094

A site plan showing the locations of the extraction well, monitoring wells, soil borings, and test pits is also included with this package.

Do not hesitate to contact me if you have any questions or require additional information.

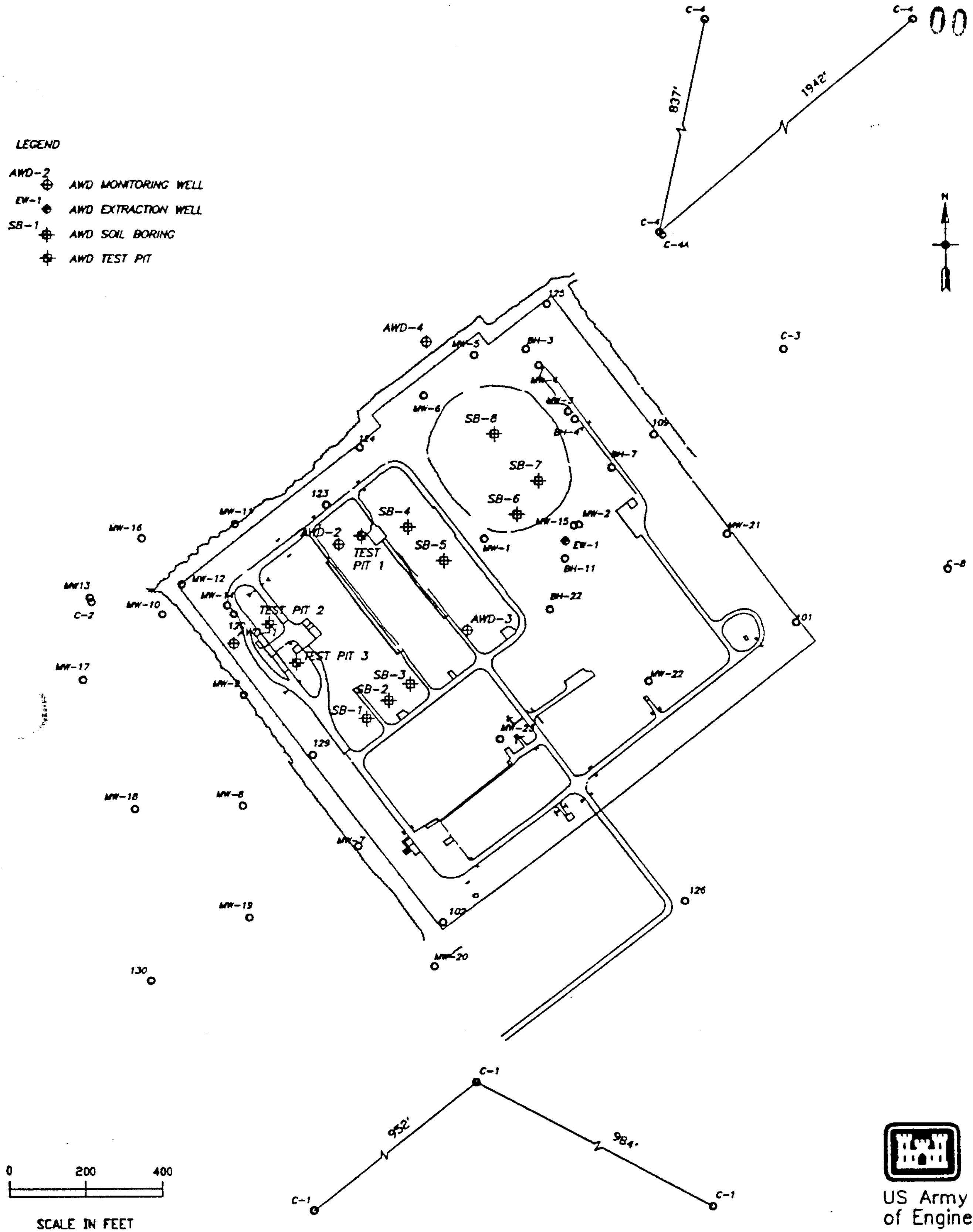
Sincerely,

Amine Bou Onk

Amine Bou Onk, P.E.
Project Manager

enclosure

cc: Wendy Lanier: USACE, Tulsa, District (3 copies of package)



US Army Corps
of Engineers
Tulsa District

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PHASE I
WELLS, SOIL BORINGS AND TEST PITS
SITE PLAN

LONGHORN ARMY AMMUNITION PLANT	KARNACK, TEXAS
PROJECT: LHAAP 18 & 24, PHASE I, IRA	PROJECT NO.: 2379
SCALE: AS SHOWN	FIGURE NUMBER
	REV

Hole No. EXTRACTION WELL-1

DRILLING LOG | DIVISION | INSTALLATION | SHEET OF SHEETS

1. PROJECT 2379
2. LOCATION (Coordinates or Station) LONGHORN AAP
3. DRILLING AGENCY CCI / ALLIANCE
4. HOLE NO. (As shown on drawing title and file number) EXTRACTION WELL-1
5. NAME OF DRILLER JOHN LODEN
6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE 38.0 FT
10. SIZE AND TYPE OF BIT 8 1/4 IN ID HSA
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL FAILING F6
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED 10 | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED 11/9/93 | COMPLETED 11/9/93
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f
	0				HSA
	5		5.0' TO 7.0' SILT: BROWN & GRAY, SOME FINE SAND, LITTLE CLAY, DAMP 6.5' SAND: BROWN, FINE GRAINED, LITTLE SILT DAMP	100	SS1
					HSA
			8.0 TO 9.5' SILT: FINE SAND, BROWN & GRAY MOTTLED, TRACE CLAY, DAMP	100	SS2
					HSA
	10		10.0'-12.0' SILT: BROWN & LT GRAY MOTTLED, SOME FINE SAND, TRACE CLAY, IRON & ORGANIC STAINING DAMP TO MOIST	50	SS3
					HSA
	15		15.0' TO 17.0' SILT: LT GRAY, IRON STAINED, LITTLE CLAY, TRACE FINE SAND AND BLACK ORGANIC STAINING, MOIST	83	SS4
					HSA
	20				

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

1. WATER LEVEL:
   22.30' BGS.; MEASURED ~ 2 HOURS AFTER COMPLETING BOREHOLE
2. JAR SAMPLES
   - SS1 : 5.0' - 7.0'
   - SS2 : 8.0 - 9.5'
   - SS3 : 10.0 - 12.0'
   - SS4 : 15.0' - 17.0'
   - SS5 : 20.0' - 22.0'
   - SS6 : 23.0' - 24.5'
   - SS7 : 25.0 - 27.0'
   - SS8 : 28.0 - 29.5'
   - SS9 : 30.0' - 32.0'
   - SS10 : 35.0 - 36.5'
3. JAR SAMPLES (PHYSICAL TESTS)
   - SS2 : 8.0'-9.5'
   - SS6 : 23.0'-24.5'
   - SS8 : 28.0'-29.5'
4. DRILLING
   8" ID HSA
   0.0' - 38.0'
   NOTE: 3" x 24" & 3" x 18" SPLIT SPOONS USED TO COLLECT SOIL SAMPLES
5. NOTE: EXTRACTION WELL INSTALLATION STARTED 11/9/93; 20-40 SILICA SAND PACK & BENTONITE SEAL EMPLACED

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PROJECT LHAAP | HOLE NO. EXTRACTION WELL - 1

Hole No. EXTRACTION WELL-1

007901

DRILLING LOG | DIVISION | INSTALLATION | SHEET OF SHEETS

1. PROJECT 2379
2. LOCATION (Coordinates or Station) LONGHORN AAP
3. DRILLING AGENCY CCI/Alliance
4. HOLE NO. (As shown on drawing title and file number) Extraction Well-1
5. NAME OF DRILLER JOHN LODEN
6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE 38.0 Ft.
10. SIZE AND TYPE OF BIT 8 1/4" ID HSA
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL FAILING F6
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN | DISTURBED 10 | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED 11/9/93 | COMPLETED 11/9/93
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

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
	20		20.0' TO 22.0' SILT: BROWN & GRAY MOTTLED, LITTLE CLAY & FINE SAND, BROWN FINE SAND @ 22.0', WET	100	SS5	6. PID HEADSPACE READINGS (PPM) SS1: <1.0 SS2: <1.0 SS3: <1.0 SS4: 9.2 SS10: 1218
			23.0 TO 24.5'		HSA	
			SAND: BROWN WITH GRAY MOTTLES, VERY FINE TO FINE GRAINED, LITTLE SILT, SATURATED	100	SS6	
	25		25.0' TO 27.0'		HSA	
			SAND: BROWN, VERY FINE TO FINE GRAINED, BROWN & GRAY MOTTLED CLAY @ 27.0', SATURATED	100	SS7	
			28.0 TO 29.5'		HSA	
			CLAY: BROWN & GRAY, LITTLE SILT & FINE SAND, MOIST, GRAY FINE SAND SEAM @ 28.5', SATURATED	100	SS8	
	30				HSA	
			30.0' TO 32.0' SAND: 30.0' - 30.5', GRAY, IRON STAINED, VERY FINE TO FINE GRAINED, SATURATED	100	SS9	
			CLAY: 30.5' TO 32.0', BROWN AND GRAY MOTTLED, SOME SILT AND VERY FINE SAND, CHEMICAL ODOR		HSA	
	35		35.0' - 36.5' CLAY & FINE SAND: BROWN, GRAY MOTTLES, BECOMING A VERY FINE TO FINE SAND, SATURATED, CHEMICAL ODOR	100	SS10	
	38		T.D. 38.0'			

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Hole No. AWD-1

DRILLING LOG	DIVISION	INSTALLATION
SHEET 1 OF 2 SHEETS		
1. PROJECT	2379	
2. LOCATION (Coordinates or Station)	LONGHORN AAP	
3. DRILLING AGENCY	CCI/ALLIANCE	
4. HOLE NO. (As shown on drawing title and file number)	AWD-1	
5. NAME OF DRILLER	JOBY BARR	
6. DIRECTION OF HOLE	☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	
7. THICKNESS OF OVERBURDEN		
8. DEPTH DRILLED INTO ROCK		
9. TOTAL DEPTH OF HOLE	26 FT	
10. SIZE AND TYPE OF BIT	6 3/4 IN ID HSA	
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)		
12. MANUFACTURER'S DESIGNATION OF DRILL	MOBILE DRILL BG1	
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN	DISTURBED: 6	UNDISTURBED:
14. TOTAL NUMBER CORE BOXES		
15. ELEVATION GROUND WATER		
16. DATE HOLE	STARTED: 11-11-93	COMPLETED: 11-11-93
17. ELEVATION TOP OF HOLE		
18. TOTAL CORE RECOVERY FOR BORING	%	
19. SIGNATURE OF INSPECTOR		

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
PERCHED WATER 1-2 FT			1.0 2.0 SOFT TO MED. STIFF RED CLAY, LITTLE SILT, GRADES TO SOFT BROWN CLAY, SOME SILT; MOIST	75%	SS-1	1. WATER LEVEL PERCHED WATER ABOVE 2.0 FT GROUNDWATER ENCOUNTERED AT APPROX. 6 FT WATER LEVEL ROSE TO 4.5 FT BGS. IN 30 MIN
			STIFF TAN SILT; DRY			
FINAL WATER LEVEL 4.5 FT	5		(BROWN CLAY)			2. CHEM. SAMPLES SS-1: 1-3 FT
			6.0 (FINE SAND) SATURATED			3. PHYSICAL SAMPLES SS-2: 10-12 FT SS-3: 15-16.5 FT SS-4: 16.5-17 FT SS-5: 20-22 FT SS-6: 25-27 FT
	10		10.0 LOOSE, LT. GRAY FINE SAND, TRACE SILT; SATURATED	100%	SS-2	4. PID HEADSPACE MEASUREMENTS SS-1 : 26 PPm SS-2 : 170 PPm SS-3 : 2177 PPm SS-4 : 2177 PPm SS-5 : 3900 PPm SS-6 : 2499 PPm 5. DRILLING
	15		15.0 MED. DENSE LT. GRAY FINE SAND, SOME SILT; MOIST		SS-3	3 IN SPLIT SPOON SAMPLES TAKEN THROUGH 6 3/4 IN ID HSA WITH PULLOUT PLUG.
			16.5 LOOSE, LT. GRAY FINE SAND, LITTLE SILT; SATURATED	15%		6. NOTE: NO RECOVERY ON 5-7 FT SAMPLE
	20					

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PROJECT
LONGHORN AAP
2379

HOLE NO.
AWD-1

Hole No. AWD-1

DRILLING LOG | DIVISION | INSTALLATION | SHEET 2 OF 2 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number) AWD-1
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE 28 FT
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL MOBILE DRILL B61
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

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
	20		MED. STIFF BROWN TO GRAY FINE SAND AND SILT; RUST MOTTLING, SATURATED	92%	SS-5	
	25		25.0 MED. STIFF LT. GRAY CLAY LITTLE SILT; BROWN MOTTLING MOIST	100%	SS-6	
			TOTAL DEPTH = 28 FT			

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PROJECT LONGHORN AAP 2379

HOLE NO. AWD-1

Hole No. AWD-2

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS
1. PROJECT 2379		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station) LONGHORN AAP		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) 6 3/4" ID HSA	
3. DRILLING AGENCY CCI / ALLIANCE		12. MANUFACTURER'S DESIGNATION OF DRILL FAILING F6	
4. HOLE NO. (As shown on drawing title and file number)	AWD-2	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN	DISTURBED 3 / UNDISTURBED
5. NAME OF DRILLER JOHN LODEN		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE	STARTED / COMPLETED
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING %	
9. TOTAL DEPTH OF HOLE	28.0 FT	19. SIGNATURE OF INSPECTOR	

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		CUTTINGS: BROWN, ORANGE-BROWN, SILT, TRACE CLAY, DAMP		HSA	1. WATER LEVEL - 11.30 FT BELOW GROUND SURFACE; MEASURED 1/2 HR AFTER COMPLETION OF BOREHOLE INSIDE OF AUGERS 2. JAR SAMPLES SS1 5.0' - 7.0' SS2 9.0' - 10.5' SS3 18.0' - 20.0' 3. JAR SAMPLES (PHYSICAL TESTS) SS1 5.0' - 7.0' SS2 9.0' - 10.5' SS3 18.0' - 20.0' 4. DRILLING 6 3/4" ID HSA 0.0' - 28.0' NOTE: SAMPLES COLLECTED WITH 3"x18" & 3"x24" SPLIT SPOON SAMPLERS 5. NOTE: MONITORING WELL INSTALLATIONS STARTED 11/10/93; 20-40 SILICA SAND PACK & BENTONITE PELLET SEAL EMPLACED
	5		5.0'-7.0' SAND: FINE GRAINED, LT GRAY, IRON STAINING ALONG PARTINGS, LITTLE CLAY, MOIST	100	SS1	
			6.5-7.0' SAND: FINE GRAINED, LT GRAY, SATURATED		HSA	
	10		9.0-10.5' SAND: FINE TO MEDIUM GRAINED, BROWN, THIN LT GRAY SILT SEAMS, SATURATED	100	SS2	
	15		CUTTINGS: LIGHT BROWN, FINE TO MEDIUM GRAINED SAND		HSA	
	20		18' TO 20' CLAY: BROWN & GRAY MOTTLES, BROWN FINE SAND @ 19.0' (3-4"), TRACE DECAYING ORGANIC MATERIAL, SATURATED	100	SS3	

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PROJECT LHAAP

HOLE NO. AWD-2

Hole No. AWD-2

DRILLING LOG

DIVISION		INSTALLATION	SHEET OF SHEETS
1. PROJECT	2379	10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station)	LONGHORN AAP	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	6¾" ID HSA
3. DRILLING AGENCY	CCI / ALLIANCE	12. MANUFACTURER'S DESIGNATION OF DRILL	FAILING F6
4. HOLE NO. (As shown on drawing title and file number)	AWD-2	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN	DISTURBED: 3 / UNDISTURBED:
5. NAME OF DRILLER	JOHN LODEN	14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE	☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.	15. ELEVATION GROUND WATER	
7. THICKNESS OF OVERBURDEN		16. DATE HOLE	STARTED: 11/9/93 / COMPLETED: 11/9/93
8. DEPTH DRILLED INTO ROCK		17. ELEVATION TOP OF HOLE	
9. TOTAL DEPTH OF HOLE	28.0 FT	18. TOTAL CORE RECOVERY FOR BORING	%
		19. SIGNATURE OF INSPECTOR	

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
	20				HSA	6. HEADSPACE RESULTS (PPM) SS1 0.0 – 1.8 SS2 5.5 SS3 3670
	25					
	28		T.D. 28.0'			

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PROJECT LHAAP

HOLE NO. AWD-2

Hole No. AWD-3

DRILLING LOG	DIVISION
INSTALLATION	SHEET / OF SHEETS
1. PROJECT	2379
2. LOCATION (Coordinates or Station)	LONGHORN AAP
3. DRILLING AGENCY	CCI / ALLIANCE
4. HOLE NO. (As shown on drawing title and file number)	AWD-3
5. NAME OF DRILLER	JOHN LODEN
6. DIRECTION OF HOLE	☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN	
8. DEPTH DRILLED INTO ROCK	
9. TOTAL DEPTH OF HOLE	35.0'
10. SIZE AND TYPE OF BIT	
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	6 3/4 ID HSA
12. MANUFACTURER'S DESIGNATION OF DRILL	FAILING F6
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED: ____ UNDISTURBED: ____
14. TOTAL NUMBER CORE BOXES	
15. ELEVATION GROUND WATER	
16. DATE HOLE	STARTED 11/11/93 COMPLETED 11/11/93
17. ELEVATION TOP OF HOLE	
18. TOTAL CORE RECOVERY FOR BORING	%
19. SIGNATURE OF INSPECTOR	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f
	0				
			4.0' TO 6.0' SILT: BROWN, DK ORANGE-BROWN, SCATTERED LT GRAY MOTTLES, LITTLE CLAY, TRACE ORGANIC DEBRIS, DAMP	100	SS1
	5				
			9.0 TO 10.5' SILT: BROWN, LT GRAY MOTTLES, SOME CLAY, TRACE BLACK ORGANIC STAINING, PLANT DEBRIS, DAMP TO MOIST	100	SS2
	10				
			14.0 TO 16.0' SILT & CLAY: BROWN, ORANGE-BROWN, LT GRAY MOTTLES, LT BROWN 3" SAND SEAM @ 14.5, ORGANIC STAINING, SATURATED	100	SS3
	15				
			19.0 TO 20.5' SILT: LT GRAY & BROWN, LITTLE CLAY, MOIST	100	SS4
	20				

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

1. WATER LEVEL:
   21.30 FT BELOW GROUND SURFACE; MEASUREMENT TAKEN 1/2 HR AFTER BOREHOLE COMPLETION INSIDE AUGERS
2. JAR SAMPLES
   - SS1 4.0' - 6.0'
   - SS2 9.0' - 10.5'
   - SS3 14.0' - 16.0'
   - SS4 19.0' - 20.5'
   - SS5 24.0' - 26.0'
   - SS6 29.0' - 30.5'
3. JAR SAMPLES (CHEMICAL SAMPLES)
   - SS1 4.0' - 6.0'
   - SS2 9.0' - 10.5'
   - SS3 14.0' - 16.0'
   - SS4 19.0' - 20.5'
4. JAR SAMPLES (PHYSICAL TESTING)
   - SS2 9.0' - 10.5'
   - SS5 24.0' - 26.0'
   - SS6 29.0 - 30.5'
5. DRILLING
   6 3/4" ID HSA
   0.0 TO 35.0'
   NOTE: SAMPLES COLLECTED WITH 3" x 18" & 3" x 24" SPLIT SPOON SAMPLERS

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT

HOLE NO.

007907

Hole No. AWD-3

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS
1. PROJECT	2379	10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station)	LONGHORN AAP	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	6 3/4" ID HSA
3. DRILLING AGENCY	CCI/ALLIANCE	12. MANUFACTURER'S DESIGNATION OF DRILL	FAILING F6
4. HOLE NO. (As shown on drawing title and file number)	AWD-3	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
5. NAME OF DRILLER	JOHN LODEN	14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE	☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER	
		16. DATE HOLE	STARTED 11/11/93 COMPLETED 11/11/93
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING	%
9. TOTAL DEPTH OF HOLE	35.0'	19. SIGNATURE OF INSPECTOR	

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
	20					6: NOTE: MONITORING WELL CONSTRUCTION INITIATED 11/11/93; 20-40 SILICA SAND & BENTONITE PELLETS EMPLACED 7. HEADSPACE RESULTS (PPM) SS1 <1 SS2 <1 SS3 9.2 SS4 5.5 SS5 9.2 SS6 31.4
					HSA	
	25		24.0' TO 26.0' SAND: BROWN, VERY FINE GRAINED, GRAY MOTTLES, LITTLE CLAY @ 26.0', SATURATED	100	SS5	
					HSA	
	30		29.0-30.5' SAND: BROWN & LT GRAY, VERY FINE TO FINE GRAINED, SATURATED	100	SS6	
					HSA	
	35		T.D. 35.0'			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. | PROJECT | HOLE NO.

HOLE NO. AWD-4

007908

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 2 SHEETS
1. PROJECT 2379		10. SIZE AND TYPE OF BIT 6 3/4 IN ID HSA	
2. LOCATION (Coordinates or Station) LONGHORN AAP		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY CCI/ALLIANCE		12. MANUFACTURER'S DESIGNATION OF DRILL MOBILE DRILL B61	
4. HOLE NO. (As shown on drawing title and file number)	AWD-4	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED 5
5. NAME OF DRILLER JOBY BARR		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE	STARTED 11-13-93 / COMPLETED 11-13-93
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING	%
9. TOTAL DEPTH OF HOLE 36 FT		19. SIGNATURE OF INSPECTOR	

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		TAN TO RED FINE SAND AND SILT; DRY			1. WATER LEVEL GROUNDWATER ENCOUNTERED AT ~16 FT DURING DRILLING 2. CHEMICAL SAMPLES SS-1 : 5-7 FT SS-2 : 10-12 FT
	5		5.0 MED. DENSE, TAN FINE SAND SOME SILT, TRACE RED CLAY LAYERS; DRY	50%	SS-1	SS-3 : 15-17 FT 3. PHYSICAL SAMPLES SS-1 : 5-7 FT SS-2 : 10-12 FT SS-3 : 15-17 FT SS-4 : 20-22 FT SS-5 : 30-32 FT
	10		10.0 LOOSE TO MED. DENSE, LT. GRAY FINE SAND, SOME SILT; MOIST	100%	SS-2	4. DRILLING Ø3 IN SHELBY TUBE SAMPLER TAKEN THROUGH 8 3/4 IN ID HSA EQUIPPED WITH PULL-OUT PLUG 5. PID HEADSPACE READINGS
▽ 16.5 FT 11/15/93	15		15.0 MED. DENSE, FINE SAND AND SILT; IRON STAINING BELOW 16.5 FT; SATURATED	100%	SS-3	SS-1 : 0 PPM SS-2 : 0 PPM SS-3 : 0 PPM SS-4 : 0 PPM SS-5 : 0 PPM
	20					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT 2379

HOLE NO. AWD-4

Hole No. AWD-4

DRILLING LOG	DIVISION	INSTALLATION
		SHEET 2 OF 2 SHEETS

1. PROJECT 2379
2. LOCATION (Coordinates or Station) LONGHORN AAP
3. DRILLING AGENCY CCI / ALLIANCE
4. HOLE NO. (As shown on drawing title and file number) AWD-4
5. NAME OF DRILLER JOBY BARR
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE 36 FT
10. SIZE AND TYPE OF BIT 5¾ in ID HSA
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL MOBILE DRILL B61
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED 5
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED 11-12-93 | COMPLETED 11-13-93
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

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
	20		STIFF TAN CLAY, LITTLE SILT, TRACE FINE SAND; SATURATED CEMENTED SILT LAYERS FROM 20.5 TO 20.7 FT.	100%	SS-4	
	25					
	30		30.0 30.5 STIFF GRAY CLAY, LITTLE SILT; IRON STAINED MOIST	100%	SS-5	
			SOFT TAN SILT, SOME SAND; IRON STAINED - SATURATED LITTLE GRAY CLAY BELOW 31.5 FT.			
	35		TOTAL DEPTH 36.0 FT			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT 2379

HOLE NO. AWD-4

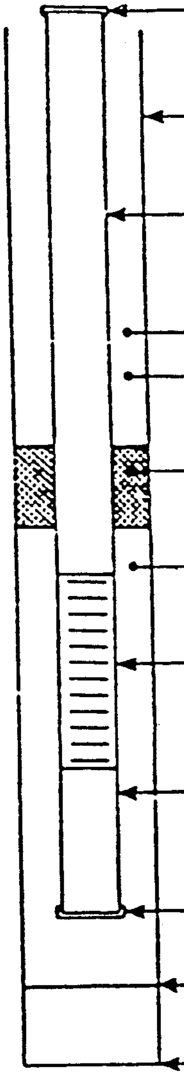
FIELD WELL COMPLETION FORM

JOB NAME: LHAAP 18 & 24

JOB NUMBER: 2379	PROJECT MANAGER: A. BouOnk
LOGGED BY: D MARTINCEK	EDITED BY:
WELL NAME: EW-1	DATE: 11/9/93

DRILLING COMPANY: CCI / ALLIANCE

EQUIPMENT: ☑ 8 1/4 INCH HOLLOW STEM AUGER ☐ ______ INCH ROTARY WASH	DRILLER: J LODEN HOURS DRILLED: 3 HRS.



TOP OF CASING AT 2.5 FEET ABOVE AT BELOW GROUND LEVEL

14 INCH DIAMETER BOREHOLE 0 to 38 feet

6 INCH DIAMETER BLANK CASING 0 to 15.5 feet

☑ BENTONITE-CEMENT SEAL OR
☐ 8-SACK CEMENT-SAND SEAL
3 to 10.8 feet

BENTONITE PELLET SEAL 10.8 to 13 feet

SILICA (NAME) 20-40 (NUMBER) SAND PACK 13 to ______ feet

6 INCH DIAMETER SLOTTED: 0.010" INCH SCREEN 15.5 to 35.5 feet

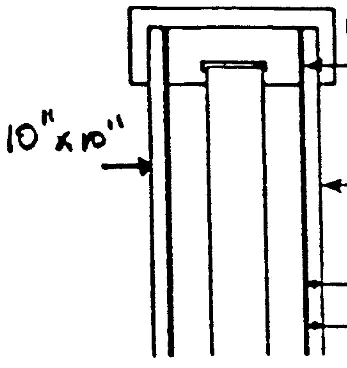
6 INCH DIAMETER BLANK SILT TRAP 35.5 to 37.5 feet

BOTTOM WELL CAP 37.5 feet

HOLE CLEANED OUT TO 38 feet

BOTTOM OF BOREHOLE 38 feet

NOT TO SCALE



☑ LOCKING STEEL COVER

______ INCH DIAMETER STEEL CONDUCTOR CASING ______ to ______ feet

______ INCH DIAMETER BOREHOLE ______ to ______ feet

☐ BENTONITE-CEMENT SEAL OR
☐ 8-SACK CEMENT-SAND SEAL
______ to ______ feet

NOT TO SCALE

ADDITIONAL INFORMATION:
4'x4'x6"
CONCRETE PAD
w/ GUARD
POSTS

AWD TECHNOLOGIES

FIELD WELL COMPLETION FORM

JOB NAME: Longhorn AAP 18;24

JOB NUMBER: 2379

PROJECT MANAGER: A. BouDak

LOGGED BY: DNM

EDITED BY:

WELL NAME: AWD-1

DATE: 11/12/93

DRILLING COMPANY: CCI / ALLIANCE

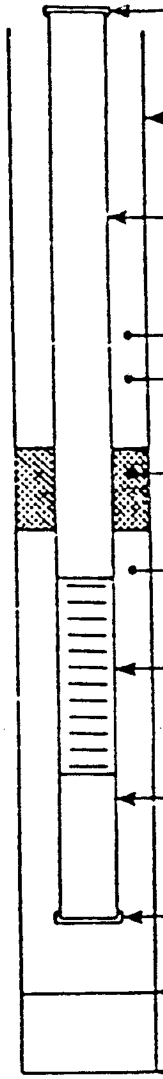
EQUIPMENT: ☒ 6 3/4 INCH HOLLOW STEM AUGER

☐ ____ INCH ROTARY WASH

DRILLER: J. BARR

HOURS DRILLED:

AWD-1



TOP OF CASING AT 2.5 FEET ABOVE AT BELOW GROUND LEVEL

10 INCH DIAMETER BOREHOLE 0 to 27 feet

4 INCH DIAMETER BLANK CASING 0 to 5 feet

☒ BENTONITE-CEMENT SEAL OR

☐ 8-SACK CEMENT-SAND SEAL

0 to 1 feet

BENTONITE PELLET SEAL 1 to 3 feet

Colorado Silica 20/40 (NAME) (NUMBER) SAND PACK 3 to 27 feet

4 INCH DIAMETER SLOTTED: 0.010" inch SCREEN 5 to 25 feet

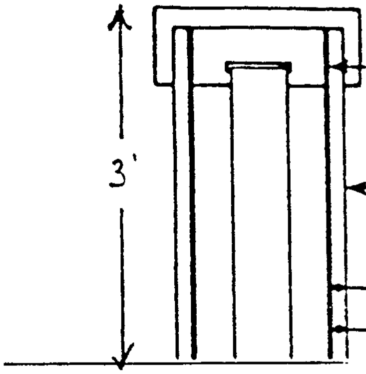
4 INCH DIAMETER BLANK SILT TRAP 25 to 27 feet

BOTTOM WELL CAP 27 feet

HOLE CLEANED OUT TO 27 feet

BOTTOM OF BOREHOLE 27 feet

NOT TO SCALE



NOT TO SCALE

☐ CHRISTY BOX

☐ LOCKING STEEL COVER

____ INCH DIAMETER STEEL CONDUCTOR CASING ____ to ____ feet

____ INCH DIAMETER BOREHOLE ____ to ____ feet

☐ BENTONITE-CEMENT SEAL OR

☐ 8-SACK CEMENT-SAND SEAL

____ to ____ feet

ADDITIONAL INFORMATION:

Soil Samples Collected with 3" x 24" Split Spoon Samplers

AWD TECHNOLOGIES

FIELD WELL COMPLETION FORM

JOB NAME: LONGHORN AAP 18 : 24

JOB NUMBER: 2379

PROJECT MANAGER: A. Bou Onk

LOGGED BY: DNM

EDITED BY:

WELL NAME: AWD-2

DATE: 11/10/93

DRILLING COMPANY: CCI / ALLIANCE

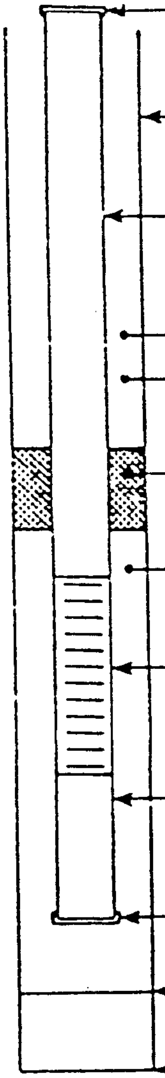
EQUIPMENT: ☑ 6 3/4" INCH HOLLOW STEM AUGER

☐ ______ INCH ROTARY WASH

DRILLER: J. LODEN

HOURS DRILLED: 1 1/2

AWD-2



TOP OF CASING AT 2.5 FEET ABOVE AT BELOW GROUND LEVEL

10 INCH DIAMETER BOREHOLE 0 to 28 feet

4 INCH DIAMETER BLANK CASING 0 to 5 feet

☑ BENTONITE-CEMENT SEAL OR

☐ 8-SACK CEMENT-SAND SEAL

1 to 2 feet

BENTONITE PELLET SEAL 2 to 3 feet

Colorado Silica 20/40 (NAME) (NUMBER) SAND PACK 3 to 28 feet

4 INCH DIAMETER SLOTTED : 0.010" inch SCREEN 5 to 25 feet

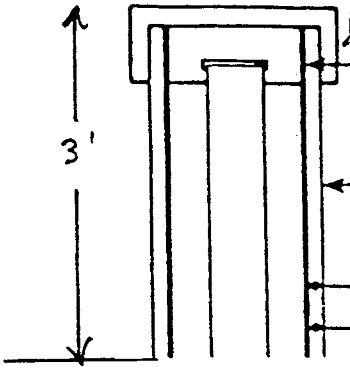
4 INCH DIAMETER BLANK SILT TRAP 25 to 27 feet

BOTTOM WELL CAP 27 feet

HOLE CLEANED OUT TO 28 feet

BOTTOM OF BOREHOLE 28 feet

NOT TO SCALE



☐ CHRISTY BOX

☒ LOCKING STEEL COVER

____ INCH DIAMETER STEEL CONDUCTOR CASING ____ to ____ feet

____ INCH DIAMETER BOREHOLE ____ to ____ feet

☐ BENTONITE-CEMENT SEAL OR

☐ 8-SACK CEMENT-SAND SEAL

____ to ____ feet

NOT TO SCALE

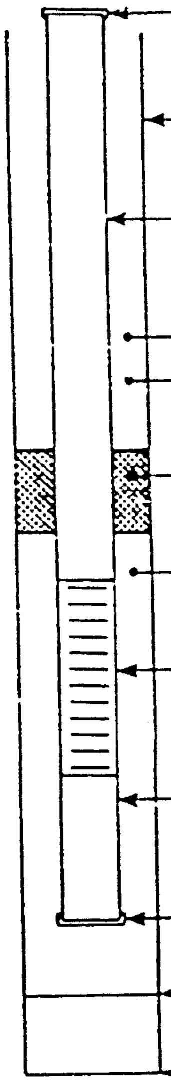
ADDITIONAL INFORMATION: Soil Samples Collected with 3" x 24" Split Spoon Samplers

AWD TECHNOLOGIES

FIELD WELL COMPLETION FORM

JOB NAME: Longhorn AAP 18:24
JOB NUMBER: 2379
PROJECT MANAGER: A BouDNK
LOGGED BY: DNM
EDITED BY:
WELL NAME: AWD-3
DATE: 11/11/93
DRILLING COMPANY: CCI / ALLIANCE
EQUIPMENT: ☑ 6 3/4" INCH HOLLOW STEM AUGER
☐ ______ INCH ROTARY WASH
DRILLER: J. Loden
HOURS DRILLED:

AWD-3



TOP OF CASING AT 2.5 FEET ABOVE AT BELOW GROUND LEVEL

10 INCH DIAMETER BOREHOLE
0 to 35 feet

4 INCH DIAMETER BLANK CASING
0 to 13 feet

☒ BENTONITE-CEMENT SEAL OR
☐ 8-SACK CEMENT-SAND SEAL
2 to 9 feet

BENTONITE PELLET SEAL
9 to 11 feet

Colorado Silica (NAME) 20/40 (NUMBER) SAND PACK
11 to 35 feet

4 INCH DIAMETER SLOTTED: 0.010" INCH SCREEN
13 to 33 feet

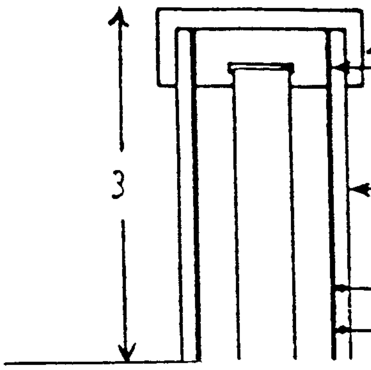
4 INCH DIAMETER BLANK SILT TRAP
33 to 35 feet

BOTTOM WELL CAP
35 feet

HOLE CLEANED OUT TO
35 feet

BOTTOM OF BOREHOLE
35 feet

NOT TO SCALE



NOT TO SCALE

☐ CHRISTY BOX
☒ LOCKING STEEL COVER

______ INCH DIAMETER STEEL CONDUCTOR CASING
______ to ______ feet

______ INCH DIAMETER BOREHOLE
______ to ______ feet

☐ BENTONITE-CEMENT SEAL OR
☐ 8-SACK CEMENT-SAND SEAL
______ to ______ feet

ADDITIONAL INFORMATION:
Soil Samples Collected
With 3" x 24"
Shelby Tubes

AWD
TECHNOLOGIES

007914

FIELD WELL COMPLETION FORM

JOB NAME: Longhorn AAP 18:24

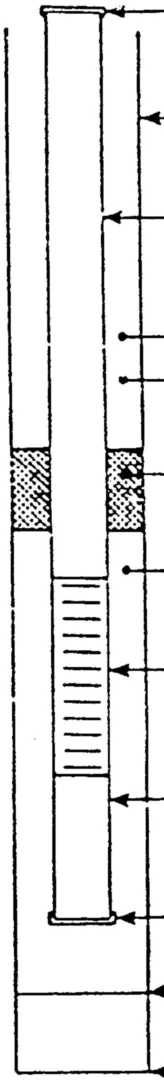
JOB NUMBER:	2379	PROJECT MANAGER:	A Bourdon
LOGGED BY:	K.D.	EDITED BY:	
WELL NAME:	AWD-4	DATE:	11/13/93

DRILLING COMPANY: CCI / ALLIANCE

EQUIPMENT: ☒ 8 3/4 INCH HOLLOW STEM AUGER — DRILLER: J. Barr

☐ ______ INCH ROTARY WASH — HOURS DRILLED: 1 1/2

AWD-4



TOP OF CASING AT 3.5 FEET ABOVE AT BELOW GROUND LEVEL

15 INCH DIAMETER BOREHOLE 0 to 35 feet

4 INCH DIAMETER BLANK CASING 0 to 13 feet

☒ BENTONITE-CEMENT SEAL OR

☐ 8 SACK CEMENT-SAND SEAL

0 to 9 feet

BENTONITE PELLET SEAL 9 to 11 feet

Colorado Silica (NAME) (NUMBER) 20/40

SAND PACK 11 to 35 feet

4 INCH DIAMETER SLOTTED : 0.010" inch SCREEN 13 to 33 feet

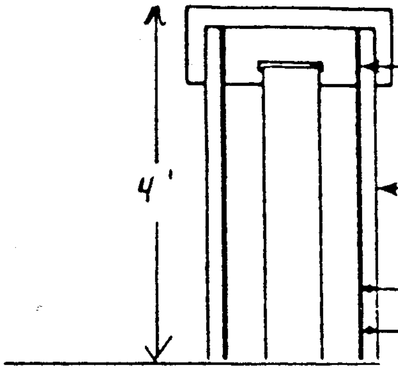
4 INCH DIAMETER BLANK SILT TRAP 33 to 35 feet

BOTTOM WELL CAP 35 feet

HOLE CLEANED OUT TO 35 feet

BOTTOM OF BOREHOLE 35 feet

NOT TO SCALE



NOT TO SCALE

☐ CHRISTY BOX

☒ LOCKING STEEL COVER

______ INCH DIAMETER STEEL CONDUCTOR CASING

______ to ______ feet

______ INCH DIAMETER BOREHOLE

______ to ______ feet

☐ BENTONITE-CEMENT SEAL OR

☐ 8 SACK CEMENT-SAND SEAL

______ to ______ feet

ADDITIONAL INFORMATION: Soil Samples Collected with 3" x 24" Shelby Tubes

AWD TECHNOLOGIES

007915

Send original copy by certified mail to: Texas Water Commission, P.O. Box 13087, Austin, Texas 78711 *Please use black ink.*

ATTENTION OWNER: *Confidentiality Privilege Notice on Reverse Side*

State of Texas WELL REPORT

EW # 1

Texas Water Well Drillers Board
P.O. Box 13087
Austin, Texas 78711

WNER LONGHORN ARMY AMMUNITION PLANT (Name) ADDRESS (Street or RFD) KARNACK TEXAS (City) (State) (Zip)

2) LOCATION OF WELL: County HARRISON , 15 miles in NE (NE, SW, etc.) direction from MARSHALL TEXAS (Town)

Driller must complete the legal description below with distance and direction from two intersecting section or survey lines, or he must locate and identify the well on an official Quarter- or Half-Scale Texas County General Highway Map and attach the map to this form.

☐ LEGAL DESCRIPTION:

Section No. ______ Block No. ______ Township ______ Abstract No. ______ Survey Name ______

Distance and direction from two intersecting section or survey lines ______

☒ SEE ATTACHED MAP

3) TYPE OF WORK (Check): ☒ New Well ☐ Deepening ☐ Reconditioning ☐ Plugging

4) PROPOSED USE (Check): ☐ Domestic ☐ Industrial ☐ Monitor ☐ Public Supply ☐ Irrigation ☐ Test Well ☐ Injection ☐ De-Watering

5) DRILLING METHOD (Check): ☐ Driven ☐ Mud Rotary ☐ Air Hammer ☐ Jetted ☐ Bored ☐ Air Rotary ☐ Cable Tool ☐ Other HSA

6) WELL LOG:

Date Drilling:
Started 11-9 19 93
Completed 11-9 19 93

DIAMETER OF HOLE

Dia. (in.)	From (ft.)	To (ft.)
12 1/4	Surface	37'

7) BOREHOLE COMPLETION:

☐ Open Hole ☐ Straight Wall ☐ Underreamed
☒ Gravel Packed ☐ Other ______

If Gravel Packed give interval . . . from 37 ft. to 13' ft.

From (ft.)	To (ft.)	Description and color of formation material
0'-5 REDISH ORANGE SI CLAY		
5'-23' BROWN AND GRAY SIH		
23'-28' BROWN AND GRAY FINE SAND		
28'-30' BROWN AND GRAY CLAY		
[illegible] GRAY V/ FINE SAND		
[illegible] BROWN AND GRAY CLAYEY SAND VERY FINE		

(Use reverse side if necessary)

8) CASING, BLANK PIPE, AND WELL SCREEN DATA:

Dia. (in.)	New or Used	Steel, Plastic, etc. Perf., Slotted, etc. Screen Mfg., if commercial	Setting (ft.) From	Setting (ft.) To	Gage Casting Screen
6"	NEW	STAINLESS STEEL (BK)	37'	35'	SUMP
6"	NEW	STAINLESS STEEL (BK)	35	15	.010 SCRE
6"	NEW	STAINLESS STEEL (BK)	15	+2 1/2'	SEH 40

9) CEMENTING DATA [Rule 287.44(1)]

Cemented from 11 ft. to 0 ft. No. of Sacks Used 5
______ ft. to ______ ft. No. of Sacks Used ______
Method used MOYNO PUMP SLRNY
Cemented by JOHN LODEN

13) TYPE PUMP: N/A
☐ Turbine ☐ Jet ☐ Submersible ☐ Cylinder
☐ Other ______
Depth to pump bowls, cylinder, jet, etc., ______ ft.

10) SURFACE COMPLETION
☒ Specified Surface Slab Installed [Rule 287.44(2)(A)]
☒ Specified Steel Sleeve Installed [Rule 287.44(3)(A)]
☐ Pitless Adapter Used [Rule 287.44(3)(B)]
☐ Approved Alternative Procedure Used [Rule 287.71]

14) WELL TESTS: N/A
Type Test: ☐ Pump ☐ Bailer ☐ Jetted ☐ Estimated
Yield: ______ gpm with ______ ft. drawdown after ______ hrs.

11) WATER LEVEL:
Static level 23 ft. below land surface Date 11-10-93
Artesian flow ______ gpm. Date ______

15) WATER QUALITY: NO
Did you knowingly penetrate any strata which contained undesirable constituents?
☒ Yes ☐ No If yes, submit "REPORT OF UNDESIRABLE WATER"
Type of water? ______ Depth of strata ______
Was a chemical analysis made? ☒ Yes ☒ No

12) PACKERS:

	Type	Depth
BENTONITE	PELLETS	13' to 11'

I hereby certify that this well was drilled by me (or under my supervision) and that each and all of the statements herein are true to the best of my knowledge and belief. I understand that failure to complete items 1 thru 15 will result in the log(s) being returned for completion and resubmittal.

COMPANY NAME OCI/ALLIANCE ENVIRONMENTAL (Type or print) WELL DRILLER'S LICENSE NO. TX 3213 DMN

2032 KARBACH (Street or RFD) HOUSTON (City) TEXAS (State) 77092 (Zip)

(Signed) John Loden (Licensed Well Driller) (Signed) ______ (Registered Driller Trainee)

Please attach electric log, chemical analysis, and other pertinent information, if available.

For TWC use only: Well No. ______ Located on map ______

TWC-0199 (Rev. 05-18-90)

TEXAS WATER COMMISSION COPY

007916

State of Texas

REPORT OF UNDESIRABLE WATER

I. To be completed by well driller. (Type or Print)

1. Well Driller: John D. Loden Jr.

Company Name: CCI Alliance

Address: 2032 Karbach (Street or RFD) Houston (City) Tx (State)

2. Landowner or Person Having Well Drilled: Longhorn Army Ammunition Plant

Address: (Street or RFD) Karnach (City) Texas (State)

3. Location of Well: County Harrison Labor

League Abstract No.

NW¼, NE¼, SW¼, SE¼, of Section Block

Survey

1 miles in East (NE, SW, etc.) direction.

from Karnach (Town)

4. Reason why Report of Undesirable Water was submitted:

- ☐ Naturally-occurring, poor-quality groundwater encountered;
- ☐ Hydrocarbon contamination encountered (includes gasoline, diesel, etc.,);
- ☒ Hazardous material/hazardous waste contamination encountered;
- ☐ Other; describe

5. Date Well Drilled: 11-9-93 Type Well: Extraction Well EW# 1

6. Has a Well Report form relating to this well been forwarded to the Texas Water Commission?

Yes X No Date 12-10-93

7. I do hereby certify that in drilling, deepening, or otherwise altering the above described well, water injurious to vegetation, to land, or to fresh water has been encountered and the landowner or person having the well drilled has been informed that such well must be completed or plugged in such a manner as to avoid injury or pollution.

Date: 11-23-93

Reg. No. (Signed) John Loden MS (Well Driller)

II. To be completed by landowner or person having well drilled. N/A

1. I do hereby certify that I have been informed that the above described well encountered water injurious to vegetation, to land or to fresh water and that the well ~~must be completed~~ or plugged in such a manner as to avoid injury or pollution.

Date (Signed) (Landowner or person having well drilled)

Send Original Copy by Certified Mail to the: TEXAS WATER COMMISSION, P.O. Box 13087, Austin, Texas 78711

WWD-015

007917

Send original copy by certified mail to: Texas Water Commission, P.O. Box 13087, Austin, Texas 78711

Please use black ink.

ATTENTION OWNER: *Confidentiality Privilege Notice on Reverse Side*

State of Texas
WELL REPORT

Texas Water Well Drillers Board
P.O. Box 13087
Austin, Texas 78711

AWD #1

WNER Chaap (Name) ADDRESS Hwy 43 (Street or RFD) Karaak (City) Tx (State) (Zip)

2) LOCATION OF WELL: County Harrison , 2 miles in E (NE, SW, etc.) direction from Karaak (Town)

Driller must complete the legal description below with distance and direction from two intersecting section or survey lines, or he must locate and identify the well on an official Quarter- or Half-Scale Texas County General Highway Map and attach the map to this form.

☐ LEGAL DESCRIPTION:

Section No. ______ Block No. ______ Township ______ Abstract No. ______ Survey Name ______

Distance and direction from two intersecting section or survey lines ______

☒ SEE ATTACHED MAP

3) TYPE OF WORK (Check): ☒ New Well ☐ Deepening ☐ Reconditioning ☐ Plugging

4) PROPOSED USE (Check): ☐ Domestic ☐ Industrial ☒ Monitor ☐ Public Supply ☐ Irrigation ☐ Test Well ☐ Injection ☐ De-Watering

5) DRILLING METHOD (Check): ☐ Driven ☐ Mud Rotary ☐ Air Hammer ☐ Jetted ☐ Bored ☐ Air Rotary ☐ Cable Tool ☒ Other HSA

6) WELL LOG:

Date Drilling: Started Nov 19 19 93

Completed ______ 19 __

DIAMETER OF HOLE

Dia. (in.)	From (ft.)	To (ft.)
12	Surface	27

7) BOREHOLE COMPLETION: ☐ Open Hole ☐ Straight Wall ☐ Underreamed ☒ Gravel Packed ☐ Other ______

If Gravel Packed give interval . . . from 27 ft. to 5 ft.

From (ft.)	To (ft.)	Description and color of formation material
0	10	Tan Lite Tan Silty Clay
10	27	Tan Lite Tan Clay Sand

(Use reverse side if necessary)

8) CASING, BLANK PIPE, AND WELL SCREEN DATA:

Dia. (in.)	New or Used	Steel, Plastic, etc. Perf., Slotted, etc. Screen Mfg., if commercial	Setting (ft.) From	Setting (ft.) To	Gage Casting Screen
4	N	Steel	27	7	.010
4	N	Steel	7	0	40

9) CEMENTING DATA [Rule 287.44(1)]

Cemented from 3 ft. to 0 ft. No. of Sacks Used 1

______ ft. to ______ ft. No. of Sacks Used ______

Method used hand mix

Cemented by OCi

10) SURFACE COMPLETION

☒ Specified Surface Slab Installed [Rule 287.44(2)(A)]

☐ Specified Steel Sleeve Installed [Rule 287.44(3)(A)]

☐ Pitless Adapter Used [Rule 287.44(3)(B)]

☐ Approved Alternative Procedure Used [Rule 287.71]

11) WATER LEVEL:

Static level ______ ft. below land surface Date ______

Artesian flow ______ gpm. Date ______

12) PACKERS: Bentonite Type Pellets Depth 5-3

13) TYPE PUMP: ☐ Turbine ☐ Jet ☐ Submersible ☐ Cylinder ☐ Other ______

Depth to pump bowls, cylinder, jet, etc., ______ ft.

14) WELL TESTS: Type Test: ☐ Pump ☐ Bailer ☐ Jetted ☐ Estimated

Yield: ______ gpm with ______ ft. drawdown after ______ hrs.

15) WATER QUALITY:

Did you knowingly penetrate any strata which contained undesirable constituents?

☐ Yes ☒ No If yes, submit "REPORT OF UNDESIRABLE WATER"

Type of water? ______ Depth of strata ______

Was a chemical analysis made? ☐ Yes ☐ No

I hereby certify that this well was drilled by me (or under my supervision) and that each and all of the statements herein are true to the best of my knowledge and belief. I understand that failure to complete items 1 thru 15 will result in the log(s) being returned for completion and resubmittal.

COMPANY NAME OCI Alliance (Type or print) WELL DRILLER'S LICENSE NO. 3182 DMJ

15289 Addison Rd. (Street or RFD) Dalls (City) Tx (State) 17248 (Zip)

(Signed) ______ (Licensed Well Driller) (Signed) ______ (Registered Driller Trainee)

Please attach electric log, chemical analysis, and other pertinent information, if available.

For TWC use only: Well No. ______ Located on map ______

TWC-0199 (Rev. 05-18-90)

TEXAS WATER COMMISSION COPY

007918

Send original copy by certified mail to: Texas Water Commission, P.O. Box 13087, Austin, Texas 78711

Please use black ink.

ATTENTION OWNER: *Confidentiality Privilege Notice on Reverse Side*

State of Texas
WELL REPORT

AWD #2

Texas Water Well Drillers Board
P.O. Box 13087
Austin, Texas 78711

NER Longhorn Army Ammunition Plant (Name) ADDRESS Karback (Street or RFD) (City) Tx (State) (Zip)

2) LOCATION OF WELL:
County Harrison , 15 miles in NE (NE, SW, etc.) direction from Marshall (Town)

Driller must complete the legal description below with distance and direction from two intersecting section or survey lines, or he must locate and identify the well on an official Quarter- or Half-Scale Texas County General Highway Map and attach the map to this form.

☐ LEGAL DESCRIPTION:
Section No. ______ Block No. ______ Township ______ Abstract No. ______ Survey Name ______
Distance and direction from two intersecting section or survey lines ______

☒ SEE ATTACHED MAP

3) TYPE OF WORK (Check):
☒ New Well ☐ Deepening
☐ Reconditioning ☐ Plugging

4) PROPOSED USE (Check):
☐ Domestic ☐ Industrial ☒ Monitor ☐ Public Supply
☐ Irrigation ☐ Test Well ☐ Injection ☐ De-Watering

5) DRILLING METHOD (Check):
☐ Driven
☐ Mud Rotary ☐ Air Hammer ☐ Jetted ☐ Bored
☐ Air Rotary ☐ Cable Tool ☐ Other HSA

6) WELL LOG:
Date Drilling:
Started 11-10 1993
Completed 11-10 1993

DIAMETER OF HOLE

Dia. (in.)	From (ft.)	To (ft.)
10 1/4	Surface	27

7) BOREHOLE COMPLETION:
☐ Open Hole ☐ Straight Wall ☐ Underreamed
☒ Gravel Packed ☐ Other ______
If Gravel Packed give interval . . . from 27' ft. to 3' ft.

From (ft.) To (ft.)	Description and color of formation material
0'-5'	Brown and Orange Clayey Silt
5'-18'	Sand Lt.Gray Fine
18'-28'	Brwon and Gray Very Fine Clayey Sand

(Use reverse side if necessary)

8) CASING, BLANK PIPE, AND WELL SCREEN DATA:

Dia. (in.)	New or Used	Steel, Plastic, etc. Perf., Slotted, etc. Screen Mfg., if commercial	Setting (ft.) From	Setting (ft.) To	Gage Casting Screen
4	New	Stainless Steel Riser	5'	2 1/2	Sch40
4	New	Stainless Steel Screen	25'	5'	.010
4	New	Stainless Steel Sump	27'	25'	Sch40

9) CEMENTING DATA [Rule 287.44(1)]
Cemented from 1 ft. to -0 ft. No. of Sacks Used 1/2
Bent. Pellets 0 ft. to 3 ft. No. of Sacks Used 1/4
Method used Sufrace Pour
Cemented by John Loden

10) SURFACE COMPLETION
☒ Specified Surface Slab Installed [Rule 287.44(2)(A)]
☒ Specified Steel Sleeve Installed [Rule 287.44(3)(A)]
☐ Pitless Adapter Used [Rule 287.44(3)(B)]
☐ Approved Alternative Procedure Used [Rule 287.71]

11) WATER LEVEL: N/A
Static level ______ ft. below land surface Date ______
Artesian flow ______ gpm. Date ______

12) PACKERS: Type Depth
Bentonite Pellets 3' to 1'

13) TYPE PUMP: N/A
☐ Turbine ☐ Jet ☐ Submersible ☐ Cylinder
☐ Other ______
Depth to pump bowls, cylinder, jet, etc., ______ ft.

14) WELL TESTS: N/A
Type Test: ☐ Pump ☐ Bailer ☐ Jetted ☐ Estimated
Yield: ______ gpm with ______ ft. drawdown after ______ hrs.

15) WATER QUALITY:
Did you knowingly penetrate any strata which contained undesirable constituents?
☒ Yes ☐ No If yes, submit "REPORT OF UNDESIRABLE WATER"
Type of water? ______ Depth of strata ______
Was a chemical analysis made? ☐ Yes ☐ No

hereby certify that this well was drilled by me (or under my supervision) and that each and all of the statements herein are true to the best of my knowledge and belief. I understand hat failure to complete items 1 thru 15 will result in the log(s) being returned for completion and resubmittal.

COMPANY NAME OCI Alliance Environmental (Type or print) WELL DRILLER'S LICENSE NO. Tx 3213 DMN

2032 Karbach (Street or RFD) Houston (City) Tx (State) 77092 (Zip)

Signed) John Loden By MS (Licensed Well Driller) (Signed) ______ (Registered Driller Trainee)

lease attach electric log, chemical analysis, and other pertinent information, if available.

For TWC use only: Well No. ______ Located on map ______

WC-0199 (Rev. 05-18-90)

State of Texas

REPORT OF UNDESIRABLE WATER

I. To be completed by well driller. (Type or Print)

1. Well Driller: John D. Loden Jr.

Company Name: OCI Alliance

Address: 2032 Karbach (Street or RFD) Houston (City) Tx (State)

2. Landowner or Person Having Well Drilled: Longhorn Army Ammunition Plant

Address: (Street or RFD) Karnach (City) Tx (State)

3. Location of Well: County Harrison Labor

League Abstract No.

NW¼, NE¼, SW¼, SE¼, of Section Block

Survey

1 miles in East (NE, SW, etc.) direction.

from Karnach (Town)

4. Reason why Report of Undesirable Water was submitted:

☐ Naturally-occurring, poor-quality groundwater encountered;

☐ Hydrocarbon contamination encountered (includes gasoline, diesel, etc.,);

☒ Hazardous material/hazardous waste contamination encountered;

☐ Other; describe

5. Date Well Drilled: 11-10-93 Type Well: Monitor AWD #2

6. Has a Well Report form relating to this well been forwarded to the Texas Water Commission?

Yes X No Date 12 05 93

7. I do hereby certify that in drilling, deepening, or otherwise altering the above described well, water injurious to vegetation, to land, or to fresh water has been encountered and the landowner or person having the well drilled has been informed that such well must be completed or plugged in such a manner as to avoid injury or pollution.

Date: 11-23-93

Reg. No. (Signed) (Well Driller)

II. To be completed by landowner or person having well drilled. N/A

1. I do hereby certify that I have been informed that the above described well encountered water injurious to vegetation, to land or to fresh water and that the well must be completed or plugged in such a manner as to avoid injury or pollution.

Date (Signed) (Landowner or person having well drilled)

Send Original Copy by Certified Mail to the: TEXAS WATER COMMISSION, P.O. Box 13087, Austin, Texas 78711

WWD-015

007920

Send original copy by certified mail to: Texas Water Commission, P.O. Box 13087, Austin, Texas 78711

Please use black ink.

ATTENTION OWNER: *Confidentiality Privilege Notice on Reverse Side*

State of Texas
WELL REPORT

AWD #3

Texas Water Well Drillers Board
P.O. Box 13087
Austin, Texas 78711

IER Longhorn Army Ammunition Plant (Name) **ADDRESS** (Street or RFD) Karnack (City) Tx (State) (Zip)

2) **LOCATION OF WELL:** County Harrison , 15 miles in NE (NE, SW, etc.) direction from Marshall Tx (Town)

Driller must complete the legal description below with distance and direction from two intersecting section or survey lines, or he must locate and identify the well on an official Quarter- or Half-Scale Texas County General Highway Map and attach the map to this form.

☐ **LEGAL DESCRIPTION:**

Section No. ______ Block No. ______ Township ______ Abstract No. ______ Survey Name ______

Distance and direction from two intersecting section or survey lines ______

☒ **SEE ATTACHED MAP**

3) **TYPE OF WORK (Check):** ☒ New Well ☐ Deepening ☐ Reconditioning ☐ Plugging

4) **PROPOSED USE (Check):** ☐ Domestic ☐ Industrial ☒ Monitor ☐ Public Supply ☐ Irrigation ☐ Test Well ☐ Injection ☐ De-Watering

5) **DRILLING METHOD (Check):** ☐ Driven ☐ Mud Rotary ☐ Air Hammer ☐ Jetted ☐ Bored ☐ Air Rotary ☐ Cable Tool ☐ Other HSA

6) **WELL LOG:**

Date Drilling:
Started 11-11 19 93
Completed 11-11 19 93

DIAMETER OF HOLE

Dia. (in.)	From (ft.)	To (ft.)
10 1/4"	Surface	35'

7) **BOREHOLE COMPLETION:**

☐ Open Hole ☐ Straight Wall ☐ Underreamed
☐ Gravel Packed ☐ Other ______
If Gravel Packed give interval . . . from 35' ft. to 11' ft.

From (ft.)	To (ft.)	Description and color of formation material
0'-5' Brown & Orange Sil Clay		
5'-24' Brown & Gray Silty Clay to Clayey Silt		
24'-35' Brwon Very Fine Sand Slightly Clayey		

(Use reverse side if necessary)

8) **CASING, BLANK PIPE, AND WELL SCREEN DATA:**

Dia. (in.)	New or Used	Steel, Plastic, etc. Perf., Slotted, etc. Screen Mfg., if commercial	Setting (ft.)		Gage Casting Screen
			From	To	
4"	N	Stainless BK	+3	13'	Sch. 40
4"	N	Stainless BK Screen	13	33'	.010
4"	N	Stainless BK Sump	33'	35	Sch. 40

9) **CEMENTING DATA** [Rule 287.44(1)]

Cemented from 9 ft. to 0 ft. No. of Sacks Used 4
______ ft. to ______ ft. No. of Sacks Used ______
Method used Moyno Pump Slurry
Cemented by John Loden

13) **TYPE PUMP:** N/A

☐ Turbine ☐ Jet ☐ Submersible ☐ Cylinder
☐ Other ______
Depth to pump bowls, cylinder, jet, etc., ______ ft.

10) **SURFACE COMPLETION**

☒ Specified Surface Slab Installed [Rule 287.44(2)(A)]
☒ Specified Steel Sleeve Installed [Rule 287.44(3)(A)]
☐ Pitless Adapter Used [Rule 287.44(3)(B)]
☐ Approved Alternative Procedure Used [Rule 287.71]

14) **WELL TESTS:** N/A

Type Test: ☐ Pump ☐ Bailer ☐ Jetted ☐ Estimated
Yield: ______ gpm with ______ ft. drawdown after ______ hrs.

11) **WATER LEVEL:**

Static level ______ ft. below land surface Date ______
Artesian flow ______ gpm. Date ______

15) **WATER QUALITY:**

Did you knowingly penetrate any strata which contained undesirable constituents?

☒ Yes ☐ No If yes, submit "REPORT OF UNDESIRABLE WATER"
Type of water? ______ Depth of strata ______
Was a chemical analysis made? ☐ Yes ☐ No

12) **PACKERS:**

	Type	Depth
Bentonite	Pellets	11' to 9'

ereby certify that this well was drilled by me (or under my supervision) and that each and all of the statements herein are true to the best of my knowledge and belief. I understand at failure to complete items 1 thru 15 will result in the log(s) being returned for completion and resubmittal.

OMPANY NAME OCI Alliance Environmental (Type or print) **WELL DRILLER'S LICENSE NO.** Tx 3213 MN

2032 Karbach (Street or RFD) Houston (City) Tx (State) 77092 (Zip)

Signed) John Loden MD (Licensed Well Driller) (Signed) ______ (Registered Driller Trainee)

ease attach electric log, chemical analysis, and other pertinent information, if available.

For TWC use only: Well No. ______ Located on map ______

C-0199 (Rev. 05-15-87)

007921

State of Texas

REPORT OF
UNDESIRABLE WATER

I. To be completed by well driller. (Type or Print)

1. Well Driller: John D. Loden Jr.

Company Name: CCI Alliance

Address: 2032 Karbach (Street or RFD) Houston (City) Tx (State)

2. Landowner or Person Having Well Drilled: Longhorn Army Ammunition Plant

Address: (Street or RFD) Karnach (City) Tx (State)

3. Location of Well: County Harrison Labor

League Abstract No.

NW¼, NE¼, SW¼, SE¼, of Section Block

Survey

1 miles in East (NE, SW, etc.) direction.

from Karnack (Town)

4. Reason why Report of Undesirable Water was submitted:

☐ Naturally-occurring, poor-quality groundwater encountered;
☐ Hydrocarbon contamination encountered (includes gasoline, diesel, etc.,);
☒ Hazardous material/hazardous waste contamination encountered;
☐ Other; describe

5. Date Well Drilled: 11-11-93 Type Well: Monitor AWD #3

6. Has a Well Report form relating to this well been forwarded to the Texas Water Commission?

Yes X No Date 12.15.93

7. I do hereby certify that in drilling, deepening, or otherwise altering the above described well, water injurious to vegetation, to land, or to fresh water has been encountered and the landowner or person having the well drilled has been informed that such well must be completed or plugged in such a manner as to avoid injury or pollution.

Date: 11-23-93

Reg. No. (Signed) John Loden (Well Driller)

II. To be completed by landowner or person having well drilled.

1. I do hereby certify that I have been informed that the above described well encountered water injurious to vegetation, to land or to fresh water and that the well must be completed or plugged in such a manner as to avoid injury or pollution.

Date (Signed) (Landowner or person having well drilled)

Send Original Copy by Certified Mail to the: TEXAS WATER COMMISSION, P.O. Box 13087, Austin, Texas 78711

WWD-015

007922

Send original copy by certified mail to: Texas Water Commission, P.O. Box 13087, Austin, Texas 78711

Please use black ink.

ATTENTION OWNER: *Confidentiality Privilege Notice on Reverse Side*

State of Texas WELL REPORT

AWD #4

Texas Water Well Drillers Board
P.O. Box 13087
Austin, Texas 78711

VNER Chaap (Name) ADDRESS Hwy 43 (Street or RFD) Karaak (City) Tx (State) (Zip)

2) LOCATION OF WELL:
County Harrison , 2 miles in E (NE, SW, etc.) direction from Karaak (Town)

Driller must complete the legal description below with distance and direction from two intersecting section or survey lines, or he must locate and identify the well on an official Quarter- or Half-Scale Texas County General Highway Map and attach the map to this form.

☐ LEGAL DESCRIPTION:
Section No. ______ Block No. ______ Township ______ Abstract No. ______ Survey Name ______
Distance and direction from two intersecting section or survey lines ______
☒ SEE ATTACHED MAP

3) TYPE OF WORK (Check): ☒ New Well ☐ Deepening ☐ Reconditioning ☐ Plugging

4) PROPOSED USE (Check): ☐ Domestic ☐ Industrial ☒ Monitor ☐ Public Supply ☐ Irrigation ☐ Test Well ☐ Injection ☐ De-Watering

5) DRILLING METHOD (Check): ☐ Driven ☐ Mud Rotary ☐ Air Hammer ☐ Jetted ☐ Bored ☐ Air Rotary ☐ Cable Tool ☒ Other HSA

6) WELL LOG:
Date Drilling:
Started Nov 19 19 93
Completed ______ 19 __

DIAMETER OF HOLE

Dia. (in.)	From (ft.)	To (ft.)
12	Surface	35

7) BOREHOLE COMPLETION:
☐ Open Hole ☐ Straight Wall ☐ Underreamed
☒ Gravel Packed ☐ Other ______
If Gravel Packed give interval ... from 35 ft. to 13 ft.

From (ft.)	To (ft.)	Description and color of formation material
0	12	Tan Lite Tan Silty Clay
12	35	Tan Lite Tan Clay

(Use reverse side if necessary)

8) CASING, BLANK PIPE, AND WELL SCREEN DATA:

Dia. (in.)	New or Used	Steel, Plastic, etc. Perf., Slotted, etc. Screen Mfg., if commercial	Setting (ft.) From	Setting (ft.) To	Gage Casting Screen
4	N	Steel	35	15	.010
4	N	Steel	15		40

9) CEMENTING DATA [Rule 287.44(1)]
Cemented from 11 ft. to 0 ft. No. of Sacks Used 5
______ ft. to ______ ft. No. of Sacks Used ______
Method used tremmie
Cemented by CCI

13) TYPE PUMP:
☐ Turbine ☐ Jet ☐ Submersible ☐ Cylinder
☐ Other ______
Depth to pump bowls, cylinder, jet, etc., ______ ft.

10) SURFACE COMPLETION
☒ Specified Surface Slab Installed [Rule 287.44(2)(A)]
☐ Specified Steel Sleeve Installed [Rule 287.44(3)(A)]
☐ Pitless Adapter Used [Rule 287.44(3)(B)]
☐ Approved Alternative Procedure Used [Rule 287.71]

14) WELL TESTS:
Type Test: ☐ Pump ☐ Bailer ☐ Jetted ☐ Estimated
Yield: ______ gpm with ______ ft. drawdown after ______ hrs.

11) WATER LEVEL:
Static level ______ ft. below land surface Date ______
Artesian flow ______ gpm. Date ______

15) WATER QUALITY:
Did you knowingly penetrate any strata which contained undesirable constituents?
☐ Yes ☒ No If yes, submit "REPORT OF UNDESIRABLE WATER"
Type of water? ______ Depth of strata ______
Was a chemical analysis made? ☐ Yes ☐ No

12) PACKERS: Bentonite Type Pellets Depth 13-11

I hereby certify that this well was drilled by me (or under my supervision) and that each and all of the statements herein are true to the best of my knowledge and belief. I understand that failure to complete items 1 thru 15 will result in the log(s) being returned for completion and resubmittal.

COMPANY NAME CCI Alliance (Type or print) WELL DRILLER'S LICENSE NO. 3182 DMI

15289 Addison Rd. (Street or RFD) Dallas (City) Tx (State) 17248 (Zip)

(Signed) ______ (Licensed Well Driller) (Signed) ______ (Registered Driller Trainee)

Please attach electric log, chemical analysis, and other pertinent information, if available.

For TWC use only: Well No. ______ Located on map ______

TWC-0199 (Rev. 05-18-90)

TEXAS WATER COMMISSION COPY

SB01

DRILLING LOG

2379

LONGHORN AAP

CCI / ALLIANCE

SB01

JOHN LODEN

16.0'

4 1/4" ID HSA

FAILING F6

4

11/12/93 | 11/12/93

0		0.0 TO 4.0' SILT & CLAY: BRIGHT ORANGE-BROWN, DAMP		HSA	1. JAR SAMPLES SS1 4.0' - 6.0' SS2 7.5' - 9.5' SS3 9.5' - 11.5' SS4 14.0' - 16.0'
5		4.0' TO 6.0' SILT: BROWN, LT GRAY MOTTLES, LITTLE TO SOME CLAY, TRACE FINE SAND, DAMP	75	SS1	2. JAR SAMPLES (CHEMICAL) SS1 4.0' - 6.0' SS3 9.5' - 11.5' SS4 14.0' - 16.0'
				HSA	
		7.5' TO 9.5' SILT & CLAY: BROWN & GRAY, LITTLE FINE SAND, DAMP	79	SS2	3. JAR SAMPLES (TREATABILITY) SS2 7.5' - 9.5'
10		9.5' TO 11.5' SILT: BROWN & GRAY SOME FINE SAND, LITTLE CLAY, DAMP TO MOIST	88	SS3	4. DRILLING 4 1/4" ID HSA 0.0' - 16.0' NOTE: SAMPLES COLLECTED WITH THIN-WALLED SHELBY TUBE SAMPLERS (3" X 30")
				HSA	
15		14.0' TO 16.0' SAND: BROWN, LITTLE LT GRAY, VERY FINE GRAINED, TRACE CLAY, MOIST	92	SS4	5. HEADSPACE RESULTS (ppm) SS1 7.6 SS2 7.6 SS3 7.6 SS4 15.3
16		T.D. - 16.0'			
20					

ENG FORM 1836

SB01

HOLE NO. SB02

DRILLING LOG	DIVISION
INSTALLATION	SHEET OF SHEETS
1. PROJECT: 2379	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station): LONGHORN AAP	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): 4¼" ID HSA
3. DRILLING AGENCY: CCI / ALLIANCE	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number): SB02	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN — DISTURBED: — UNDISTURBED: 4
5. NAME OF DRILLER: JOHN LODEN	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE: VERTICAL INCLINED DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED: 11/12/93 — COMPLETED: 11/12/93
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING
9. TOTAL DEPTH OF HOLE: 17.0'	19. SIGNATURE OF INSPECTOR

ELEVATION	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	% CORE RECOVERY	BOX OR SAMPLE NO.
	0		0.0-4.0' SILT & CLAY: ORANGE-BROWN, MOIST		
			4.0'-6.0' SILT: BROWN-GRAY, LT GRAY, SOME CLAY, MOIST	67	SS1
	5				
			9.0' TO 11.0' SILT: BROWN, LT GRAY, IRON-STAINED, SOME FINE SAND, TRACE TO LITTLE CLAY, BLACK ORGANIC STAINING, MOIST	96	SS2
	10				
			12.5' TO 15.0' SAND: BROWN, DARK ORANGE-BROWN, FINE GRAINED, LITTLE CLAY, MOIST	60	SS3
	15		15.0' TO 17.0' SAND: DARK BROWN, BROWN, FINE TO MEDIUM GRAINED, MINOR SEAMS OF VERY FINE SAND & SILT, DAMP	50	SS4
	17		T.D. – 17.0'		
	20				

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

1. JAR SAMPLES

SS1	4.0 – 6.0'
SS2	9.0 – 11.0'
SS3	12.5 – 15.0'
SS4	15.0' – 17.0'

2. JAR SAMPLES (CHEMICAL)

SS1	4.0' – 6.0'
SS2	9.0 – 11.0'
SS4	15.0 – 17.0'

3. JAR SAMPLES (TREATABILITY)

SS3 12.5 – 15.0'

4. DRILLING

4¼" ID HSA
0.0 – 17.0'

NOTE: SAMPLES COLLECTED WITH THIN-WALLED SHELBY TUBE SAMPLER (3" x 30")

5. HEADSPACE RESULTS (ppm)

SS1	230
SS2	61
SS3	<7.6
SS4	<7.6

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO. SB02

DRILLING LOG

HOLE NO. SB03

1. PROJECT 2379	10. SIZE AND TYPE OF BIT 4 1/4" ID HSA
2. LOCATION LONGHORN AAP	11. DATUM FOR ELEVATION SHOWN
3. DRILLING AGENCY CCI / ALLIANCE	12. MANUFACTURER'S DESIGNATION OF DRILL FAILING F6
4. HOLE NO. SB03	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN
5. NAME OF DRILLER JOHN LODEN	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE STARTED 11/13/93 COMPLETED 11/13/93
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE 16.0'	18. TOTAL CORE RECOVERY FOR BORING
	19. SIGNATURE OF INSPECTOR

DEPTH	CLASSIFICATION OF MATERIALS	% CORE RECOVERY	BOX OR SAMPLE NO.
0	0.0 - 4.0' SILT & CLAY: ORANGE-BROWN		HSA
4.0-6.0	4.0' TO 6.0' SILT: LT GRAY, IRON STAINED, LITTLE CLAY, MOIST	83	SS1
6.0-7.5			HSA
7.5-9.5	7.5' TO 9.5' SAND: GRAY-BROWN, IRON STAINED, VERY FINE GRAINED, TRACE CLAY, MOIST	92	SS2
9.5-11.5	9.5' TO 11.5' SILT: BROWN & GRAY, LITTLE CLAY & VERY FINE SAND, MOIST	79	SS3
11.5-14.0			HSA
14.0-16.0	14.0' TO 16.0' SILT & SAND: LT GRAY & BROWN, IRON STAINING, TRACE CLAY, MOIST	83	SS4
16	T.D. 16.0 FEET		

REMARKS

1. JAR SAMPLES
   - SS1 4.0' - 6.0'
   - SS2 7.5' - 9.5'
   - SS3 9.5' - 11.5'
   - SS4 14.0' - 16.0'
2. JAR SAMPLES (CHEMICAL)
   - SS1 4.0' - 6.0'
   - SS3 9.5' - 11.5'
   - SS4 14.0' - 16.0'
3. JAR SAMPLES (TREATABILITY)
   - SS2 7.5 - 9.5'
4. JAR SAMPLES (PHYSICAL)
   - SS1 4.0' - 6.0'
   - SS2 7.5' - 9.5'
   - SS3 9.5' - 11.5'
   - SS4 14.0' - 16.0'
5. DRILLING
   4 1/4" ID HSA
   0.0' TO 16.0'
   NOTE: SAMPLES COLLECTED WITH THIN-WALLED SHELBY TUBE SAMPLER (3" x 30")
6. HEADSPACE RESULTS (ppm)

SS1	<1
SS2	<1
SS3	<1
SS4	12.5

HOLE NO. SB04

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF SHEETS
1. PROJECT 2379		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station) LONGHORN AAP		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) 4¼" ID HSA	
3. DRILLING AGENCY CCI/ALLIANCE		12. MANUFACTURER'S DESIGNATION OF DRILL FALLING F6	
4. HOLE NO. (As shown on drawing title and file number)	SB04	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED: UNDISTURBED: 5
5. NAME OF DRILLER JOHN LODEN		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
7. THICKNESS OF OVERBURDEN		16. DATE HOLE	STARTED 11/17/93 COMPLETED 11/12/93
8. DEPTH DRILLED INTO ROCK		17. ELEVATION TOP OF HOLE	
9. TOTAL DEPTH OF HOLE	17.0'	18. TOTAL CORE RECOVERY FOR BORING %	
		19. SIGNATURE OF INSPECTOR	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f
	0		0.0 To 6.0' SILT & CLAY: DARK ORANGE-BROWN & GRAY		HSA
	5		4.0' TO 6.0' SILT & CLAY: LT GRAY, HEAVY IRON STAINING, DAMP TO MOIST	54	SS1
					HSA
			7.5' TO 9.5' SAND: LT ORANGE-BROWN & LT GRAY, FINE GRAINED, LITTLE SILT & CLAY, MOIST	88	SS2
	10		9.5' To 11.5 SILT & CLAY: BROWN & LT GRAY MOTTLED, BLACK ORGANIC STAINING, TIGHT, DAMP	96	SS3
					HSA
			12.5' To 15.0' SILT & CLAY: BROWN, LT GRAY MOTTLES, LITTLE FINE SAND 14.0'-15.0' SAND: BROWN, VERY FINE TO FINE GRAINED, MOIST	70	SS4
	15		15.0' To 17.0' SILT: LT GRAY, HEAVY IRON STAINING, SOME CLAY, ABUNDANT ORGANIC STAINING, MOIST	79	SS5
			T.D. 17.0'		
	20				

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

1. JAR SAMPLES

SS1	4.0' - 6.0'
SS2	7.5' - 9.5'
SS3	9.5' - 11.5'
SS4	12.5' - 15.0'
SS5	15.0' - 17.0'

2. JAR SAMPLES (CHEMICAL)

SS1	4.0' - 6.0'
SS3	9.5' - 11.5'
SS5	15.0' - 17.0'

3. JAR SAMPLES (TREATABILITY)

SS2 7.5' - 9.5'

4. DRILLING

4¼" ID HSA
0.0' - 17.0'

NOTE: SAMPLES COLLECTED WITH THIN-WALLED SHELBY TUBE SAMPLERS (3"x30")

5. HEADSPACE RESULTS (ppm)

SS1	<7.6
SS3	<7.6
SS4	<7.6
SS5	7.6

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. | PROJECT | HOLE NO. SB04

SB05

DRILLING LOG

2379

LONGHORN AAP

CCI / ALLIANCE

SB05

☑

16.0'

4 1/4" ID HSA

FAILING F6

4

11/12/93 11/12/93

David M [illegible]

ELEVATION	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% CORE RECOVERY	BOX OR SAMPLE NO.	REMARKS
	0		0.0. TO 4.0' SILT & CLAY: BRIGHT ORANGE-BROWN		HSA	1. JAR SAMPLES SS1 4.0' - 6.0' SS2 7.5' - 9.5' SS3 9.5' - 11.5' SS4 14.0' - 16.0'
	5		4.0' TO 6.0' SILT & CLAY: BRIGHT ORANGE-BROWN & LT GRAY, TIGHT, TRACE ORGANIC MATERIAL, DAMP	46	SS1	2. JAR SAMPLES (CHEMICAL) SS1 4.0' - 6.0' SS. 9.5' - 11.5' SS4 14.0' - 16.0'
					HSA	3. JAR SAMPLES (TREATABILITY) SS2 7.5' - 9.5'
			7.5' TO 9.5' SILT: ORANGE-BROWN, SOME CLAY, DAMP	79	SS2	
	10		9.5' TO 11.5' CLAY & SILT: BROWN & ORANGE-BROWN, LT GRAY MOTTLES, INCREASING SILT PERCENTAGE TO 11.5', MOIST	96	SS3	4. DRILLING 4 1/4" ID HSA 0.0 - 16.0' NOTE: SAMPLES COLLECTED WITH THIN-WALLED SHELBY TUBE SAMPLER (3"x30")
					HSA	5. HEADSPACE RESULTS (ppm)
	15		14.0' TO 16.0' SILT & CLAY: LT GRAY, LITTLE IRON STAINING, MINOR SEAMS OF FINE SAND, DAMP	79	SS4	SS1 < 7.6 SS2 7.6 SS3 < 7.6 SS4 < 7.6
			T.D. - 16.0'			
	20					

ENG FORM 1836

SB05

Hole No. SB-6

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 2 SHEETS
1. PROJECT 2379		10. SIZE AND TYPE OF BIT 6 3/4 IN ID HSA	
2. LOCATION (Coordinates or Station) LONGHORN AAP		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY CCI / ALLIANCE		12. MANUFACTURER'S DESIGNATION OF DRILL MOBILE DRILL B61	
4. HOLE NO. (As shown on drawing title and file number) SB-6		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED 7 UNDISTURBED
5. NAME OF DRILLER JOBY BARR		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE	STARTED 11-9-93 COMPLETED 11-9-93
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING	%
9. TOTAL DEPTH OF HOLE 27.0 FT		19. SIGNATURE OF INSPECTOR	

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					1. PERCHED WATER ENCOUNTERED BETWEEN 23 - 23.5' 2. SAMPLES SS-1 : 5-7' SS-2 : 10-12' SS-3 : 15-17' SS-4 : 17.5-19' SS-5 : 20-21' SS-6 : 23-24.5' SS-7 : 25-27' 3. DRILLING 3 IN SPLIT SPOON SAMPLES TAKEN THROUGH 6 3/4 IN ID HOLLOW STEM AUGER WITH PULL OUT PLUG 4. HOLE ABANDONED WITH GROUT 5. PID HEADSPACE RESULTS: SS-1 : 0 PPM SS-2 : 9.2 PPM SS-3 : 31 PPM SS-4 : 205 PPM SS-5 : 67 PPM SS-6 : 1017 PPM SS-7 : 711 PPM
	5		5.0 STIFF RED CLAY FILL; DAMP-MOIST	85%	SS-1	
			6.5 MED STIFF TO STIFF TAN SILT, LITTLE CLAY (FILL); DAMP			
	10			90%	SS-2	
	15		15.0 MED. STIFF TO STIFF LT. BROWN AND LT. GRAY SILT AND CLAY (FILL); DAMP TO MOIST	90%	SS-3	
				90%	SS-4	
			19.1 MED. DENSE TAN TO BROWN FINE SAND, TR. SILT-MOIST			
	20					

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PROJECT

HOLE NO. SB-6

Hole No. SB-6

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 2 SHEETS
1. PROJECT 2379		10. SIZE AND TYPE OF BIT 6 3/4" ID HSA	
2. LOCATION (Coordinates or Station) LONGHORN AAP		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY CCI / ALLIANCE		12. MANUFACTURER'S DESIGNATION OF DRILL MOBILE DRILL B61	
4. HOLE NO. (As shown on drawing title and file number)	SB-6	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN	DISTURBED 7 UNDISTURBED
5. NAME OF DRILLER JOBY BARR		14. TOTAL NUMBER CORE BOXES	
		15. ELEVATION GROUND WATER	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		16. DATE HOLE	STARTED 11-9-93 COMPLETED 11-9-93
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING %	
9. TOTAL DEPTH OF HOLE 27.0 FT		19. SIGNATURE OF INSPECTOR	

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
	20		LOOSE TO MED. DENSE LT. GRAY TO BROWN FINE SAND, SOME SILT; DAMP	50%	SS-5	
			23.0			
			23.5 LOOSE BROWN FINE SAND; WET	100%	SS-6	
			23.7 STIFF, RUST SILT; DRY			
	25		25.0 MED. STIFF LT. GRAY SILT DRY	90%	SS-7	
			25.3 MED. DENSE RUST FINE SAND; DAMP			
			STIFF LT. TAN AND RUST SILT AND CLAY; DAMP			
			TOTAL DEPTH: 27.0 FT			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT

HOLE NO. SB-6

Hole No. SB-7

DRILLING LOG	DIVISION	INSTALLATION 6 3/4 ID HSA / 3 in Split spoon	SHEET 1 OF 2 SHEETS
1. PROJECT 2379		10. SIZE AND TYPE OF BIT 6 3/4 in ID HSA	
2. LOCATION (Coordinates or Station) LONGHORN AAP		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY CCI/ALLIANCE		12. MANUFACTURER'S DESIGNATION OF DRILL MOBILE DRILL B61	
4. HOLE NO. (As shown on drawing title and file number)	SB-7	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED 7 | UNDISTURBED
5. NAME OF DRILLER J.B. BARR		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE	STARTED 11-9-93 | COMPLETED 11-9-93
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING %	
9. TOTAL DEPTH OF HOLE	27.0 FT	19. SIGNATURE OF INSPECTOR	

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					1. NO GROUNDWATER ENCOUNTERED TO 27 FT DEPTH. 2. SAMPLES SS-1: 5-7' SS-2: 10-12' SS-3: 15-17' SS-4: 17.5-19.5' SS-5: 20-22' SS-6: 22.5-24.5' SS-7: 25-27'
	5		5.0 STIFF RED AND TAN CLAY (FILL) DAMP	85%	SS-1	3. DRILLING 3 in ID SPLIT SPOON SAMPLES TAKEN THROUGH 6 3/4 in ID Hollow STEM AUGERS WITH Pull OUT Plug
			6.5 STIFF TAN CLAY (FILL) SOME SILT DAMP			
	10		10.0 STIFF TAN SILT, LITTLE CLAY (FILL); DAMP	85%	SS-2	4. HOLE ABANDONED WITH GROUT 5. PID HEADSPACE RESULTS: SS-1: 0 PPM SS-2: 0 PPM SS-3: 0 PPM SS-4: 0 PPM SS-5: 0 PPM SS-6: 0 PPM SS-7: 0 PPM
	15		15.0 STIFF BROWN SILT AND CLAY (FILL); DAMP	100%	SS-3	
			17.6 LOOSE LT. TAN VERY FINE SAND TRACE BROWN SILT; DRY-DAMP.	100%	SS-4	
	20					

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MAR 71

PROJECT

HOLE NO. SB-7

Hole No. SB-7

DRILLING LOG	DIVISION	INSTALLATION 6 3/4 I D HSA / 3 IN SPLITSPOON	SHEET 2 OF 2 SHEETS

1. PROJECT 2379

2. LOCATION (Coordinates or Station) LONGHORN AAP

3. DRILLING AGENCY CCI / ALLIANCE

4. HOLE NO. (As shown on drawing title and file number) SB-7

5. NAME OF DRILLER JOBY BARR

6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.

7. THICKNESS OF OVERBURDEN

8. DEPTH DRILLED INTO ROCK

9. TOTAL DEPTH OF HOLE 27.0 FT

10. SIZE AND TYPE OF BIT 6 3/4 IN ID HSA

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)

12. MANUFACTURER'S DESIGNATION OF DRILL MOBILE DRILL B61

13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 7 | UNDISTURBED

14. TOTAL NUMBER CORE BOXES

15. ELEVATION GROUND WATER

16. DATE HOLE: STARTED | COMPLETED

17. ELEVATION TOP OF HOLE

18. TOTAL CORE RECOVERY FOR BORING %

19. SIGNATURE OF INSPECTOR

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
	20		20.3 LOOSE LT. TAN V. FINE SAND; DRY	100%	SS-5	
			LOOSE LT. TAN TO LT. BROWN FINE SAND, LITTLE SILT; DAMP	90%	SS-6	
	25		25.0 LOOSE LT. GRAY FINE SAND LITTLE LT. BROWN SILT; DAMP	85%	SS-7	
			26.0 LOOSE LT. GRAY FINE SAND V. DRY Sand Silt			
			TOTAL DEPTH = 27FT			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. | PROJECT | HOLE NO. SB-7

Hole No. SB-8

DRILLING LOG	DIVISION	INSTALLATION
1. PROJECT 2379		SHEET 1 OF 2 SHEETS
2. LOCATION LONGHORN AAP	10. SIZE AND TYPE OF BIT	
3. DRILLING AGENCY CCI/ALLIANCE	11. DATUM FOR ELEVATION SHOWN	
4. HOLE NO. SB-8	12. MANUFACTURER'S DESIGNATION OF DRILL MOBILE DRILL B61	
5. NAME OF DRILLER JOBY BARR	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN	DISTURBED 7 / UNDISTURBED
6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	14. TOTAL NUMBER CORE BOXES	
7. THICKNESS OF OVERBURDEN	15. ELEVATION GROUND WATER	
8. DEPTH DRILLED INTO ROCK	16. DATE HOLE	STARTED 11-10-93 / COMPLETED 11-10-93
9. TOTAL DEPTH OF HOLE 32 FT	17. ELEVATION TOP OF HOLE	
	18. TOTAL CORE RECOVERY FOR BORING	
	19. SIGNATURE OF INSPECTOR	

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		BROWN FINE SAND; DRY			1. GROUNDWATER ENCOUNTERED AT 30 FT.
			2.5			2. CHEM. SAMPLES SS-1: 5-7 FT SS-2: 10-12 FT
			3.0 LT. BROWN FINE SAND; DRY			SS-3: 15-17 FT
			RED CLAY; MOIST			SS-4: 17.5-18.5 FT
	5		5.0 MED. STIFF, RED CLAY, SOME SILT (FILL); MOIST	80%	SS-1	SS-5: 20-22 FT SS-6: 25-27 FT SS-7: 30-32 FT 3. PHYSICAL SAMPLES SS-1: 5-7 FT SS-2: 10-12 FT SS-3: 15-17 FT SS-4: 17.5-18.5 FT SS-5: 20-22 FT SS-6: 25-27 FT
	10		10.0 SOFT TO MED. STIFF TAN SILT, LITTLE CLAY; DRY (FILL)	80%	SS-2	SS-7: 30-32 FT 4. PID HEADSPACE MEASUREMENTS SS-1 0 PPM SS-2 0 PPM SS-3 0 PPM SS-4 0 PPM SS-5 0 PPM SS-7 0 PPM
	15		15.0 STIFF TAN CLAY AND SILT; DRY (FILL)	90%	SS-3	5. DRILLING 3 IN SPLIT SPOON SAMPLES TAKEN THROUGH 6 3/4 IN ID HSA WITH PULLOUT PLUG
			17.5 STIFF, TAN AND BROWN SILT, SOME FINE SAND; DRY, MOTTLED (FILL)	60%	SS-4	
	20					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT LONGHORN AAP 2379

HOLE NO. SB-8

DRILLING LOG	DIVISION	INSTALLATION	Hole No. SB-8 SHEET 2 OF 2 SHEETS

1. PROJECT	2379
2. LOCATION	LONGHORN AAP
3. DRILLING AGENCY	CCI/ALLIANCE
4. HOLE NO. (As shown on drawing title and file number)	SB-8
5. NAME OF DRILLER	JOBY BARR
6. DIRECTION OF HOLE	☒ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN	
8. DEPTH DRILLED INTO ROCK	
9. TOTAL DEPTH OF HOLE	32 FT
10. SIZE AND TYPE OF BIT	
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
12. MANUFACTURER'S DESIGNATION OF DRILL	MOBILE DRILL B61
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED: 7 UNDISTURBED:
14. TOTAL NUMBER CORE BOXES	
15. ELEVATION GROUND WATER	
16. DATE HOLE	STARTED: 11-10-93 COMPLETED: 11-10-93
17. ELEVATION TOP OF HOLE	
18. TOTAL CORE RECOVERY FOR BORING	
19. SIGNATURE OF INSPECTOR	

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
	20		MED. STIFF, BROWN SILT, TRACE FINE SAND AND ORGANIC MATTER (FILL); DRY	90%	SS-5	
	25		25.0 LOOSE, TAN FINE SAND LITTLE SILT; DRY	90%	SS-6	
▽	30		30.0 LOOSE BROWN FINE SAND AND SILT; SATURATED 31.0 MED. STIFF GRAY CLAY; BROWN MOTTLING, MOIST TOTAL DEPTH 32 FT	95%	SS-7	
	35					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.
MAR 71

PROJECT LONGHORN AAP 2379

HOLE NO. SB-8

Hole No. SB09

007934

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 1 SHEETS
1. PROJECT 2379		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station) LONGHORN AAP		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) 4 1/4" ID HSA	
3. DRILLING AGENCY CCI / ALLIANCE		12. MANUFACTURER'S DESIGNATION OF DRILL FAILING F6	
4. HOLE NO. (As shown on drawing title and file number)	SB09	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED | UNDISTURBED
5. NAME OF DRILLER JOHN LODEN		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED ___ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
7. THICKNESS OF OVERBURDEN		16. DATE HOLE	STARTED 11/13/93 | COMPLETED 11/13/93
8. DEPTH DRILLED INTO ROCK		17. ELEVATION TOP OF HOLE	
9. TOTAL DEPTH OF HOLE 6.0'		18. TOTAL CORE RECOVERY FOR BORING %	
		19. SIGNATURE OF INSPECTOR	

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				HSA	1. JAR SAMPLES SS1 4.0-6.0' 2. JAR SAMPLES (CHEMICAL) SS1 4.0'-6.0'
			4.0' TO 6.0'			
	5		SILT & SAND: LT GRAY-BROWN, LT. BROWN, LITTLE CLAY MOIST	96	SS1	3. DRILLING 4 1/4" ID HSA 0.0' TO 6.0' NOTE: SAMPLE COLLECTED WITH THIN-WALLED SHELBY TUBE SAMPLER (3" x 30")
	6		T.D - 6.0'			4. HEADSPACE RESULT (ppm) SS1 <1

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE | PROJECT | HOLE NO. SB09

DRILLING LOG	DIVISION	INSTALLATION	Hole No. SB10 SHEET OF SHEETS
1. PROJECT 2379		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station) LONGHORN AAP		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY CCI / ALLIANCE		12. MANUFACTURER'S DESIGNATION OF DRILL FAILING F6	
4. HOLE NO. (As shown on drawing title and file number)	SB10	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED 4
5. NAME OF DRILLER JOHN JODEN		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE	STARTED 11/13/93 COMPLETED 11/13/93
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING	
9. TOTAL DEPTH OF HOLE 21.0'		19. SIGNATURE OF INSPECTOR	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f
	0				HSA
	5		4.0 TO 6.0' SILT & CLAY: RED-BROWN, LT GRAY MOTTLES, TRACE ORGANIC MATERIAL, DAMP	66	SS1
					HSA
	10		9.0 TO 11.0 VERY FINE SAND: LT BROWN-GRAY, LT GRAY MOTTLES, BLACK ORGANIC STAINING, LITTLE CLAY, MOIST	91	SS2
					HSA
	15		14.0' TO 16.0' SILT & CLAY: LT GRAY & ORANGE-BROWN MOTTLES; INCREASING FINE SAND AND DECREASING SILT PERCENTAGES WITH DEPTH, MOIST	83	SS3
					HSA
	20		19.0' TO 21.0' SAND: VERY FINE TO FINE GRAINED, LT GRAY	88	SS4

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

1. JAR SAMPLES

SS1	4.0' - 6.0'
SS2	9.0' - 11.0'
SS3	14.0' - 16.0'
SS4	14.0' - 21.0'

2. JAR SAMPLES (CHEMICAL)

SS1	4.0' - 6.0'
SS2	9.0' - 11.0'
SS3	14.0' - 16.0'
SS4	19.0' - 21.0'

3. DRILLING

4 1/4" ID HSA 0.0' - 21.0'

NOTE: SAMPLES COLLECTED WITH THIN-WALLED SHELBY TUBE SAMPLERS (3" x 30")

4. HEADSPACE RESULTS (ppm)

SS1	12.5
SS2	12.5
SS3	12.5
SS4	21

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO. SB10

HOLE NO. SB10

DRILLING LOG

DIVISION

INSTALLATION

SHEET
OF SHEETS

1. PROJECT 2379

2. LOCATION (Coordinates or Station) LONGHORN AAP

3. DRILLING AGENCY CCI / ALLIANCE

4. HOLE NO. (As shown on drawing title and file number) SB10

5. NAME OF DRILLER JOHN LODEN

6. DIRECTION OF HOLE
☑ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.

7. THICKNESS OF OVERBURDEN

8. DEPTH DRILLED INTO ROCK

9. TOTAL DEPTH OF HOLE 21.0'

10. SIZE AND TYPE OF BIT

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)

12. MANUFACTURER'S DESIGNATION OF DRILL FAILING F6

13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED 4

14. TOTAL NUMBER CORE BOXES

15. ELEVATION GROUND WATER

16. DATE HOLE | STARTED 11/13/93 | COMPLETED 11/13/93

17. ELEVATION TOP OF HOLE

18. TOTAL CORE RECOVERY FOR BORING %

19. SIGNATURE OF INSPECTOR David Mattimeh

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
	20		AND ORANGE BROWN, TRACE CLAY, WET @ 21.0'	88	SS4	
	21		T.D. - 21.0'			

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.
MAR 71

PROJECT

HOLE NO. SB10

ARK-LA-TEX SURVEYING CO., INC.

P.O. Box 910 • 305 W. Rusk • Marshall, Texas 75671 • 903/938-9939 • FAX 903/938-0601

January 25, 1994

MONITORING WELLS

	X Coord.	Y Coord.	Z Elev.
AWD-1			
Well	3,040,093.100	380,601.687	
"x" in Slab			178.48'
Casing			181.06'
Cover			181.03'
Natural Ground			177.87'
AWD-2			
Well	3,040,368.409	380,860.421	
"x" in Slab			183.88'
Casing			186.75'
Cover			186.91'
Natural Ground			183.42'
AWD-3			
Well	3,040,701.110	380,636.144	
"x" in Slab			197.59'
Casing			200.13'
Cover			200.13'
Natural Ground			197.04'
AWD-4			
Well	3,040,599.684	381,381.439	
"x" in Slab			190.61'
Casing			193.56'
Cover			193.46'
Natural Ground			190.13'
EW-1			
Well	3,040,957.225	380,867.664	
"x" in Slab			196.34'
Casing			198.63'
Cover			198.61'
Natural Ground			195.80'

ARK-LA-TEX SURVEYING CO., INC.
P.O. Box 910 • 305 W. Rusk • Marshall, Texas 75671 • 903/938-9939 • FAX 903/938-0601

January 25, 1994

SOIL BORING LOCATIONS

	X Coord.	Y Coord.	Z Elev.
SB-1	3,040,438.813	380,407.100	191.99'
SB-2	3,040,496.800	380,454.128	192.32'
SB-3	3,040,552.607	380,496.593	192.90'
SB-4	3,040,549.000	380,903.967	193.15'
SB-5	3,040,642.431	380,817.805	196.04'
SB-6	3,040,831.757	380,935.212	202.76'
SB-7	3,040,887.980	381,022.389	204.15'
SB-8	3,040,774.856	381,143.619	205.46'

TABLE X

FIELD PARAMETERS - LHAAP 18 & 24 WELL PURGING AND SAMPLING

MW-6

Volume (Gallons)	pH	Conductivity (mmhos)	Temp. (°F)	Comments
18	5.63	1571	71	Clear purge water
20				Purging interrupted for recharge
21	5.69	1662	70	
23	5.72	1675	70	Purging interrupted for recharge
30	5.74	1668	69	Purging completed

MW-7

Volume (Gallons)	pH	Conductivity (mmhos)	Temp. (°F)	Comments
9	7.21	1478	65	Purging interrupted for recharge
18	7.08	1488	65	Purging interrupted for recharge
22	6.99	1540	64	Purging completed
	7.06	1515	65	Measurement while sampling

MW-8

Volume (Gallons)	pH	Conductivity (mmhos)	Temp. (°F)	Comments
18				Purging interrupted for recharge
	4.78	709	64	
25	4.72	540	64	Purging completed

TABLE X

FIELD PARAMETERS - LHAAP 18 & 24 WELL PURGING AND SAMPLING

MW-15

Volume (Gallons)	pH	Conductivity (mmhos)	Temp. (°F)	Comments
110	5.85	547	68	
128	5.87	552	68	
165				Purging completed

MW-16

17	5.57	582	63	Orange-brown silt
36	6.07	623	64	
62	6.15	640	64	
85	6.18	643	64	
105	6.19	647	64	Purging completed

MW-17

9	6.89	894	64	
16				Purging interrupted for recharge
17	6.86	930	64	
18	6.85	934	63	Well bailed dry; pale olive purge water

MW-18

Time (11/21/93)	pH	Conductivity (mmhos)	Temp. (°F)	Comments
1500				Start purging
1515	6.48	491	70	
1525	6.57	492	70	

TABLE X

FIELD PARAMETERS - LHAAP 18 & 24 WELL PURGING AND SAMPLING

Volume (Gallons)	pH	Conductivity (mmhos)	Temp. (°F)	Comments
MW-22				
16	10.54	2480	70	Purging interrupted for recharge
17	10.11	2550	69	Well pumped dry; sample collected
MW-23				
18	7.89	1508	69	Purging interrupted for recharge; clear purge water
20	6.44	1865	65	
21	6.58	1735	65	Purging completed
102				
12	5.51	098	64	Measured while sampling
109				
9	6.02	305	68	
	6.13	316	68	
	6.13	315	68	
	6.09	319	68	
10	6.10	316	68	Purging completed
120				
9	5.11	5500	72	
10	5.05	5900	72	
11	5.09	5970	72	
12	5.07	5950	72	Purging completed

TABLE X

FIELD PARAMETERS - LHAAP 18 & 24 WELL PURGING AND SAMPLING

Volume (Gallons)	pH	Conductivity (mmhos)	Temp. (°F)	Comments
123				
3				Well bailed dry; very silty
5				Well bailed dry: recharge for sampling
124				
3				Well bailed dry; very silty
	5.91	118	65	Measurement while sampling
125				
4	5.86	158	67	
5	5.90	154	67	Pale orange-brown purge water
7	5.94	151	66	
10	5.89	151	67	Purging completed
126				
2	5.95	5350	64	
4	5.94	5230	65	
6	5.96	4660	65	
8	5.96	4700	65	
10	5.93	4300	nm	
16	5.92	4060	63	
18	5.95	4480	66	
20	5.93	4110	65	
21	5.95	4180	66	Purging completed

TABLE X

FIELD PARAMETERS - LHAAP 18 & 24 WELL PURGING AND SAMPLING

C10

Volume (Gallons)	pH	Conductivity (mmhos)	Temp. (°F)	Comments
183	6.70	1512	67	
191	6.71	1507	67	Clear purge water
201	6.75	1516	67	Purging completed

MW-1

18	5.50	3730	70	
24	5.60	3690	70	
36	5.71	3740	70	
55	5.68	3660	70	Purging completed

MW-2

18				Pumping interrupted for recharge
24				Pumping interrupted for recharge
33	5.94	2320	68	
36				Purging completed

MW-3

24	5.53	1473	69	
27	5.54	1542	69	Clear purge water
36	5.56	1629	69	
38	5.57	1656	69	
50	5.56	1673	69	
57	5.61	1696	69	
64	5.57	1706	69	
73	5.57	1725	69	Clear purge water

TABLE X

FIELD PARAMETERS - LHAAP 18 & 24 WELL PURGING AND SAMPLING

MW-3 (cont.)

Volume (Gallons)	pH	Conductivity (mmhos)	Temp. (°F)	Comments
82	5.55	1729	69	Clear purge water
88				Purging completed
MW-4				
30	6.16	2600	67	
	6.05	2620		
	6.09	2570		
45	6.10	2620	65	
60	6.12	2590	65	
74	6.11	2610	65	Purging completed; clear purge water
MW-5				
18				Purging interrupted for recharge
22	4.82	1136	nm	Purging interrupted for recharge
27	4.78	1119	65	
	4.77	1123	71	
	4.78	1132	70	
	4.79	1140	72	
	4.80	1180	72	
71	4.83	1137	72	Purging completed

TABLE X

FIELD PARAMETERS - LHAAP 18 & 24 WELL PURGING AND SAMPLING

MW-9

Volume (Gallons)	pH	Conductivity (mmhos)	Temp. (°F)	Comments
15	5.63	126	64	Purging interrupted for recharge
18				Purging completed
	5.33	100	66	Measurement prior to sampling

MW-10

20				Purging interrupted for recharge
27	6.46	925	64	
36	6.45	917	65	
	5.69	807	65	Measurement while sampling

MW-11

8	6.02	132	67	Very pale orange-brown purge water
15	6.05	128	67	
18	6.08	133	68	Purging interrupted for recharge
22				Purging interrupted for recharge
27	5.97	145	68	Purging interrupted for recharge
34	6.31	169	68	
36	5.83	158	67	
37	6.13	158	67	Purging completed

TABLE X

FIELD PARAMETERS - LHAAP 18 & 24 WELL PURGING AND SAMPLING

MW-12

Volume (Gallons)	pH	Conductivity (mmhos)	Temp. (°F)	Comments
30	4.65	1280	67	
50	4.79	1426	67	
65	4.86	1467	67	
66	4.90	1463	67	
82	4.86	1500	67	
91	4.95	1508	67	
95	4.96	1510	67	
100	4.97	1514	67	Purging completed

MW-13

22	6.95	984	63	
36	6.93	967	64	
55	6.83	933	64	
73	6.84	931	64	
91	6.79	921	64	
110	6.79	916	64	
128	6.76	909	65	
146	6.70	879	64	Purging completed

MW-14

119	5.77	1297	68	
128	5.76	1283	68	
137	5.77	1280	68	
160	5.76	1279	68	Purging completed

TABLE X

FIELD PARAMETERS - LHAAP 18 & 24 WELL PURGING AND SAMPLING

MW-18 (cont.)

Time (11/21/93)	pH	Conductivity (mmhos)	Temp. (°F)	Comments
1540	6.62	451	70	
1610	6.67	468	70	Staggered pumping/recharge
1645	6.63	489	68	Purging completed; 65 gallons purged

MW-19

Volume (Gallons)	pH	Conductivity (mmhos)	Temp. (°F)	Comments
18	5.73	6610	64	
22	5.85	6730	64	
25				Purging interrupted for recharge
73	5.97	7090	66	
77	6.01	7110	66	
88	6.04	7090	67	
	6.07	6910	67	Measurement while sampling

MW-20

6				Purging interrupted for recharge
12	7.30	316	63	Purging completed

MW-21

9	5.31	3690	67	Clear purge water
17				Well pumped dry; sample collected

TABLE X

FIELD PARAMETERS - LHAAP 18 & 24 WELL PURGING AND SAMPLING

C1

Volume (Gallons)	pH	Conductivity (mmhos)	Temp. (°F)	Comments
55	6.11	2330	66	Clear purge water
73	6.10	2400	67	
91	6.11	2400	67	
93				Purging completed

C2

22	6.67	754	65	Pumped dry; recharge
27	6.54	735	65	Purging completed
	5.87	658	63	Measurement while sampling

C3

55	5.41	1313	64	Pale orange-brown purge water
80	5.49	1319	65	
110	5.54	1309	65	
130	5.56	1312	65	Purging completed, clear purge water

C4

110	5.74	166	64	Purging completed, Clear purge water
	5.80	189	64	Measurements prior to sampling
	5.78	185	64	
	5.82	181	64	

TABLE X

FIELD PARAMETERS - LHAAP 18 & 24 WELL PURGING AND SAMPLING

C4A

Volume (Gallons)	pH	Conductivity (mmhos)	Temp. (°F)	Comments
23	6.94	543	64	
36	7.07	553	64	
40	7.12	555	65	
50	7.16	555	65	Clear purge water
65	7.15	553	66	Pumping stopped for recharge
95				Purging completed

C5

45	6.23	340	64	Clear purge water
65	6.23	343	64	Clear purge water
70	6.24	343	64	Clear purge water
110				Purging completed

C5 - Resample 12/7/93

55	6.20	353	63	Clear purge water
73	6.18	351	63	
91	6.20	353	63	Clear purge water
105				Purging completed

C6

50	6.04	1572	66	
58	6.03	1588	65	
73	6.04	1587	65	
91	6.02	1519	65	Clear purge water
110	6.07	1582	65	Purging completed

TABLE X

FIELD PARAMETERS - LHAAP 18 & 24 WELL PURGING AND SAMPLING

Volume (Gallons)	pH	Conductivity (mmhos)	Temp. (°F)	Comments
C7				
5	6.47	578	67	
6	6.46	595	67	
9				Purging interrupted for recharge
10	6.56	588	68	Pale olive purge water
11	6.53	583	68	
14	6.55	582	68	
16				Purging interrupted for recharge
18	6.56	583	68	Purging completed; pale olive purge water
C8				
20	6.35	4490	65	
25	6.36	4530	65	
40	6.40	4550	65	
45				Purging completed
C9				
7	6.35	9860	nm	Purging interrupted for recharge
10	6.36	9860	68	Purging completed

TABLE X

CALCULATED WELL VOLUMES AND PURGE DATA SUMMARY SHEET

Well ID	C1	C2	C3	C3*
Date Purged	12/8/93	11/22/93	11/17/93	12/6/93
Date Sampled	12/8/93	11/23/93	11/18/93	12/6/93
DTW (1)	20.06	3.69	23.19	
WTD (2)	47.02	29.90	62.18	
Water Column (Ft)	26.96	26.21	38.99	
Calculated Well Volume (Gallons)	17.59	17.10	25.45	
5V (3)	87.95	85.50	127.25	
Water Volume Purged (Gallons)	93.0	27.0	130.0	105.0

Well ID	C4	C4A	C5	C5*
Date Purged	11/17/93	12/7/93	11/17/93	12/7/93
Date Sampled	11/18/93	12/7/93	11/18/93	12/7/93
DTW	21.76	21.93	9.44	
WTD	55.40	121.00	39.40	
Water Column (Ft)	33.64	99.07	29.96	
Calculated Well Volume (Gallons)	21.96	64.67	19.56	
5V	109.80	323.35	97.80	
Water Volume Purged (Gallons)	110.0	95.0	110.0	105.0

TABLE X

CALCULATED WELL VOLUMES AND PURGE DATA SUMMARY SHEET

Well ID	MW-4	MW-5	MW-6	MW-7
Date Purged	12/1/93	12/1/93	12/3/93	11/21/93
Date Sampled	12/1/93	12/1/93	12/3/93	11/22/93
DTW	22.80	21.65	18.92	13.75
WTD	45.30	43.60	47.80	24.50
Water Column (Ft)	22.50	21.95	28.88	10.75
Calculated Well Volume (Gallons)	14.69	14.33	18.85	7.02
5V	73.45	71.65	94.25	35.10
Water Volume Purged (Gallons)	74.0	72.0	30.0	22.0

Well ID	MW-8	MW-9	MW-10	MW-11
Date Purged	11/30/93	11/21/93	11/22/93	11/23/93
Date Sampled	11/30/93	11/22/93	11/23/93	11/23/93
DTW	11.62	9.35	4.80	3.16
WTD	33.60	29.75	36.70	13.20
Water Column (Ft)	21.98	20.40	31.90	10.04
Calculated Well Volume (Gallons)	14.35	13.32	20.82	6.55
5V	71.75	66.60	104.00	32.75
Water Volume Purged (Gallons)	25.0	18.0	21.0	37.0

TABLE X

CALCULATED WELL VOLUMES AND PURGE DATA SUMMARY SHEET

Well ID	MW-12	MW-13	MW-14	MW-15
Date Purged	11/19/93	11/22/93	11/19/93	12/8/93
Date Sampled	11/19/93	11/23/93	11/19/93	12/8/93
DTW	5.22	4.29	5.92	23.86
WTD	31.20	48.80	53.80	71.80
Water Column (Ft)	25.98	44.51	47.88	47.94
Calculated Well Volume (Gallons)	16.96	29.06	31.26	31.30
5V	84.80	145.30	156.30	156.50
Water Volume Purged (Gallons)	100.0	146.0	160.0	165.0

Well ID	MW-16	MW-17	MW-18	MW-19
Date Purged	11/22/93	11/22/93	11/21/93	11/30/93
Date Sampled	11/23/93	11/23/93	11/22/93	11/30/93
DTW	3.04	7.35	6.00	5.57
WTD	33.70	28.70	33.70	33.75
Water Column (Ft)	30.66	21.35	27.70	28.18
Calculated Well Volume (Gallons)	20.01	13.94	18.08	18.40
5V	100.05	69.70	90.40	92.00
Water Volume Purged (Gallons)	105.0	18.0	65.0	88.0

TABLE X

CALCULATED WELL VOLUMES AND PURGE DATA SUMMARY SHEET

Well ID	MW-20	MW-21	MW-22	MW-23
Date Purged	11/30/93	12/3/93	12/3/93	12/6/93
Date Sampled	11/30/93	12/3/93	12/3/93	12/7/93
DTW	11.21	24.45	22.80	23.34
WTD	20.00	46.80	43.80	46.80
Water Column (Ft)	8.79	22.35	21.00	23.46
Calculated Well Volume (Gallons)	5.74	14.59	13.71	15.31
5V	28.70	72.95	68.55	76.55
Water Volume Purged (Gallons)	12.0	17.0	17.0	21.0

Well ID	102	109	120	123
Date Purged	11/21/93	12/1/93	11/19/93	12/2/93
Date Sampled	11/22/93	12/2/93	11/19/93	12/3/93
DTW	18.00	22.16	8.90	10.85
WTD	32.72	34.50	27.00	21.10
Water Column (Ft)	14.72	12.34	18.10	10.25
Calculated Well Volume (Gallons)	2.40	2.01	2.95	1.67
5V	12.0	10.05	14.75	8.35
Water Volume Purged (Gallons)	12.0	10.0	12.0	5.0

TABLE X

CALCULATED WELL VOLUMES AND PURGE DATA SUMMARY SHEET

Well ID	124	125	126	129
Date Purged	12/1/93	12/1/93	12/7/93	11/19/93
Date Sampled	12/2/93	12/1/93	12/8/93	11/19/93
DTW	11.80	21.60	25.20	21.20
WTD	26.00	27.60	39.30	36.70
Water Column (Ft)	14.20	6.00	14.10	15.50
Calculated Well Volume (Gallons)	2.32	0.98	2.30	2.53
5V	11.60	4.90	11.50	12.65
Water Volume Purged (Gallons)	3.0	10.0	21.0	15.0

Well ID	130	AWD-1	AWD-2	AWD-3
Date Purged	11/21/93	11/19/93	12/5/93	12/6/93
Date Sampled	11/22/93	11/19/93	12/6/93	12/6/93
DTW	3.90	6.62	8.10	24.12
WTD	29.60	27.90	29.50	37.40
Water Column (Ft)	25.70	21.28	21.40	13.28
Calculated Well Volume (Gallons)	4.19	13.89	13.97	8.67
5V	20.95	69.50	69.85	43.35
Water Volume Purged (Gallons)	16.0	91.0	70.0	28.0

TABLE X

FIELD PARAMETERS - LHAAP 18 & 24 WELL PURGING AND SAMPLING

129

Volume (Gallons)	pH	Conductivity (mmhos)	Temp. (°F)	Comments
15	5.57	430	64	Measurements prior to sampling
	5.47	330	64	
	5.45	330	64	
	5.49	330	64	
	5.47	330	64	

130

10				Bailed dry; recharge
16				Bailed dry; recharge
	6.42	4590	67	Measurement while sampling

AWD-1

70				Pumped dry; recharge
73	5.96	767	69	
78	5.92	669	69	
82	5.90	663	69	
86	5.90	693	69	
91	5.89	703	69	Purging completed

AWD-2

	5.09	433	69	
	5.05	559	70	
	5.01	598	70	
	5.05	570	70	

TABLE X

FIELD PARAMETERS - LHAAP 18 & 24 WELL PURGING AND SAMPLING

AWD-2 (cont.)

Volume (Gallons)	pH	Conductivity (mmhos)	Temp. (°F)	Comments
50				Clear purge water
	5.08	514	70	
	4.90	449	70	
70	4.92	478	70	Purging completed

AWD-3

Volume (Gallons)	pH	Conductivity (mmhos)	Temp. (°F)	Comments
17				Pumped dry; recharge
18	5.98	432	66	
21				Pumped dry; recharge
26	5.93	678	68	Pale olive purge water
27	5.97	697	69	
28				Pumped dry; sample

AWD-4

Volume (Gallons)	pH	Conductivity (mmhos)	Temp. (°F)	Comments
22				Pumped dry; recharge
45	5.45	683	66	
60	5.56	763	67	
65				Pumped dry; recharge
71	5.26	872	66	
73	5.33	688	66	
82	5.40	559	66	
88	5.41	592	66	
91	5.44	700	66	Purging completed; silty

TABLE X

FIELD PARAMETERS - LHAAP 18 & 24 WELL PURGING AND SAMPLING

EW-1

Volume (Gallons)	pH	Conductivity (mmhos)	Temp. (°F)	Comments
	5.78	1246	68	Clear purge water
	5.97	1830	68	
	5.93	1552	68	
	5.86	1465	68	
90	5.88	1525	68	Well pumped dry; recharge - chemical odor
110	5.87	1380	67	
114	5.78	1280	68	
120	5.76	1262	68	Purging completed, clear purge water

C3 - Resample 12/6/93

28	5.56	1411	63	
34	5.54	1409	64	
71	5.53	1406	64	
80	5.55	1408	64	

TABLE X

CALCULATED WELL VOLUMES AND PURGE DATA SUMMARY SHEET

Well ID	C6	C7	C8	C9
Date Purged	12/1/93	12/9/93	11/17/93	12/9/93
Date Sampled	12/1/93	12/9/93	11/18/93	12/9/93
DTW	22.40	23.45	18.98	28.82
WTD	54.90	29.20	33.00	42.90
Water Column (Ft)	32.50	5.75	14.02	14.08
Calculated Well Volume (Gallons)	21.22	3.75	9.15	9.19
5V	106.10	18.75	45.75	45.95
Water Volume Purged (Gallons)	110.0	18.0	45.0	10.0

Well ID	C10	MW-1	MW-2	MW-3
Date Purged	12/9/93	12/5/93	12/8/93	12/2/93
Date Sampled	12/9/93	12/6/93	12/8/93	12/2/93
DTW	26.10	23.10	21.60	22.62
WTD	82.80	40.30	43.00	49.60
Water Column (Ft)	56.70	17.20	21.40	26.98
Calculated Well Volume (Gallons)	37.01	11.23	13.96	17.61
5V	185.05	56.15	69.80	88.05
Water Volume Purged (Gallons)	201.0	55.0	36.0	88.0

TABLE X

CALCULATED WELL VOLUMES AND PURGE DATA SUMMARY SHEET

Well ID	AWD-4	EW-1		
Date Purged	12/2/93- 12/3/93	12/5/93		
Date Sampled	12/3/93	12/6/93		
DTW	20.15	22.95		
WTD	38.60	39.60		
Water Column (Ft)	18.45	16.65		
Calculated Well Volume (Gallons)	12.04	24.45		
5V	60.20	122.25		
Water Volume Purged (Gallons)	91.0	120.0		

NOTES:

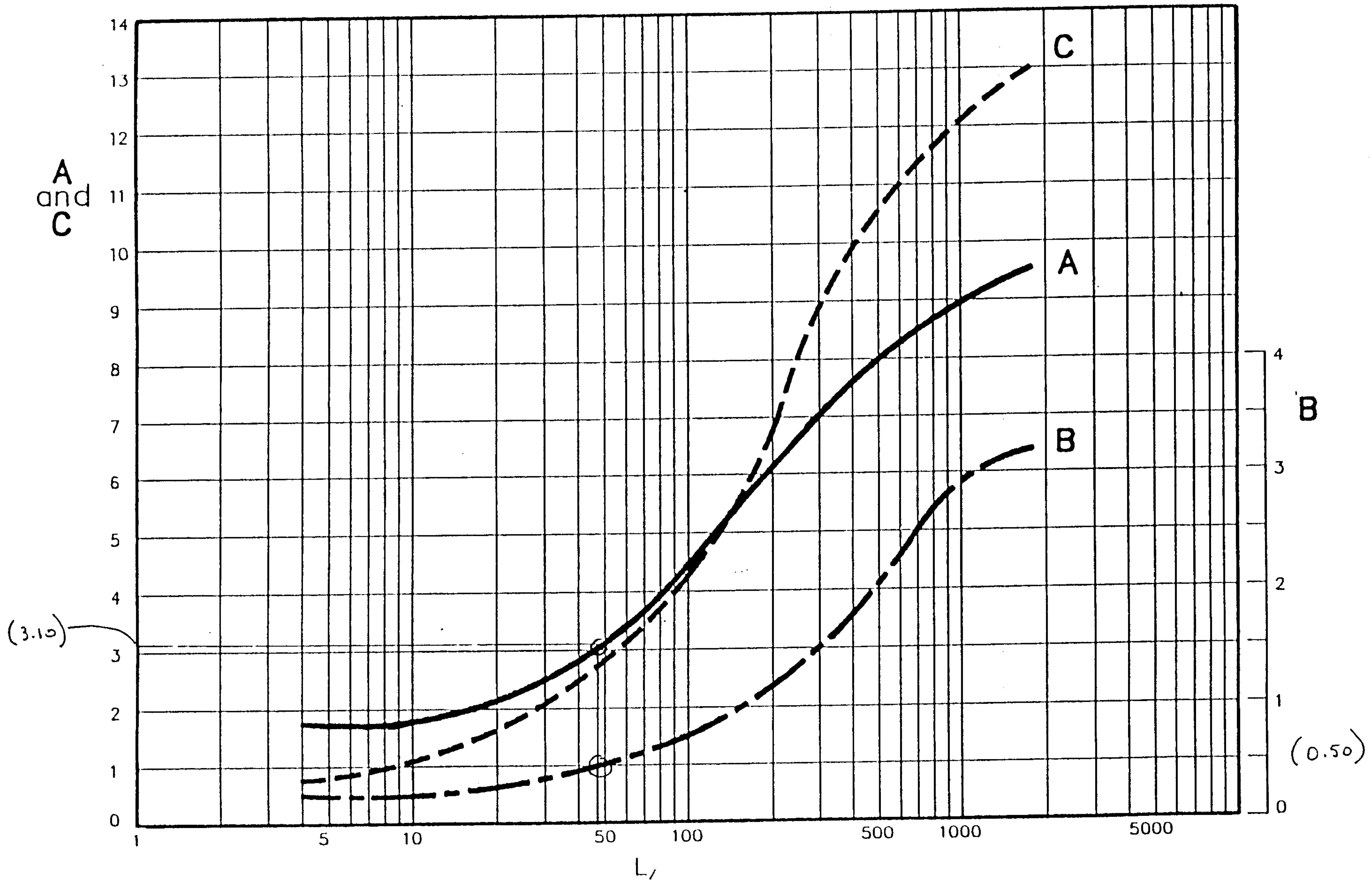
(*) Well Resampled

(1) DTW - Depth to Water (Top of Casing) in Feet

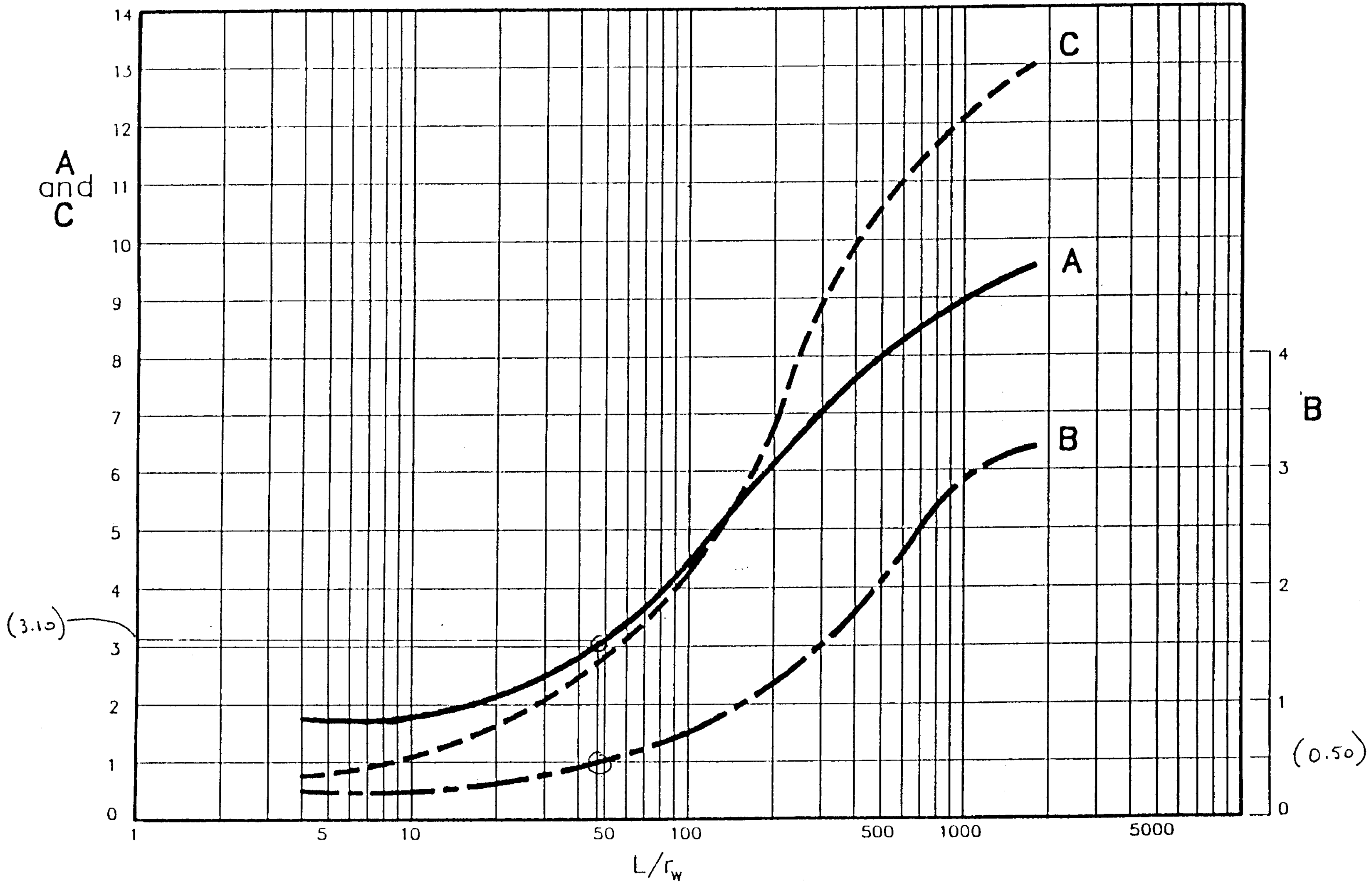
(2) WTD - Well Total Depth (Top of Casing) in Feet

(3) 5V - 5 X Calculated Well Volumes in Gallons

BOUWER AND RICE SLUG TEST CURVES



BOUWER AND RICE SLUG TEST CURVES



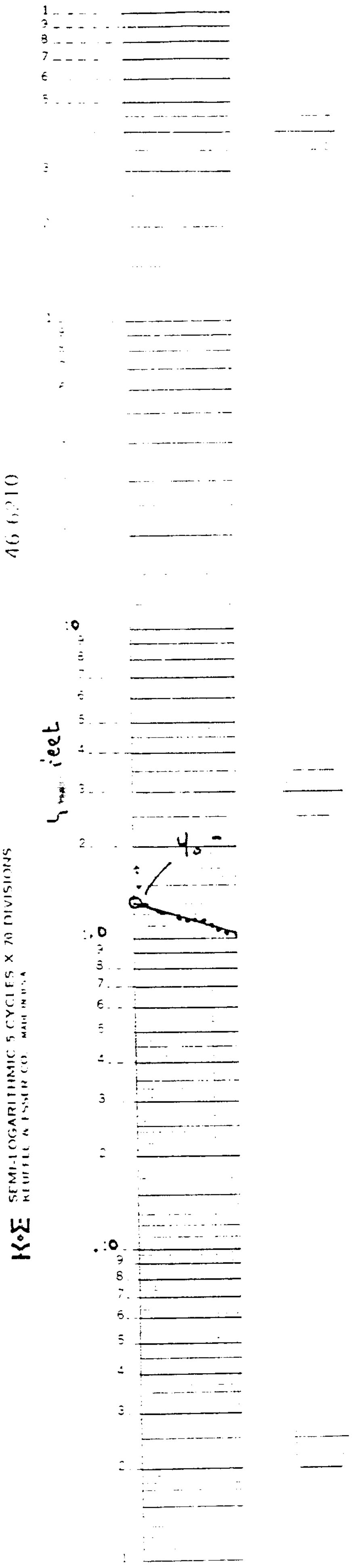
Curves relating coefficien' B and C to L/r_w

AWD - 1

SLUG TEST DATA

TEST PERFORMED
12/4/93

TEST # 0



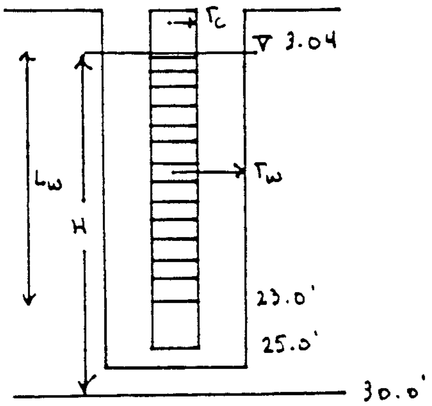
```
Ready

        SE1000B
  Environmental Logger
     12/04  18:00

  Unit# 00000  Test# 0

INPUT 1:  Level (F) TOC

Reference          0.00
Scale factor      20.29
Offset           - 0.35

Step# 0   12/04  11:31

Elapsed Time    Value
------------  ---------
   0.0000         0.03
   0.0033         0.03
   0.0066         0.03
   0.0099         0.03
   0.0133         0.03
   0.0166         0.03
   0.0200         0.30
   0.0233         1.19
   0.0266       - 0.56
   0.0300         0.00
   0.0333         1.68
   0.0500         1.72
   0.0666         1.49
   0.0833         1.29
   0.1000         1.29
   0.1166         1.30
   0.1333         1.30
   0.1500         1.29
   0.1666         1.28
   0.1833         1.28
   0.2000         1.27
   0.2166         1.27
   0.2333         1.26
   0.2500         1.26
   0.2666         1.25
   0.2833         1.25
   0.3000         1.24
   0.3166         1.24
   0.3333         1.23
   0.4167         1.20
   0.5000         1.18
   0.5833         1.17
   0.6667         1.14
   0.7500         1.13
   0.8333         1.10
   0.9167         1.08
   1.0000         1.06
   1.0833         1.05

   1.1667         1.03
   1.2500         1.01
   1.3333         0.99
   1.4166         0.97
   1.5000         0.97
   1.5833         0.94
   1.6667         0.93
   1.7500         0.92
   1.8333         0.90
   1.9167         0.88
   2.0000         0.88
   2.5000         0.79
   3.0000         0.72
   3.5000         0.67
   4.0000         0.62
   4.5000         0.57
   5.0000         0.52
   5.5000         0.48
   6.0000         0.45
   6.5000         0.42
   7.0000         0.39
   7.5000         0.36
   8.0000         0.34
   8.5000         0.32
   9.0000         0.29
   9.5000         0.27
  10.0000         0.25
  12.0000         0.20
  14.0000         0.15
  16.0000         0.12
  18.0000         0.10
  20.0000         0.08
  22.0000         0.08
  24.0000         0.07
  26.0000         0.07
  28.0000         0.05
  30.0000         0.05
  32.0000         0.04
END
```

AWD Technologies, Inc

AWD TECHNOLOGIES

CALCULATION WORKSHEET

CLIENT: COE	FILE NO.: 2379	BY: DNM	PAGE 1 OF 1
SUBJECT: AWD-1 Slug Test Test # 0		CHECKED BY:	DATE: 12/22/93



B.H. Dia - 0.83' (r_w - 0.42')
Well I.D. - 0.33' (r_c - 0.17')
Well TD - 25.0'
Screen Length (L_e) - 20.0'
Static w/L - 3.04 BGS

$L_e / r_w = 20.0\,\text{ft} / 0.42\,\text{ft} = 47.6$

L_w - 19.96 ft < H - 26.96 ft

$L_w < H$

* Top of confining layer assumed to be 30.0 ft-bgs.

A from graph - 3.10
B from graph - 0.50

Solve for $\ln R_e/r_w$

$$= \left[\frac{1.1}{\ln(L_w/r_w)} + \frac{A + B\ln[(H-L_w)/r_w]}{L_e/r_w} \right]^{-1}$$

$$= \left[\frac{1.1}{\ln(19.96'/0.42')} + \frac{3.10 + 0.50\ln[(26.96-19.96)/0.42]}{47.6} \right]^{-1}$$

$$= (0.285 + 0.0947)^{-1} = \underline{2.63}$$

Solve for k

$$= \frac{r_c^2 \ln(R_e/r_w)}{2L_e} \, 1/t \, \ln y_0/y_t$$

From Graph - $y_0 = 1.30$; $y_t = 0.88$; t - 115 sec

$$= \frac{(0.17)^2(2.63)}{2(20)} \, 1/115 \, \ln 1.30/0.88$$

$$= 6.40 \times 10^{-6}\ \text{ft/s}$$

$$= \underline{\underline{1.97 \times 10^{-4}}}\ \text{cm/s}$$

AWD - 1

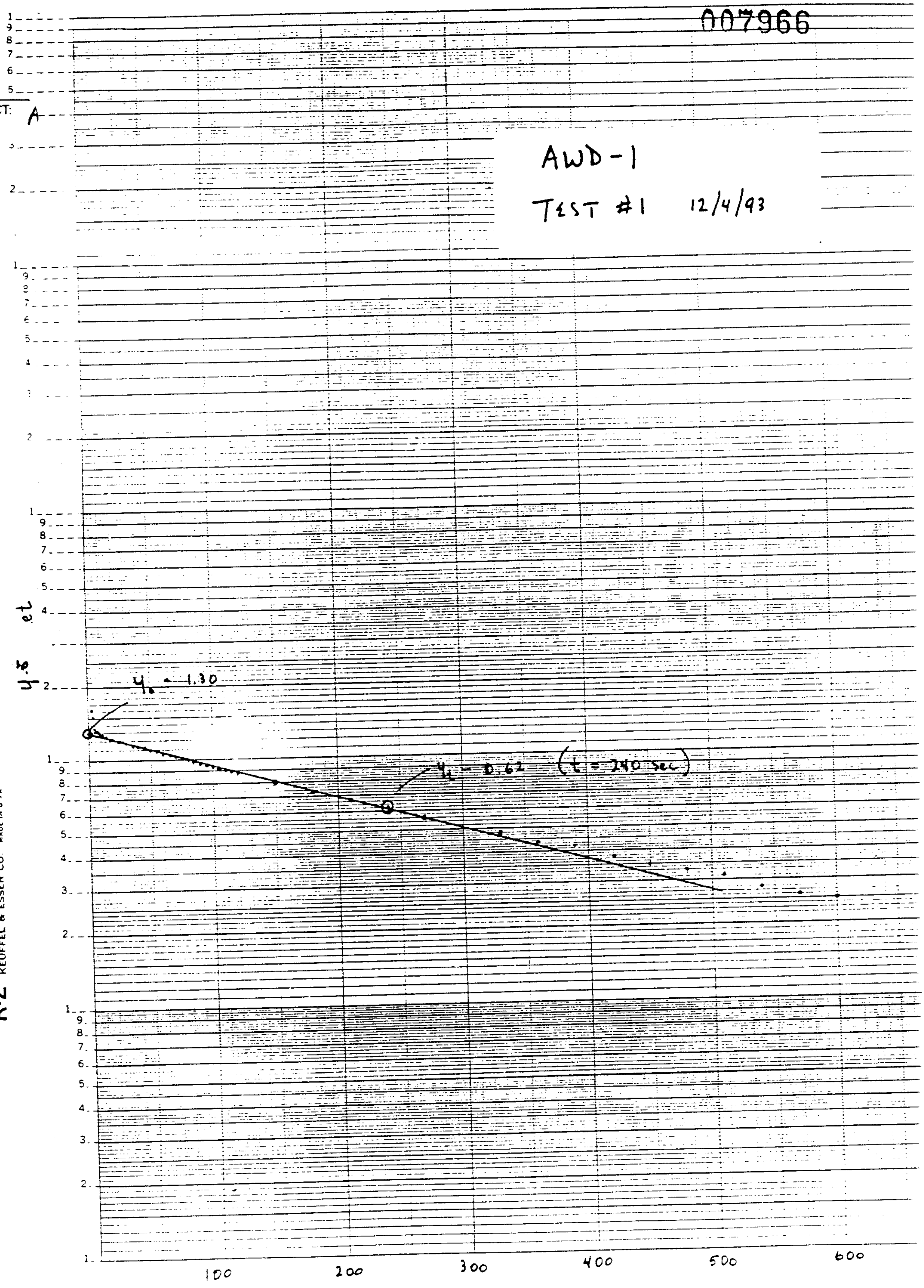
SLUG TEST DATA

TEST PERFORMED
12/4/93

TEST #1

```
        SE1000B
  Environmental Logger
     12/04  15:08

 Unit# 00000  Test# 1

INPUT 1:  Level (F) TOC

Reference          0.00
Scale factor      20.29
Offset           - 0.05

Step# 0   12/04  14:29

Elapsed Time     Value
------------   ---------
    0.0000         0.00
    0.0033         0.55
    0.0066         1.50
    0.0099     -   1.45
    0.0133     -   1.31
    0.0166         2.22
    0.0200         2.20
    0.0233     -   1.42
    0.0266         0.03
    0.0300         3.00
    0.0333     -   0.03
    0.0500         1.63
    0.0666         1.51
    0.0833         1.75
    0.1000         1.31
    0.1166         1.30
    0.1333         1.31
    0.1500         1.29
    0.1666         1.29
    0.1833         1.29
    0.2000         1.27
    0.2166         1.26
    0.2333         1.26
    0.2500         1.25
    0.2666         1.24
    0.2833         1.24
    0.3000         1.24
    0.3166         1.23
    0.3333         1.22
    0.4167         1.20
    0.5000         1.18
    0.5833         1.16
    0.6667         1.13
    0.7500         1.11
    0.8333         1.10
    0.9167         1.08
    1.0000         1.06
    1.0833         1.04
```

```
    1.1667         1.03
    1.2500         1.01
    1.3333         1.00
    1.4166         0.98
    1.5000         0.96
    1.5833         0.95
    1.6667         0.94
    1.7500         0.92
    1.8333         0.90
    1.9167         0.89
    2.0000         0.88
    2.5000         0.80
    3.0000         0.73
    3.5000         0.67
    4.0000         0.62
    4.5000         0.57
    5.0000         0.51
    5.5000         0.48
    6.0000         0.44
    6.5000         0.42
    7.0000         0.38
    7.5000         0.35
    8.0000         0.33
    8.5000         0.31
    9.0000         0.28
    9.5000         0.26
   10.0000         0.25
   12.0000         0.19
   14.0000         0.15
   16.0000         0.12
   18.0000         0.10
   20.0000         0.08
   22.0000         0.07
   24.0000         0.06
   26.0000         0.05
   28.0000         0.05
   30.0000         0.04
   32.0000         0.04
END
```



AWD-1

TEST #1 12/4/93

AWD - 2

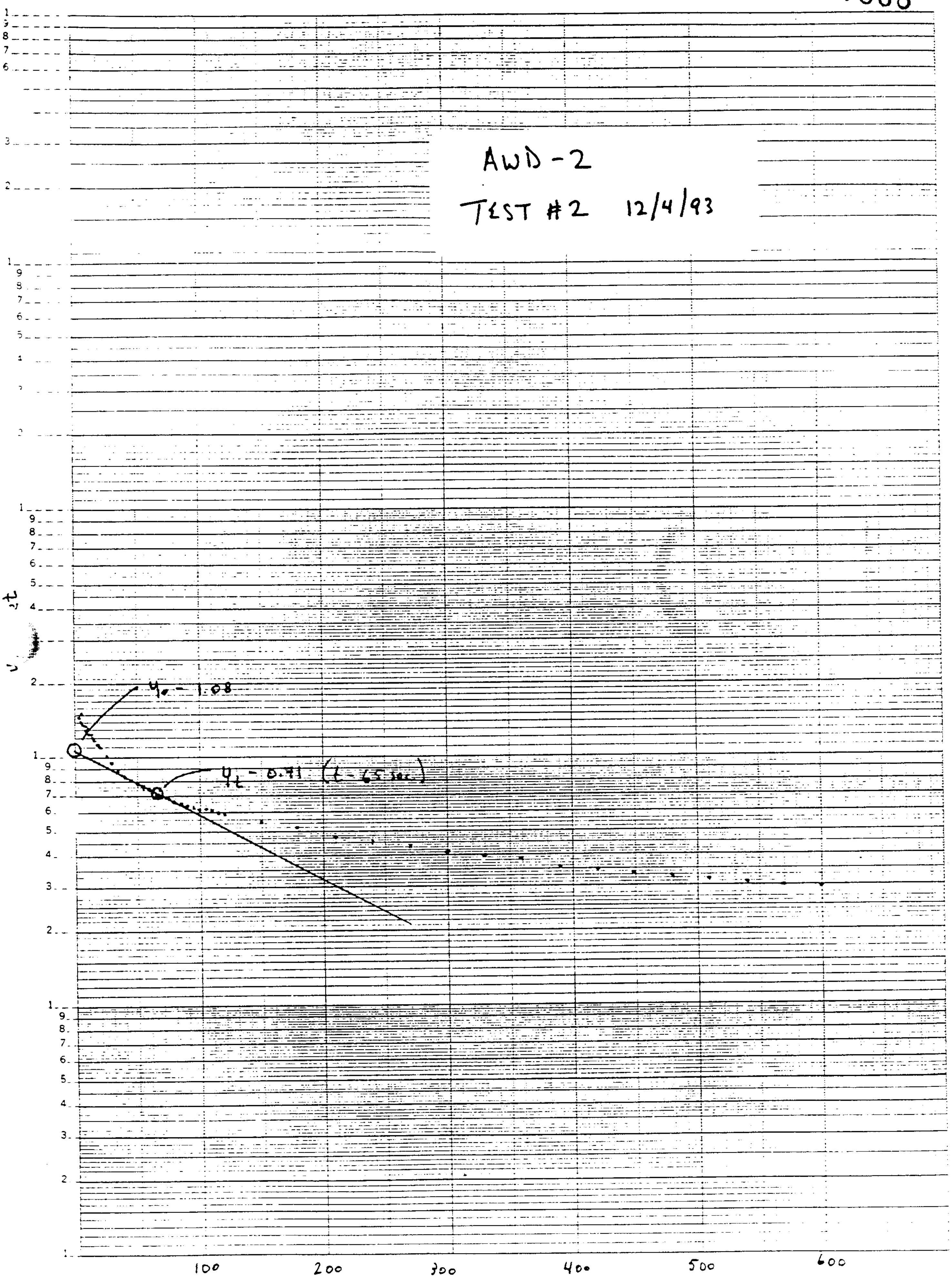
SLUG TEST DATA

TEST PERFORMED
12/4/93

TEST #2

```
Page

         SE1000E
  Environmental Logger
     12/04   13:11

 Unit# 00000  Test 2

INPUT 1:  Level  F  TOC

Reference              0.00
Scale factor          [illegible]
Offset               - [illegible]

Step# 0    12 04   15:27

Elapsed Time        Value
------------      ---------
                     0.17
   0.0000            0.17
   0.0033            0.17
   0.0066            0.21
   0.0099            1.78
   0.0133            1.75
   0.0166      -     1.51
   0.0200      -     [illegible]
   0.0233            2.42
   0.0266            2.90
   0.0300      -     3.17
   0.0333            2.77
   0.0500            1.49
   0.0666            1.40
   0.0833            1.51
   0.1000            1.38
   0.1166            1.38
   0.1333            1.37
   0.1500            1.30
   0.1666            1.31
   0.1833            1.26
   0.2000            1.25
   0.2166            1.21
   0.2333            1.20
   0.2500            1.18
   0.2666            1.16
   0.2833            1.13
   0.3000            1.12
   0.3166            1.10
   0.3333            1.01
   0.4167            0.95
   0.5000            0.89
   0.5833            0.84
   0.6667            0.81
   0.7500            0.78
   0.8333            0.76
   0.9167            0.74
   1.0000            0.71
   1.0833            0.71
   1.1667            0.69
   1.2500            0.67
   1.3333            0.66
   1.4166
```

```
   1.5000            0.64
   1.5833            0.6[illegible]
   1.6667            0.6[illegible]
   1.7500            0.62
   1.8333            0.61
   1.9167            0.60
   2.0000            0.59
   2.5000            0.55
   3.0000            0.52
   3.5000            0.49
   4.0000            0.46
   4.5000            0.44
   5.0000            0.41
   5.5000            0.40
   6.0000            0.38
   6.5000            0.36
   7.0000            0.35
   7.5000            0.34
   8.0000            0.33
   8.5000            0.32
   9.0000            0.31
   9.5000            0.30
  10.0000            0.30
  12.0000            0.27
  14.0000            0.26
  16.0000            0.23
  18.0000            0.23
  20.0000            0.22
  22.0000            0.22
  24.0000            0.21
  26.0000            0.21
  28.0000            0.20
  30.0000            0.21
  32.0000            0.21
  34.0000            0.21
  36.0000            0.20
  38.0000            0.21
  40.0000            0.20
  42.0000            0.20
  44.0000            0.20
END
```


AWD-2

TEST #2 12/4/93

AWD TECHNOLOGIES

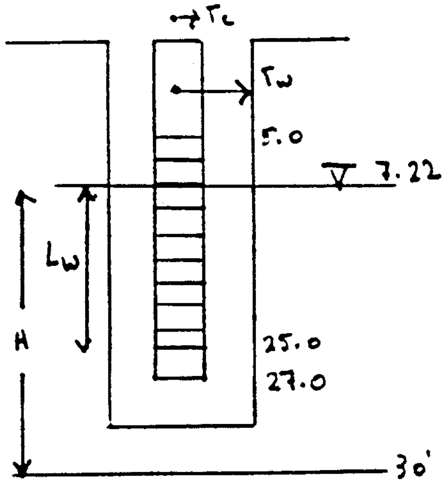
CALCULATION WORKSHEET

007969

CLIENT: USCOE	FILE NO.: 2379	BY: DNM	PAGE 1 OF 1
SUBJECT: AWD-2 SLUG TEST CALCULATIONS (TEST #2)		CHECKED BY:	DATE: 12/22/93

BOUWER & RICE SLUG TEST METHOD

AWD-2



B.H. DIA - 0.83' (r_w - 0.42')
Well ID - 0.33' (r_c - 0.165')
Well TD - 27.0'
Screen Length (L_e) - 20.0'
Static w/L - 7.22 ft-bgs

$L_e/r_w = 20.0/0.42 = 47.6$

L_w - 17.78 ft H - 22.78'
$L_w < H$

A from graph - 3.10 ; B from graph - 0.50

* Assume top of lower confining layer ~ 30 ft-bgs.

Solve for $\ln R_e/r_w$ $= \left[\dfrac{1.1}{\ln(L_w/r_w)} + \dfrac{A + B\ln[(H-L_w)/r_w]}{L_e/r_w}\right]^{-1}$

$$= \left[\frac{1.1}{\ln(17.78'/0.42')} + \frac{3.10 + 0.50\ln[(22.78-17.78)/0.42]}{47.6}\right]^{-1}$$

$$= (0.293 + 0.0911)^{-1} = 2.60$$

Solve for k $= \dfrac{r_c^2 \ln(R_e/r_w)}{2L_e} \, 1/t \, \ln y_0/y_t$

From graph $t = 65$ sec ; y_0 - 1.08 ft ; y_t - 0.71 ft

$$= \frac{(0.165\text{ ft})^2(2.60)}{2(20.0\text{ ft})} \, 1/65 \, \ln 1.08/0.71$$

$$= 1.14 \times 10^{-5}\text{ ft/s} = \underline{\underline{3.48 \times 10^{-4}}}\text{ cm/s}$$

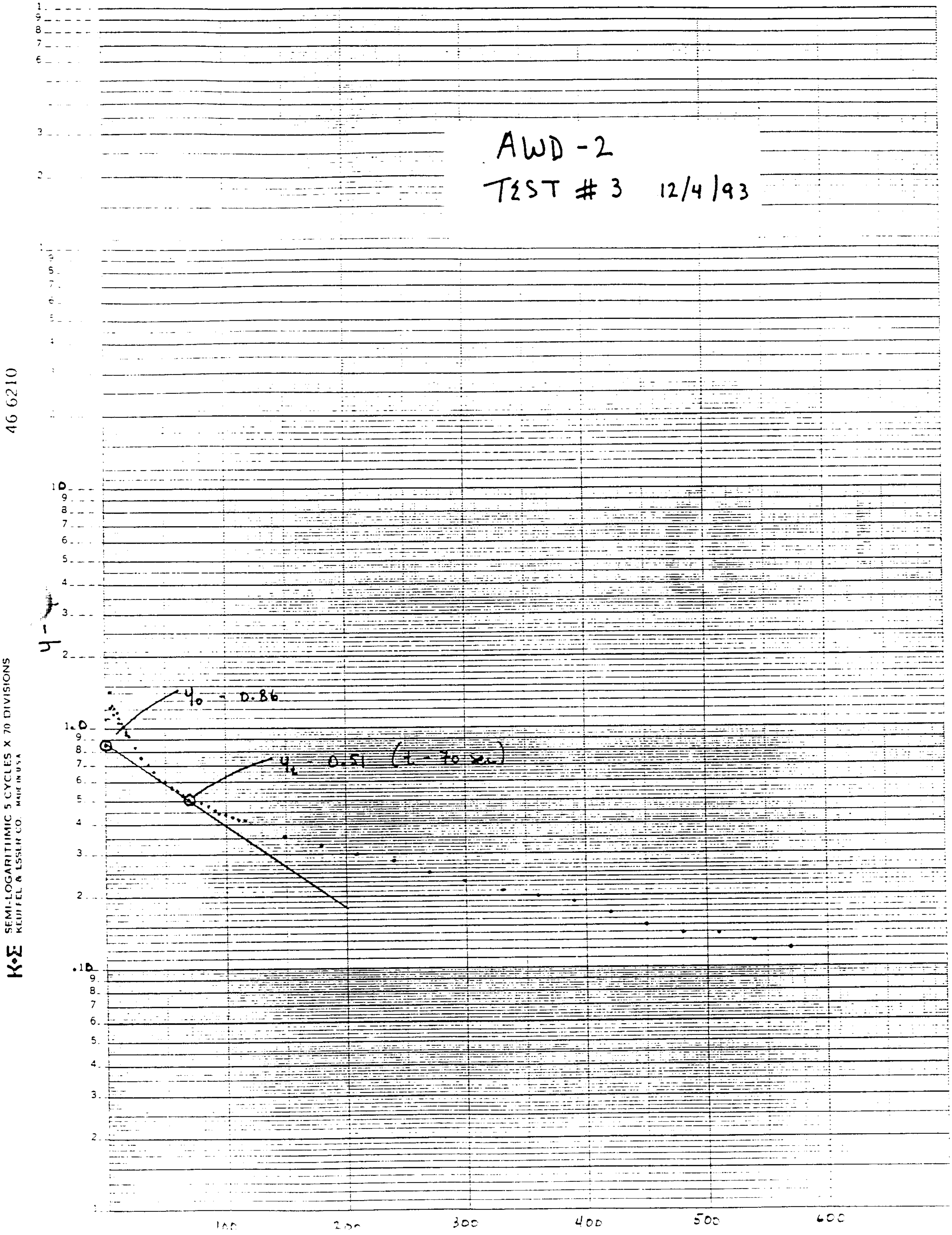
AWD - 2

SLUG TEST DATA

TEST PERFORMED
12/4/93

TEST # 3

```
Ready

    [illegible]
 Environmental Logger
    12/04  19:14

 Unit# 00000  Test# 3

INPUT 1:  Level (F) TOC

Reference         0.00
Scale factor     20.29
Offset          - 0.35

Step# 0   12/04  15:56

Elapsed Time    Value
------------  ---------
    0.0000        0.00
    0.0033        7.00
    0.0066     -  3.00
    0.0099        2.35
    0.0133        1.56
    0.0166        1.51
    0.0200     -  1.22
    0.0233     -  0.17
    0.0266        1.92
    0.0300     -  0.10
    0.0333     -  0.34
    0.0500        1.93
    0.0666        1.10
    0.0833        1.43
    0.1000        1.22
    0.1166        1.25
    0.1333        1.22
    0.1500        1.16
    0.1666        1.17
    0.1833        1.11
    0.2000        1.10
    0.2166        1.06
    0.2333        1.05
    0.2500        1.01
    0.2666        1.01
    0.2833        0.97
    0.3000        0.95
    0.3166        0.94
    0.3333        0.92
    [illegible]   0.87

    [illegible]   [illegible]
    [illegible]   [illegible]
    [illegible]
    0.6667        [illegible]
    0.7500        [illegible]
    0.8333        [illegible]
    0.9166        0.57
    1.0000        [illegible]
    1.0833        [illegible]
    1.1667        0.51
    1.2500        0.50
    1.3333        0.49
    1.4166        0.48
    1.5000        0.46
    1.5833        0.45
    1.6667        0.44
    1.7500        0.43
    1.8333        0.42
    1.9167        0.42
    2.0000        0.40
    2.5000        0.36
    3.0000        0.33
    3.5000        0.30
    4.0000        0.28
    4.5000        0.25
    5.0000        [illegible]
    5.5000        0.21
    6.0000        0.20
    6.5000        0.19
    7.0000        0.17
    7.5000        0.15
    8.0000        0.14
    8.5000        0.14
    9.0000        0.13
    9.5000        0.12
   10.0000        0.12
   12.0000        0.09
   14.0000        0.07
   16.0000        0.06
   18.0000        0.06
   20.0000        0.05
   22.0000        0.04
   24.0000        0.04
   26.0000        0.03
   28.0000        [illegible]
   30.0000        [illegible]
End
```



AWD-2
TEST #3 12/4/93

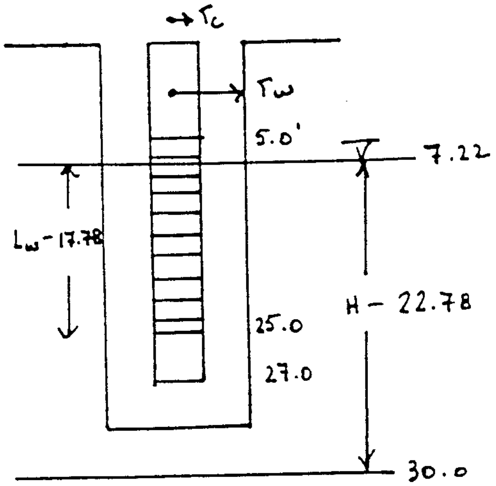
007972

AWD TECHNOLOGIES

CALCULATION WORKSHEET

CLIENT: USCOE	FILE NO.: 2379	BY: DNM	PAGE 1 OF 1
SUBJECT: AWD-2 SLUG TEST CALCULATION TEST #3		CHECKED BY:	DATE: 12/23/93

BOUWER & RICE SLUG TEST METHOD



B.H. DIA - 0.83' (r_w - 0.42')
Well ID - 0.33' (r_c - 0.165')
Well TD - 27.0'
Screen Length (L_e) - 20.0'
Static W/L - 7.22 ft-bgs.

$L_e / r_w \Rightarrow 20.0/0.42 = 47.6$

L_w - 17.78 ft H - 22.78 ft
$L_w < H$

* Assume top of lower confining layer ~ 30 ft-bgs.

A from graph - 3.10
B from graph - 0.50

Solve for $\ln R_e/r_w$:

$$\ln R_e/r_w = \left[\frac{1.1}{\ln(L_w/r_w)} + \frac{A + B\ln[(H-L_w)/r_w]}{L_e/r_w} \right]^{-1}$$

$$= \left[\frac{1.1}{\ln(17.78/0.42)} + \frac{3.10 + 0.50\ln[(22.78-17.78)/0.42]}{47.6} \right]^{-1}$$

$$= (0.293 + 0.0911)^{-1} = \underline{2.60}$$

Solve for K:

$$K = \frac{r_c^2 \ln(R_e/r_w)}{2 L_e} \frac{1}{t} \ln \frac{y_0}{y_t}$$

From graph t - 70 seconds ; y_0 - 0.86 ; y_t - 0.51

$$= \frac{(0.165)^2 (2.60)}{2(20.0)} \frac{1}{70} \ln \frac{0.86}{0.51}$$

$$= 1.32 \times 10^{-5} \text{ ft/s}$$

$$= \underline{4.03 \times 10^{-4} \text{ cm/s}}$$

AWD-4

007973

SLUG TEST DATA

TEST PERFORMED 12/7/93

TEST #5

```
       SE1000E
 Environmental Logger
     12/07 17:49

  Unit# 00000  Test# 5

INPUT 1:  Level (F) TOC

Reference          0.00
Scale factor      20.09
Offset           - 0.35

Step# 0   12/07  11:01

Elapsed Time     Value
------------   ---------
   0.0000       -  0.00
   0.0033          0.00
   0.0066          0.10
   0.0099          1.29
   0.0133          1.47
   0.0166          0.17
   0.0200          0.28
   0.0233          0.35
   0.0266          0.50
   0.0300          0.55
   0.0333          1.23
   0.0500          1.78
   0.0666          1.43
   0.0833          1.35
   0.1000          1.36
   0.1166          1.49
   0.1333          1.30
   0.1500          1.29
   0.1666          1.25
   0.1833          1.20
   0.2000          1.15
   0.2166          1.14
   0.2333          1.11
   0.2500          1.10
   0.2666          1.07
   0.2833          1.05
   0.3000          1.03
   0.3166          1.01
   0.3333          0.99
   0.4166          0.91
   0.5000          0.84
   0.5833          0.78
   0.6666          0.74
   0.7500          0.71
   0.8333          0.67
   0.9166          0.65
   1.0000          0.63
   1.0833          0.62
   1.1666          0.60
   1.2500          0.59
   1.3333          0.58
   1.4166          0.59
   1.5000          0.56
   1.5833          0.56
   1.6666          0.55
   1.7500          0.54

   1.8333     [illegible]
   1.9166     [illegible]
   2.0000     [illegible]
   2.5000     [illegible]
   3.0000          0.44
   3.5000          0.44
   4.0000          0.42
   4.5000          0.41
   5.0000          0.39
   5.5000          0.38
   6.0000          0.37
   6.5000          0.35
   7.0000          0.35
   7.5000          0.34
   8.0000          0.33
   8.5000          0.32
   9.0000          0.31
   9.5000          0.30
  10.0000          0.28
  12.0000          0.25
  14.0000          0.24
  16.0000          0.21
  18.0000          0.20
  20.0000          0.18
  22.0000          0.16
  24.0000          0.14
  26.0000          0.14
  28.0000          0.13
  30.0000          0.11
  32.0000          0.10
  34.0000          0.08
  36.0000          0.08
  38.0000          0.07
  40.0000          0.07
  42.0000          0.05
  44.0000          0.05
  46.0000          0.04
  48.0000          0.03
  50.0000          0.03
  52.0000          0.02
  54.0000          0.02
  56.0000     [illegible]
  58.0000     [illegible]
  60.0000     [illegible]
END
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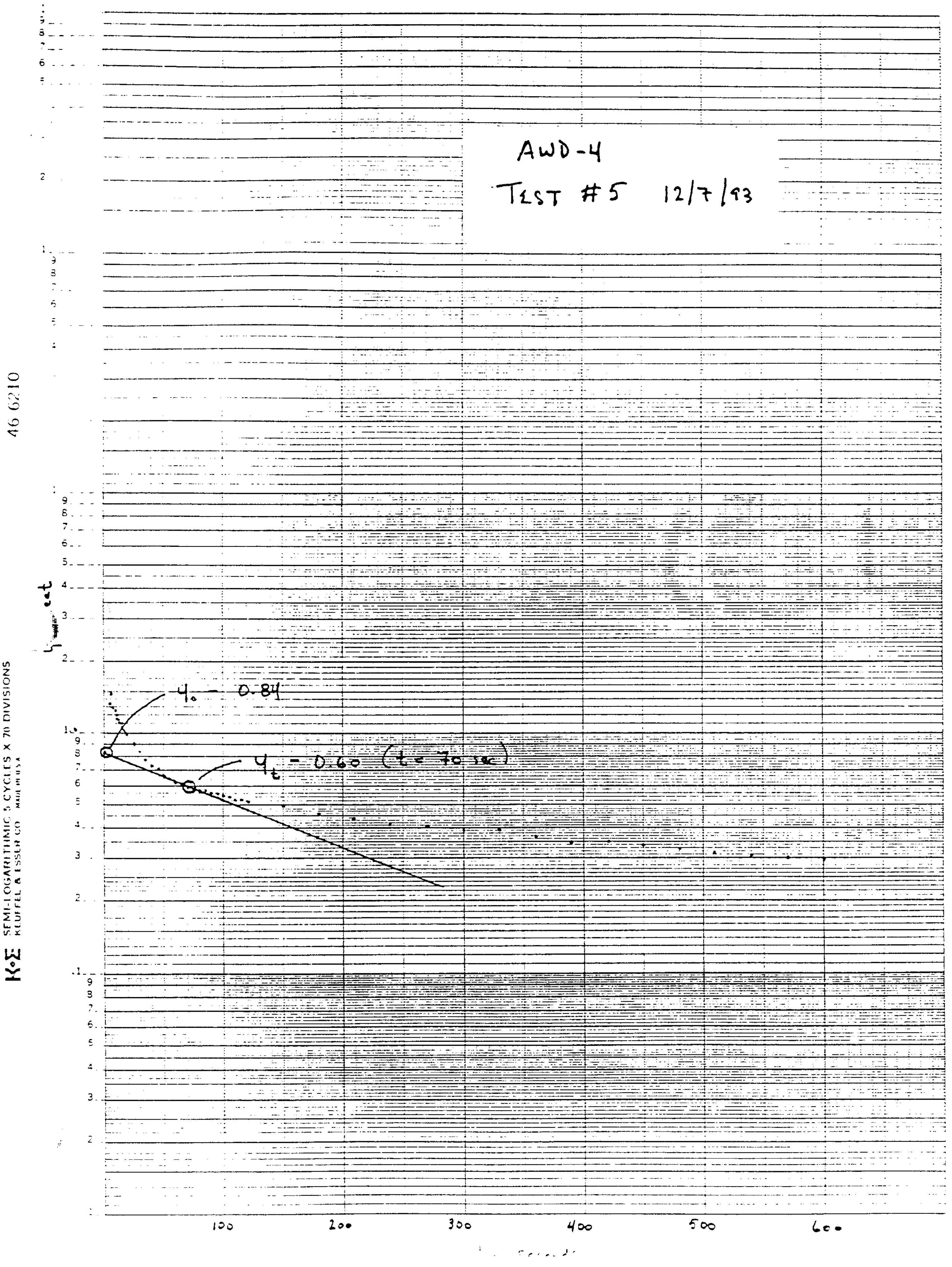


AWD-4

TEST #5 12/7/93

y_0 - 0.84

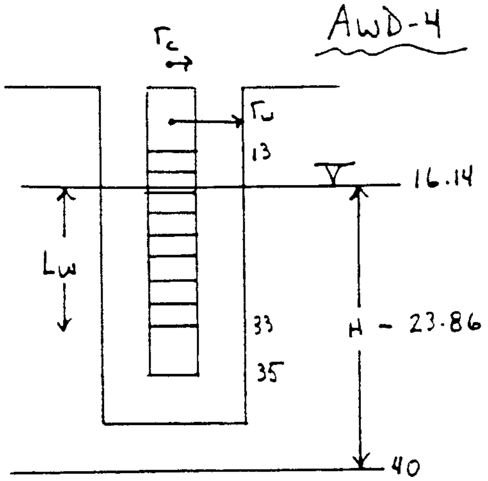
y_t - 0.60 (t = 70 sec)

AWD TECHNOLOGIES

CALCULATION WORKSHEET

CLIENT: USCOE	FILE NO.: 2379	BY: DNM	PAGE 1 OF 1
SUBJECT: AWD-4 SLUG TEST CALCULATION TEST # 5		CHECKED BY:	DATE: 12/27/93

AWD-4



Bouwer & Rice Slug Test Method

B.H. Dia. - 0.83' (r_w - 0.42')
Well I.D. - 0.33' (r_c - 0.165')
Well TD - 35.0'
Screen Length - 20.0'
Static W/L - 16.14 ft-bgs

L_e / r_w - 20.0' / 0.42' = 47.6'

L_w - 16.86' < H - 23.86'

* Assume top of lower confining layer ~ 40 ft-bgs

A - from graph - 3.10
B - from graph - 0.50

Solve for ln Re/r_w

$$= \left[\frac{1.1}{\ln(L_w / r_w)} + \frac{A + B \ln[(H - L_w)/r_w]}{L_e / r_w} \right]^{-1}$$

$$= \left[\frac{1.1}{\ln(16.86'/0.42')} + \frac{3.10 + 0.50 \ln[(23.86 - 16.86)/0.42]}{47.6'} \right]^{-1}$$

$$= (0.30 + 0.095)^{-1} = \underline{\underline{2.53}}$$

Solve for K

$$= \frac{r_c^2 \ln(R_e / r_w)}{2 L_e} \, \frac{1}{t} \ln \frac{y_0}{y_t}$$

From graph:

y_0 - 0.84'
y_t - 0.60'
t - 70 sec.

$$= \frac{(0.165')^2 (2.53)}{2 (20.0')} \, \frac{1}{70 \text{ sec}} \ln \frac{0.84}{0.60}$$

$$= 8.3 \times 10^{-6} \text{ ft/s}$$

$$= \underline{\underline{2.5 \times 10^{-4} \text{ cm/s}}}$$

AWD-4

007976

SLUG TEST DATA

TEST PERFORMED
12/5/93

TEST # 4

```
eady

      SE1000B
 E    ronmental Logger
    12/05  17:44

 Unit# 00000  Test# 4

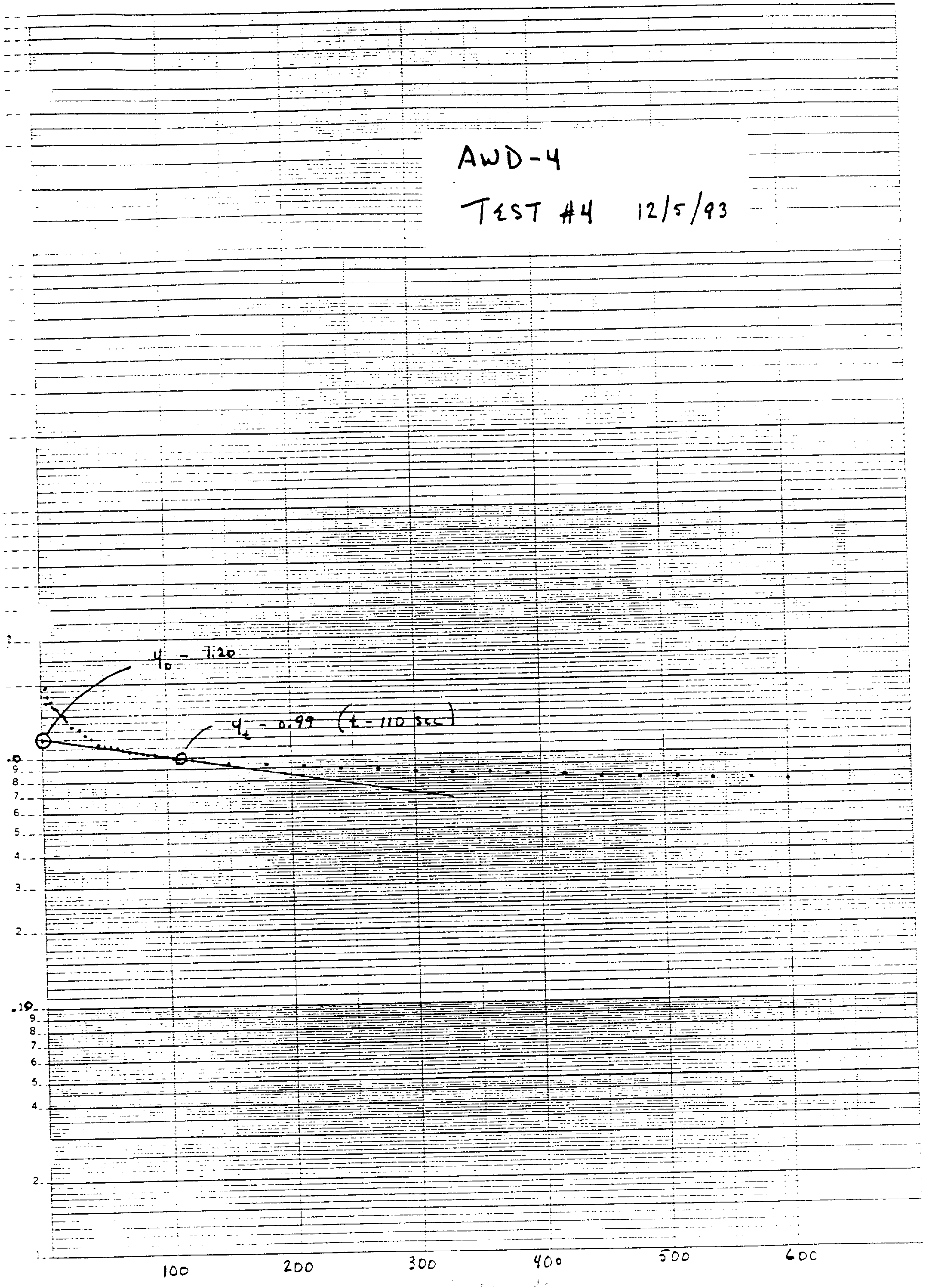
NPUT 1:  Level (F) TOC

eference          0.00
cale factor      10.0?
ffset            -0.75

tep# 0    12/05  17:05

lapsed Time     Value
--  ---       -  ---
eady
   0.0000         0.41
   0.0033         1.46
   0.0066         1.47
   0.0100         1.88
   0.0133         2.20
   0.0166         1.[illegible]
   0.0200         2.20
   0.0233         0.79
   0.0266         1.10
   0.0300         1.1[illegible]
   0.0333         1.[illegible]
   0.0500         1.57
   0.0666         1.86
   0.0833         1.70
   0.1000         1.81
   0.1166         1.79
   0.1333         1.72
   0.1500         1.68
   0.1666         1.66
   0.1833         1.64
   0.2000         1.61
   0.2166         1.59
   0.2333         1.58
   0.2500         1.56
   0.2666         1.54
   0.2833         1.52
   0.3000         1.49
   0.3166         1.48
   0.3333         1.46
   0.4167         1.37
   0.5000         1.31
   0.5833         1.25
   0.6667         1.20
   0.7500         1.17
   0.8333         1.13
   0.9167         1.11
   1.0000         1.10
   1.0833         1.08
   1.1667         1.06
   1.2500         1.06
   1.3333         1.04
   1.4166         1.04
   1.5000         1.03
   1.5833         1.01
   1.6667         1.01
   1.7500         1.00
   1.8333         0.99
   1.9167         0.99
   2.0000         0.98
   2.5000         0.95
   3.0000         0.9[illegible]
   3.5000         0.91
   4.0000         0.90
   4.5000         0.88
   5.0000         0.8[illegible]
```

```
  5.5000       0.85
  6.0000       0.84
  6.5000       [illegible]
  7.0000       [illegible]
  7.5000       0.81
  8.0000       0.79
  8.5000       0.78
  9.0000       0.75
  9.5000       0.73
 10.0000       0.75
 12.0000       0.7[illegible]
 14.0000       0.70
 16.0000       0.68
 18.0000       0.65
 20.0000       0.64
 22.0000       0.63
 24.0000       0.61
 26.0000       0.60
 28.0000       0.58
 30.0000       0.59
 32.0000       0.56
 34.0000       0.56
 36.0000       0.54
 38.0000       0.53
 40.0000       0.52
 42.0000       0.52
 44.0000       0.51
 46.0000       0.51
 48.0000       0.50
 50.0000       0.49
 52.0000       0.49
 54.0000       0.47
 56.0000       0.48
 58.0000       0.47
 60.0000       0.47
 62.0000       0.46
 64.0000       0.46
 66.0000       0.46
 68.0000       0.46
 70.0000       0.45
 72.0000       0.44
 74.0000       0.44
 76.0000       0.44
 78.0000       0.44
 80.0000       0.44
 82.0000       0.44
 84.0000       0.44
 86.0000       0.44
 88.0000       0.44
 90.0000       0.43
 92.0000       0.43
 94.0000       0.43
 96.0000       0.43
 98.0000       0.43
 100.000       0.43
 110.000       0.42
 120.000       0.42
 130.000       0.42
 140.000       0.42
 150.000       0.41
END
```



AWD-4

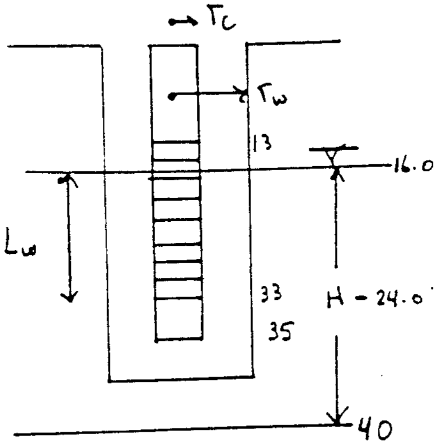
TEST #4 12/5/93

AWD TECHNOLOGIES

CALCULATION WORKSHEET

CLIENT: USCOE	FILE NO.: 2379	BY: DNM	PAGE 1 OF 1
SUBJECT: AWD-4 Slug Test Calculation Test #4		CHECKED BY:	DATE: 12/23/93

Bouwer & Rice Slug Test Method



B.H. Dia - 0.83' (r_w - 0.42')
Well ID - 0.33' (r_c - 0.165')
Well TD - 35.0' ft-bgs
Screen Length (L_e) - 20.0' ft
Static w/L - 16.0 ft-bgs

L_e/r_w - 20.0/0.42' - 47.6
L_w - 17.0 ft H - 24.0 ft

* Assume top of lower confining ~ 40 ft-bgs.

A from graph - 3.10
B from graph - 0.50

Solve for $\ln R_e/r_w$

$$= \left[\frac{1.1}{\ln(L_w/r_w)} + \frac{A + B\ln\left[(H-L_w)/r_w\right]}{L_e/r_w}\right]^{-1}$$

$$= \left[\frac{1.1}{\ln(17.0/0.42)} + \frac{3.10 + 0.50\ln\left[(24.0-17.0)/0.42\right]}{47.6}\right]^{-1}$$

$$= (0.29 + 0.0947)^{-1} = \underline{2.60}$$

Solve for k

$$= \frac{r_c^2 \ln(R_e/r_w)}{2L_e} \, {}^1\!/_t \, \ln {}^{y_0}\!/_{y_t}$$

From graph:
t - 110 sec
y_0 - 1.20
y_t - 0.99

$$= \frac{(0.165)^2\,(2.60)}{2\,(20.0)} \, {}^1\!/_{110} \, \ln {}^{1.20}\!/_{0.99}$$

$$= 3.1 \times 10^{-6} \text{ ft/s}$$

$$= \underline{\underline{9.43 \times 10^{-5}}} \text{ cm/s}$$

007979

AWD-3

SLUG TEST DATA

TEST PERFORMED
12/8/93

TEST # 7

```
        SE1000C
  Environmental Logger
   [illegible]

 Unit# [illegible]  Test# [illegible]

INPUT [illegible]

Reference            [illegible]
Scale factor         [illegible]
Offset               [illegible]

Step 0  [illegible]

Elapsed Time     Value
------------   ---------
   0.0000      [illegible]
 [illegible]   [illegible]
 [illegible]   [illegible]
 [illegible]   [illegible]
 [illegible]   [illegible]
 [illegible]   [illegible]
 [illegible]   [illegible]
 [illegible]   [illegible]
   0.0266      [illegible]
   0.0300      [illegible]
 [illegible]   [illegible]
 [illegible]   [illegible]
 [illegible]   [illegible]
 [illegible]      1.40
   0.1000      [illegible]
   0.1166      [illegible]
 [illegible]      1.32
   0.1500         1.29
   0.1666      [illegible]
 [illegible]      1.25
   0.2000      [illegible]
   0.2166      [illegible]
 [illegible]   [illegible]
 [illegible]   [illegible]
 [illegible]   [illegible]
 [illegible]   [illegible]
 [illegible]      1.11
 [illegible]   [illegible]
 [illegible]   [illegible]
 [illegible]   [illegible]
   0.5000      [illegible]
 [illegible]   [illegible]
 [illegible]      0.81
   0.7500         0.77
 [illegible]      0.74
 [illegible]      0.72
   1.0000         0.70
 [illegible]   [illegible]
 [illegible]   [illegible]
 [illegible]      0.56
 [illegible]      0.55
 [illegible]   [illegible]
 [illegible]   [illegible]
 [illegible]   [illegible]
 [illegible]   [illegible]
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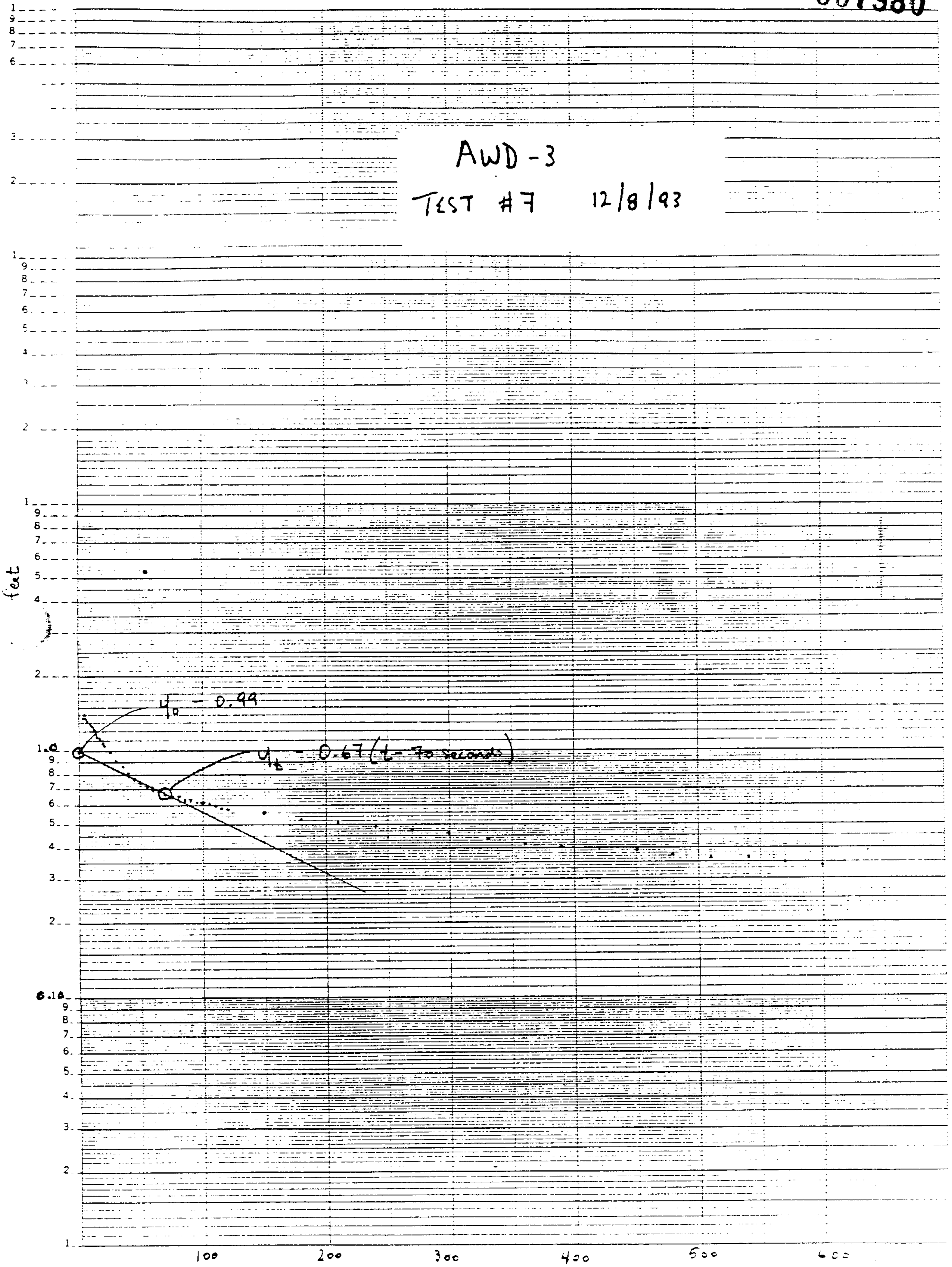
007980



AWD-3

TEST #7 12/8/93

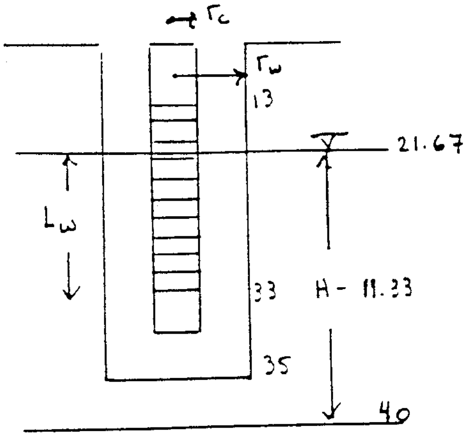
AWD TECHNOLOGIES

CALCULATION WORKSHEET

007981

CLIENT: USCOE	FILE NO.: LitAAP 18:24 2379	BY: DNM	PAGE 1 OF 1
SUBJECT: AWD-3 Slug Test Calculation Test # 7		CHECKED BY:	DATE: 12/27/93

AWD-3



*Assume top of lower confining layer ~ 40' ft-bgs.

Bouwer & Rice Slug Test Method

B.H. Dia - 0.83' (r_w - 0.42')
Well I.D. - 0.33' (r_c - 0.165')
Well TD - 35.0'
Screen Length - 20.0'
Static w/L - 21.67 ft-bgs

L_e / r_w - 20.0/0.42' - 47.6

L_w - 11.33' < H 18.33'

A from graph 3.10
B from graph 0.50

Solve for $\ln R_e/r_w$

$$= \left[\frac{1.1}{\ln(L_w/r_w)} + \frac{A + B \ln[(H-L_w)/r_w]}{L_e/r_w} \right]^{-1}$$

$$= \left[\frac{1.1}{\ln(11.33/0.42)} + \frac{3.10 + 0.50 \ln[(18.33-11.33)/0.42']}{47.6} \right]^{-1}$$

$$= (0.334 + 0.095)^{-1} = \underline{\underline{2.33}}$$

Solve for k

$$= \frac{r_c^2 \ln(R_e/r_w)}{2 L_e} \, {}^1\!/_t \, \ln {}^{y_0}\!/_{y_t}$$

from graph : y_0 - 0.99 ; y_t - 0.67 ; t - 70 sec)

$$= \frac{(0.165)^2 (2.33)}{2(20.0)} \, {}^1\!/_{70} \, \ln {}^{0.99}\!/_{0.67}$$

$$= 8.8 \times 10^{-6} \text{ ft/s} = \underline{2.7 \times 10^{-4} \text{ cm/s}}$$

AWD-3

SLUG TEST DATA

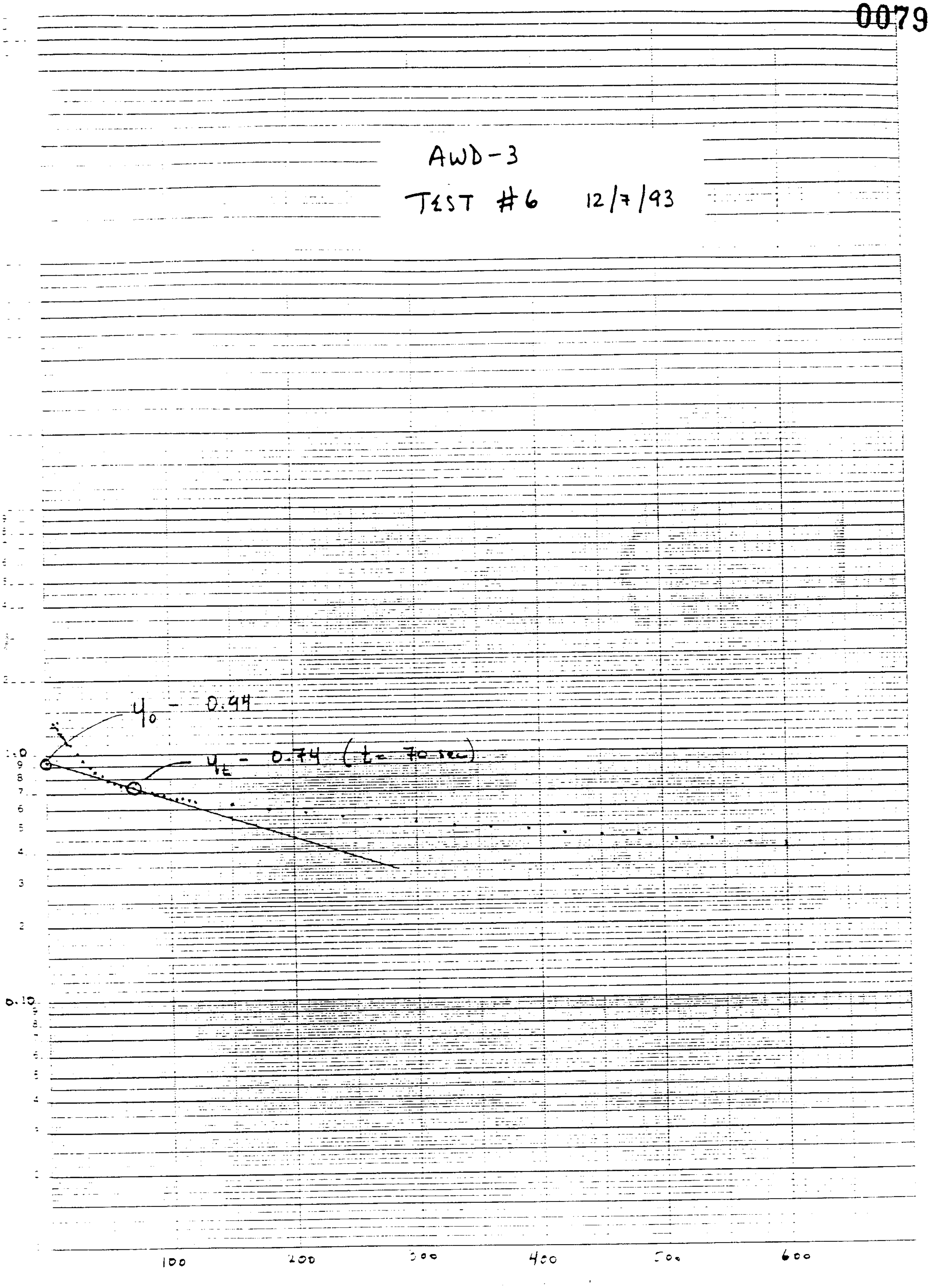
TEST PERFORMED
12/7/93

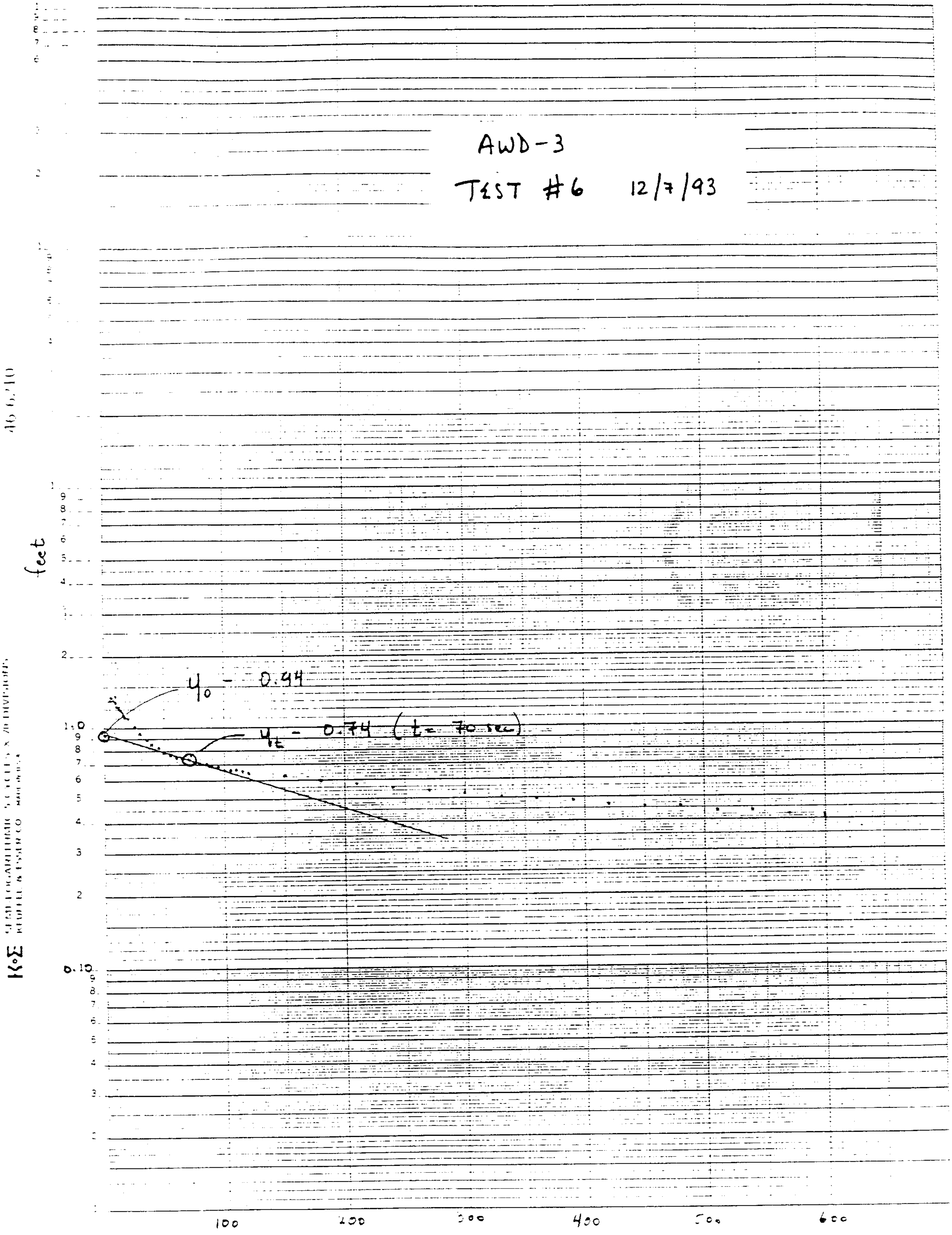
TEST #6

[illegible]

AWD-3

TEST #6 12/7/93





AWD-3

TEST #6 12/7/93

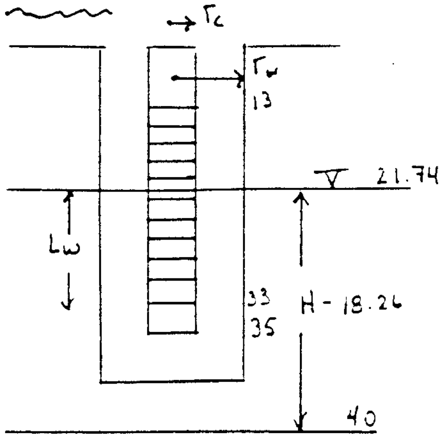
AWD TECHNOLOGIES

CALCULATION WORKSHEET

007985

CLIENT: US COE	FILE NO.: LHAAP 18 : 24 2379	BY: JNM	PAGE 1 OF 1
SUBJECT: AWD-3 Slug Test Calculation Test #6		CHECKED BY:	DATE: 12/27/93

AWD-3



Bouwer & Rice Slug Test Method

B.H. Dia. - 0.83' (r_w - 0.42')

Well ID - 0.33' (r_c - 0.165')

Well TD - 35.0'

Screen Length - 20.0'

Static w/L - 21.74'

L_e / r_w - 20.0/0.42' - 47.6

L_w - 11.26' < H = 18.26'

$\left\{ \begin{array}{l} \text{A from graph - 3.10} \\ \text{B from graph - 0.50'} \end{array} \right.$

* Assume top of lower confining layer ~ 40.0' ft-bgs.

Solve for k $= \left[\dfrac{1.1}{\ln (L_w / r_w)} + \dfrac{A + B \ln \left[(H - L_w) / r_w \right]}{L_e / r_w} \right]^{-1}$

$= \left[\dfrac{1.1}{\ln (11.26 / 0.42')} + \dfrac{3.10 + 0.5 \ln \left[(18.26' - 11.26) / 0.42' \right]}{47.6} \right]^{-1}$

$= (0.334 + 0.095)^{-1} = \underline{\underline{2.33}}$

Solve for k $= \dfrac{r_c^2 \ln (R_e / r_w)}{2 L_e} \; {}^{1}/_{t} \; \ln {}^{y_0}/_{y_t}$

from graph : y_0 - 0.94 ; y_t - 0.74 ; t - 70 sec

$= \dfrac{(0.165')^2 \, (2.33)}{2 (20.0)} \; {}^{1}/_{70 \text{ sec}} \; \ln {}^{0.94}/_{0.74}$

$= 5.4 \times 10^{-6}$ ft/s $=$ 1.65×10^{-4} cm/s

DEPARTMENT OF THE ARMY
LONGHORN/LOUISIANA ARMY AMMUNITION PLANTS
MARSHALL, TEXAS 75671-1059

REPLY TO
ATTENTION OF

007986

RECEIVED
REGION VI
MAR -2 AM 8 47
SUPERFUND BRANCH

22 February, 1994

SMCLO-EN-EV

SUBJECT: Meeting, Longhorn Army Ammunition Plant, for Technical Review Committee (TRC) - March 10, 1994.

Environmental Protection Agency
ATTN: Lisa M. Price (6H-ET)
1445 Ross Avenue
Dallas, Texas 75202

Dear Ms. Price:

Enclosed is a tentative agenda for the TRC Meeting. This will be the ninth meeting for the TRC, and we hope that you will be able to attend.

If you have any questions or suggestions regarding the meeting or agenda, contact Mr. Lynn Muckelrath (903) 679-2980.

Sincerely,

Lawrence J. Sowa

Lawrence J. Sowa
Lieutenant Colonel, U. S. Army
Commanding Officer

Enclosure

DEPARTMENT OF THE ARMY
LONGHORN/LOUISIANA ARMY AMMUNITION PLANTS
MARSHALL, TEXAS 75671-1059

RECEIVED
EPA REGION VI
1994 MAR -1 AM [illegible]
SUPERFUND BRANCH

007987

REPLY TO
ATTENTION OF

February 22, 1994

Environmental Office

Ms. Lisa Price
Superfund Enforcement
U.S. Environmental Protection Agency
1445 Ross Avenue
Dallas, Texas 75202

Dear Ms. Price:

This is the official transmittal letter for the Draft Final Phase I Field Investigation Summary Report for Group II, sent on February 18, 1994.

Please review and send your comments back to us no later than March 4, 1994.

If there are any questions, please contact Mr. Lynn Muckelrath, (903)679-2980.

Sincerely,

Law - J Sowa
Lawrence J. Sowa
Lieutenant Colonel, U.S. Army
Commanding Officer

Enclosures

COGNIS
A Company for Biological and Environmental Technology

007988

AWD TECHNOLOGIES
LONGHORN ARMY AMMUNITION SOIL

FINAL REPORT
COGNIS TerraMet™ Metal Extraction
Phase I Treatability Study

COGNIS, Inc. • 2330 Circadian Way • Santa Rosa, CA 95407
(707) 575-7155 • Fax: (707) 575-7833

TERRAMET™ METAL EXTRACTION TECHNOLOGY

PHASE I TREATABILITY STUDY

LONGHORN ARMY AMMUNITION PLANT BURNING GROUND 3

Prepared For:

AWD Technologies
15204 Omega Drive
Suite 200
Rockville, MA 20850

February 22, 1994

William E. Fristad, Ph.D.
Director, TerraMet™ Technology

TABLE OF CONTENTS

STATEMENT OF THE PROBLEM

COGNIS, Inc. (COGNIS) is to perform a Phase I Treatability Study on soils from the Longhorn Army Ammunition Plant site believed to be contaminated with heavy metals (primarily barium) at unknown concentrations and with high concentrations of solvents (primarily trichloroethylene (TCE) and methylene chloride (MEC)). COGNIS is to characterize two soil samples provided from the Longhorn site with regard to the amounts and types of metal contaminants present. The volatile organic compounds will be removed prior to this characterization as they are not part of this particular study. COGNIS is to then determine whether the proprietary COGNIS metals extraction process (TerraMet™) is amenable to removing or significantly lowering the metals found at elevated concentrations and determine what type of metal recovery process(es) will be applicable to the Longhorn site.

COGNIS was requested to perform the Treatability Study for AWD Technologies based on a contract with a final signature on December 9, 1993.

CONCLUSIONS

No significant metal contamination was found in either of the two samples provided to COGNIS from the Longhorn Army Ammunition Site. Barium levels in both soils from the site were found to be within the background concentration range published for soils in Texas.

Both COGNIS and AWD Technologies agreed upon review of the data in the following sections to cease work on the Longhorn Site samples as it appeared there was no significant metal contamination in these samples.

SCOPE OF WORK

The scope of work is as follows:

- Soil Characterization including pH, % organic matter, gravel, sand, silt, and clay.
- Screening of pretreatment samples utilizing X-Ray Fluorescence (XRF) to determine qualitatively the metallic contamination.
- Quantitative determination of metal contamination, found in qualitative screening, utilizing ICP and/or AA. This will provide a baseline for treatment.
- TCLP on pre-treatment samples.
- Soil classification and metal analysis in the sand and silt/clay fractions.
- Leachability study on whole soil samples with several leachants to determine optimum leachant. Leached and residual metals in soil will be determined. Specific experimental conditions will be chosen and a tailored test plan designed based on the level(s) and type(s) of heavy metal contamination present, this will be determined through the treatability study soil characterization and/or site characterization by AWD.
- TCLP on post-treatment samples to measure leaching success.
- Summary report containing a description of the experimental procedures and all experimental data.

PHASE I TREATABILITY STUDY

Physical Characterization of Soil Sample

Two samples were received from the Longhorn Army Ammunition Site. One of the samples was extracted from Test Pit #1. It was checked in to COGNIS and given Treatability Study (TS) #236. The second sample consisted of a composite of sub-samples taken from Test Pits #2 and #3 and was assigned TS #237 upon check-in at COGNIS. The samples will be referred to by these TS numbers throughout this report. Both samples were damp upon arrival with no standing water and had a definite organic solvent odor. The samples were spread out in a fume hood overnight to allow any volatile organic compounds present to evaporate.

TS #236 appeared nonhomogeneous and high in clay content. The orange, black and white clay balls that were present were quite pliable. TS #227 seemed to be a sandier soil and arrived homogeneous.

A representative sample of each of the soils was dried to a constant weight in a 60 °C oven, all clumps were crushed with a mortar and pestle and the samples blended well. The dried/blended soil samples were used for all further study.

Particle Size Analysis

One kilogram of each of the soils was forwarded to Environmental Technical Services, Petaluma, CA for Particle Size Analysis. The materials were analyzed by ASTM D-422, *Standard Test Method for Particle-Size Analysis of Soils* the results of which are shown in Table I below. Additionally, the samples were analyzed for pH, salinity and organic content.

Table I.
Particle Size Analysis Data

TS Sample				Percent Passing Sieve Size Indicated						Fines Hydrometer Percentage			Fines % of Total
				Medium Sand		Fine Sand			Sand % of Total				
	pH	ECe	Organic Matter %	#20	#40	#60	#140	#200		Silt 0.074 mm	Clay 0.005 mm	Colloid	
#236	5.8	4.4	0.9	1.6	4.8	6.8	12.3	7.8	33.3	36.7	21.6	8.4	66.7
#237	5.0	2.6	0.9	0.1	1.2	5.7	43.9	15.9	66.8	17.4	10.3	5.5	33.2

ECe (mS/cm at 25° C) = salinity/conductivity.
Silt and Clay hydrometer measurements given in millimeters.

As was observed in physical appearance TS #236 was found to be quite high in fines, whereas TS #237 was analyzed to be a sandier soil. Neither soil had any coarse sand or gravel. Both soils were slightly acidic. Neither soil had substantial salinity as indicated by the ECe values. While TS #236 had almost twice the salinity of TS #237, both soils would be considered more or less within the "normal" range for soil salinity. Both soils have a lower than normal organic material concentration (< 1%wt).

Pre-Treatment Metals Analysis

The samples were analyzed by X-Ray Fluorescence (XRF) for a semi-quantitative analysis of the metals present, results are shown in Tables II and III below. Additionally, COGNIS Analytical acid digested 2 gram samples of each soil and analyzed them for those metals of interest found by the initial XRF screening. All metal results are compiled in Tables II and III below.

Table II.
Metals Analysis TS #236 (Soil from Test Pit #1)

Metal	XRF µg/g[1]	DIGEST / ICP µg/g[1]	TEXAS MEAN[2] µg/g
Cr	15	ca. 15[3]	40
Ag	38	-	-
Se	33	< 0.005[3]	0.32
Hg	8	-	0.064
Pb	2	< 26[3]	13
Cd	38	< 14.3[3]	1.04
Sn	1	-	0.97
Ba	385	154	404
Ti	3,298	-	2,390
Mn	167	-	594
Co	174	< 15[3]	4.9
Ni	13	-	12
Cu	0	-	15
Zn	324	39	39
Rb	84	-	60
Sr	99	-	172
Zr	514	-	255
Mo	5	-	0.03
Sb	12	-	< 1.0
As	16	22.3	6.4
K	14,730	-	-
Ca	2,417	-	-
Fe	21,276	-	25,000

[1] Average of three samples.
[2] Reference: *Elements in North American Soils*
[3] Values at or below detection limit for method.

Table III
Metal Analysis TS #237 (Soil from Test Pit # 2 + 3)

Metal	XRF µg/g[1]	DIGEST / ICP µg/g[1]	TEXAS MEAN[2] µg/g
Cr	76	15.8	40
Ag	37	-	0
Se	13	< 0.005[3]	0.32
Hg	0	-	0.064
Pb	7	< 26[3]	13
Cd	7	< 14.3[3]	1.04
Sn	0	-	0.97
Ba	371	661	404
Ti	1,606	-	2,390
Mn	343	-	594
Co	45	< 15[3]	4.9
Ni	0	-	12
Cu	7	-	15
Zn	57	32	39
Rb	41	-	60
Sr	71	-	172
Zr	610	-	255
Mo	0	-	0.03
Sb	14	-	< 1.0
As	5	8.1	6.4
K	8,196	-	-
Ca	2,151	-	-
Fe	9,161	-	25,000

[1] Average of three.

[2] Reference: *Elements in North American Soils*

[3] Values at or below detection limit for method.

The barium value for both treatability study samples fall well within the published range for Texas soils of 150 - 1000 ppm. The value of TS #236 at 154 ppm falls well below the Texas mean of 404 ppm (+/-200 ppm is one standard deviation) and the barium value for TS #237 at 661 ppm falls just outside one standard deviation, but still within the published range.

Pre-Treatment EPA-TCLP Test

The standard EPA TCLP test on extractable metals was conducted on the two soil samples by an independent laboratory, D&M Laboratories, Petaluma, CA. The results are shown in Table IV below.

Table IV.
Pre-Treatment TCLP Results

Metal	TS #236 (mg/L)	TS #237 (mg/L)	Detection Limit (mg/L)
Ba	1.5	3.4	0.10
Cd	ND	ND	0.10
Cr	ND	ND	0.050
Pb	ND	ND	0.15
Ag	ND	ND	0.050
As	ND	ND	0.025
Se	ND	ND	0.025
Hg	ND	ND	0.0032

As shown in the Table both soils displayed a non-detect result for all TCLP metals except barium. Both soils pass the TCLP for barium however by a large margin, the level at which barium is considered hazardous by TCLP is 100 mg/L.

Due to the fact that the barium concentrations for both samples were within the normal range for soils in the Texas area and that the soils clearly passed the EPA TCLP test for all metals no further work was done on these samples.

DRAFT

TREATABILITY VERIFICATION OF AIR STRIPPING ON CONTAMINATED GROUND WATER FROM LONGHORN ARMY AMMUNITION PLANT

February 24, 1994

Performed for:

AWD Technologies, Inc.
Suite 200
15204 Omega Drive
Rockville, Maryland 20850

by

IC Technologies, Inc.
11475 West I-70 Frontage Road North
Wheat Ridge, Colorado 80033

John E Litz
John E. Litz
President

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ABSTRACT

Air stripping studies were performed in the laboratory on samples of ground water from the Longhorn Army Ammunition Plant. The groundwater contained 3,000 mg/L methylene chloride and 90 mg/L trichloroethylene as the principal volatile organics. The laboratory tests reduced the methylene chloride to 0.0069 mg/L (6.9 parts per billion) and the trichloroethylene to 0.0006 mg/L (0.6 parts per billion). This data showed 99.9997% removal of the methylene chloride.

A pilot scale air stripper was designed and costed to treat 20 gpm of site groundwater. The air stripper off-gas, containing the methylene chloride and trichloroethylene, would be oxidized to hydrochloric acid and carbon dioxide by a catalytic oxidizer. The hydrochloric acid and carbon dioxide would then be removed using an alkaline scrubbing solution. The installed cost for an air stripper system to treat 20 gpm of groundwater is estimated at $114,000.

INTRODUCTION AND SUMMARY

Burning Ground 3 and the Unlined Evaporation Pond site at the Longhorn Army Ammunition Plant (LAAP) are underlain with contaminated ground water containing 0.1-200 mg/L trichloroethylene (TCE), 0.1-9,000 mg/L methylene chloride (MEC), and heavy metals such as barium, lead, and chromium. Extraction and treatment of this contaminated ground water is part of an interim remedial action program being implemented by the Tulsa District, U. S. Army Corps of Engineers.

Air stripping has proven to be a technically and economically feasible method for removing volatile organic compounds (VOC's) in groundwater to meet drinking water regulations. Air stripping is most viable when the contaminants of concern have Henry's Law constants that are smaller than 2,000. Air stripping, therefore, is an effective method for removing TCE and MEC from the contaminated groundwater at the LAAP site as their Henry's Law constants are 648 and 138, respectively.

A series of tests was performed by passing 55-gallon quantities of ground water through a 4-inch diameter by 64-inch packed section air stripper column. These tests demonstrated that at least seven passes through the air stripper were required to reduce the methylene chloride and trichloroethylene to below drinking water standards.

The laboratory data was used to size a pilot column. A pilot column 14-inches diameter by 45-feet tall with an air flow of 100 scfm was determined to be suitable for achieving the desired contaminant removal. The volatile containing off-gas would be incinerated using a catalytic oxidation unit. The oxidized gas then would be alkali-scrubbed to remove the hydrochloric acid and carbon dioxide that formed in the oxidizer. The estimated installed cost for the pilot air stripper is $114,000.

TECHNOLOGY REVIEW

The design parameters for an air stripping facility are influenced by a number of factors. These include:

1. The maximum concentration of strippable contaminants in the feed water
2. The target effluent levels, usually drinking water standards
3. The quantity of elements or components that may precipitate during air stripping.
4. The potential for algae deposition and fouling.
5. The compatibility with other unit operations that may be used, i.e., to remove the metals.

A review was made of relevant literature in the IC Technologies' library and technical files and a computer search was made of Chemical Abstracts and National Technical Information Service (NTIS) for papers relevant to air stripping of methylene chloride or trichloroethylene. Although many references were found relative to stripping to remove trichloroethylene, only one reference contained any information on methylene chloride. This probably is due to the fact that methylene chloride is so volatile, that it seldom is around to follow a water stream into the groundwater.

SAMPLES - CHARACTERIZATION

Five 55-gallon metal drums containing water from the LAAP site were received for testing. The two drums, designated MW-1, MW-2, were prepared for analysis by creating a composite of equal representative portions of each drum. Sample EW-1, one of three 55-gallon drums, was submitted for analysis in its as-received condition. Analyses are summarized in Table 1.

The inorganic content of the water samples was relatively low, 1100-1300 mg/L of common ions. The nitrate levels were significant at 31-73 mg/L. The silica also was significant at 35-40 mg/ L. Barium was fairly low, 2.1-3.4 mg/L.

Solids removal

Following initial sampling for characterization, small (~175-milliliter) aliquots of each groundwater sample (MW-1, MW-2, & EW-1) were taken. The samples were transferred to 200-mL volumetric flasks fitted with sparge tubes. Each sample was air-sparged for 64 hours to evaluate and quantify solids precipitation. A small quantity of orange-colored, fine precipitate, presumable iron hydroxide, formed in each of the samples. Filtration of the samples showed the following:

Sample ID	mg Precipitate ($Fe(OH)_2$)
MW-1	8
MW-2	18
EW-1	8

These data predict a potential average precipitated solids concentration of ~57 mg/L, assuming contributions of 20% MW-1, 20% MW-2, and 60% EW-1 groundwater (this was the ratio of quantities received). This concentration was judged to be insignificant with respect to efficient air stripper operation; optimization of precipitation conditions, and pretreatment of site water for air stripping tests were deemed unnecessary.

Table 1

LONGHORN ARMY AMMUNITION PLANT
Monitor and Extraction Well Analyses and Ion Balance

	Monitor Well Composite		Extraction Well	
	mg/L	Ion Balance meq/L	mg/L	Ion Balance meq/L
Anions				
Chloride	918	25.86	324	9.13
Nitrite	<2.5		1.66	
Nitrate	31.4	0.51	73	1.18
Bromide	1.78	0.02	0.66	0.01
Ortho-phosphate	<0.25		<0.25	
Sulfate	6.33	0.13	4.25	0.09
Fluoride	1.53	0.08	<0.4	
Silica, SiO2	35	1.17	40	1.33
Anion sum		27.76		11.73
Cations				
Ammonia (N)	<0.8		<0.8	
Lead	<0.055		<0.055	
Barium	4.7	0.07	1.5	0.02
Chromium	<0.016		<0.016	
Manganese	1.7	0.06	0.62	0.02
Iron	18	0.64	12	0.43
Calcium	120	6.00	39	1.95
Magnesium	95	7.82	29	2.39
Sodium	370	16.09	200	8.70
Potassium	5.2	0.13	1.5	0.04
Cation sum		30.81		13.54
Organics				
Benzoic acid	0.3		0.94	
Chloromethane	46		12	
Methylene chloride	4,600		3,000	
Chloroform	10			
Acetone			130	
Trichloroethene	94		90	
Xylenes, total			8.4	

Analyses by Evergreen:
Organics by 8240 and 8270

AIR STRIPPER BENCH TESTING

Test work conducted to evaluate air stripping as a treatment technology for Longhorn Army Ammunition Plant (LAAP) contaminated groundwater proceeded in accordance with the Work Plan prepared by IC Technologies. The Test Program was comprised of three areas of investigation: solids removal, air stripping optimization, and air stripping demonstration.

Apparatus

All air stripper testing was conducted with a four-inch (0.01-m) diameter, nominally six-foot tall column constructed of transparent polyvinyl chloride. The active stripping height of the column was ~5.4 feet (1.65 m) as determined by the height of packing. One-inch (2.54-cm) diameter spherical Jaeger Tri-Packs were used as packing. Freeboard of approximately seven inches (18 cm) was provided at the top of the stripper for sprayer head and exhaust piping. The sprayer head was fabricated to disperse influent over the packing thereby minimizing channeling as much as possible.

Influent was introduced to the stripper from 55-gallon containers by a submersible, centrifugal pump, that was valved to permit control of the flow rate. The flow rates were adjusted and confirmed by weight per unit time using plain water. The calibration procedure was conducted by pumping water (down flow) through the stripper with air flow within the anticipated operating range. Pumping rate was determined by delivery at the stripper discharge.

Air was supplied by compressor; flow rates were measured by two rotameters piped in parallel. One rotameter's range permitted measurements to 0.7 scfm, while the second allowed measurements to 10 scfm. Air flow rates were corrected for altitude (625 mm Hg) for all tests.

Influent Water

Samples of contaminated groundwater received from AWD included one 55-gallon drum labeled MW-1, one drum labeled MW-2 and three drums labeled EW-1. This ratio was preserved in creation of several composite samples for air stripping test work. All air stripping tests utilized 55 gallons influent at a composite ratio of 20% MW-1, 20% MW-2, and 60% EW-1.

Sampling

Proper sampling of solutions containing volatile organic compounds was important not only from a quality control/assurance perspective, but also to the accurate interpretation of analytical data. All head, control, and QA/QC samples were obtained using standard sampling procedures for volatile organic compounds, i.e. collected into zero head space, septum to 40-mL vials. All samples were preserved with hydrochloric acid and refrigerated during storage prior to analysis.

Test Series

Laboratory studies were performed by passing contaminated groundwater down flow through the laboratory-scale air stripper, with continuous air up flow. Influent pumping rate was fixed at 2 gallons per minute (20 gpm/sq ft, 13.6 kg/m^2/sec) for all testing; air flow rate was varied during optimization testing. Testing discussed below is summarized in Table 2. Because of the high concentrations of methylene chloride, other components were not followed during the air stripping studies, except on those samples that were approaching the target concentration levels..

Series One: The first series of tests, 1002-79, consisted of three passes through the stripper at air flow rates of 0.35, 0.7, 2.0, 5.0, and 7.8 scfm (3.5, 7.0, 20, 50, and 78 scfm/sq ft or 1.018, 0.036, 0.10, 0.25, and 0.40 m^3/m^2/sec. The tests were conducted by increasing the air flow rate every five minutes, with sampling of stripper effluent one minute before each condition change. This procedure was repeated for each pass. At the conclusion of each pass, the combined, blended stripper effluent for that pass was sampled, then pumped to the stripper as influent for the next pass. A total of 18 samples resulted. Analysis for methylene chloride (MEC) by gas chromatography showed the influent composite sample at 2,380 mg/L MEC. Analysis of effluent composite samples showed MEC at 1,300 mg/L or 45.4% removal at pass #1, 525 mg/L or 77.9% removal at pass #2, and 139 mg/L or 94.2% removal at pass #3. As expected, analysis of kinetic samples showed increasing stripper efficiency with increasing air flow rate. Removal efficiency as a function of air flow rate also increased with decreasing influent concentrations. MEC removal was maximized for all air flow rates on the third pass through the stripper. Examination of average efficiency per pass at each flow rate showed ~29% removal at 0.35 scfm, ~33% at 0.7 scfm, ~60% removal at 2 scfm, ~75% removal at 5 scfm, and ~85% removal at 7.8 scfm.

This first set of tests was important in providing basic stripping data; subsequent tests were run at the higher air flow rates of 5.0 and 7.8 scfm.

Series Two: Test series two (1002-82) investigated the effect of three passes at maximum air flow rate, 7.8 scfm. Again, a solution influent flow rate of 2 gpm was used. A new groundwater composite sample created for this

ble 2

LONGHORN ARMY AMMUNITION PLANT

Summary of Air Stripper Operating Conditions and Results

	Feed Solution				Stripper Effluent Analysis, mg/L MEC						Stripper Efficiency, % Removal (MEC) (2)						
					Air Flow, scfm						Air Flow, scfm						
ICT Test Number	Identification	mg/L MEC	Pass	Sample Type	0.35	0.7	2	5	7.8	Effluent Comp.	0.35	0.7	2	5	7.8	Effluent Comp.	Overall
1002-79	Composite (1)	2380	1	Kinetic	2900	2220	1204	851	547	1300	-21.8%	6.7%	49.4%	64.2%	77.0%	45.4%	45.4%
		1300	2	Kinetic	849	786	516	262	151	525	34.7%	39.5%	60.3%	79.8%	88.4%	59.6%	77.9%
		525	3	Kinetic	398	252	162	96.7	54.9	139	24.2%	52.0%	69.1%	81.6%	89.5%	73.5%	94.2%
1002-82	Composite (1)	2300	1	Composite					360						84.3%		84.3%
		360	2	Composite					30.3						91.6%		98.68%
		30.3	3	Kinetic					6.7	5.67					77.9%	81.3%	99.71%
1002-85	1002-82 Effluent Comp.	5.67	1	Composite						NA							
			2	Composite						NA							
			3	Composite						NA							
1002-87	Composite (1)	2918	1	Kinetic					131	151					95.5%	94.8%	94.8%
		151	2	Kinetic				35.4	4.68	18				76.6%	96.9%	88.1%	99.4%
		18	3	Kinetic				2.9	1.25	2.24				83.9%	93.1%	87.6%	99.9%
1002-88A	Composite (1)	2710	1	Composite					351						87.0%		87.0%
		351	2	Composite					200						43.0%		92.6%
		200	3	Composite					4.3						97.9%		99.8%
		4.3	4	Composite					0.81						81.2%		99.97%
		0.81	5	Composite					0.074						90.9%		99.997%

Table 2
LONGHORN ARMY AMMUNITION PLANT
Summary of Air Stripper Operating Conditions and Results

	Feed Solution				Stripper Effluent Analysis, mg/L MEC						Stripper Efficiency, % Removal (MEC) (2)						
					Air Flow, scfm						Air Flow, scfm						
ICT Test Number	Identification	mg/L MEC	Pass	Sample Type	0.35	0.7	2	5	7.8	Effluent Comp.	0.35	0.7	2	5	7.8	Effluent Comp.	Overall
1002-88B	Composite (2)	4600	1	Composite					1073						76.7%		76.7%
		1073	2	Composite					56.8						98.8%		98.8%
		56.8	3	Composite					13.8						99.7%		99.7%
		13.8	4	Composite					2.11						100.0%		99.95%
		2.11	5	Composite					0.74						100.0%		99.984%
1002-90A	1002-88A Effluent Comp.	0.074	1	Composite					0.019						74.3%		
		0.019	2	Composite					0.0069						90.68%		
1002-90B	1002-88B Effluent Comp.	0.74	1	Composite					0.306						58.6%		
		0.306	2	Composite					0.04						94.6%		
1002-92A	1002-79 Effluent Comp.	143	1	Composite					27.5						80.8%		
		27.5	2	Composite					5.9						95.9%		
		5.9	3	Composite					1.3						99.1%		
		1.3	4	Composite					0.23						99.8%		
1002-92B	1002-87 Effluent Comp.	9.5	1	Composite					1.45						84.7%		
		1.45	2	Composite					0.34						96.4%		

(1) Composite of 20% MW-1, 20% MW-2, 60% EW-1

(2) This composite included a disproportionate amount of either MW-1 or MW-2 solution, resulting in an MEC stripper influent concentration significantly higher than other te

(3) Efficiency calculated on a per stage basis using each pass's influent MEC concentration; overall efficiency calculated against influent composite MEC analysis.

test showed a concentration of 2,300 mg/L MEC, indicating good correspondence with the first composite sample tested. Both kinetic and effluent composite samples were taken. Analytical data showed overall MEC stripping of 99.71%. Values for passes 1, 2, and 3 were 84.3%, 91.6%, and 77.9%, respectively. The MEC concentration of the final effluent from this series was 5.67 mg/L.

Series Three: Three passes using Series Two final effluent at an air flow rate of 7.8 scfm were made. The effluent from these tests was shipped to our associate for subsequent reverse osmosis testing.

Series Four: This test series (1002-87) used freshly composited groundwater which assayed 2,918 mg/L MEC. Two air flow rates were tested; three passes through the column were made. Each flow rate was maintained for approximately 12 minutes, with kinetic sampling at 11 minutes. Intermediate effluent composites were sampled and analyzed as well. The final effluent sample showed 2.24 mg/L MEC, translating to >99.9% stripping efficiency. Kinetic and intermediate composite sample analysis results showed better performance at the higher air flow rate, but a loss of efficiency as influent concentrations were reduced by each pass.

Demonstration Runs

Optimization testing results implied that the relatively high stripper influent concentration of 2,300-3,000 mg/L MEC required the highest practical air flow rate for efficient removal of contaminant(s). Demonstration testing was designed using an air flow rate of 7.8 scfm, with five passes followed by analysis of effluent composite samples. Additional passes would be made as indicated by analytical results.

Series Five: Two, fifty-five gallon batches of freshly composited groundwater samples were used with the intention of performing a duplicate series of tests at optimized conditions. The first composite, for Test 1002-88A, assayed 2,710 mg/L MEC, well within the expected range for composited MW-1, MW-2, & EW-1 samples. The second composite (Test 1002-88B), however, assayed 4,600 mg/L, a factor of 1.7 higher. It appears that an error in compositing may have occurred during this composite make-up. The air stripping data for each of the two dissimilar composites show noteworthy results.

The two series were run using an air flow rate of 7.8 scfm over five passes through the air stripper. The first series' final effluent composite assayed 0.074 mg/L MEC, while the second series' final effluent composite showed 0.74 mg/L. These values provide for stripping efficiencies of 99.997% and 99.984%, respectively. It was significant that final effluent composites' MEC concentrations differed by an order of magnitude, while influent concentrations differed by less than a factor of two.

Stripping efficiency through the first pass for the two composites was 87.0% and 76.7%, respectively, reflecting the concentration difference of the influents. This difference narrowed considerably through each subsequent pass.

Series Six: Final effluents from Series Five duplicate runs were subjected to two additional passes through the air stripper at conditions identical to those for Series Five, reference Tests 1002-90A & 90B.

Series Seven: These tests were run on final effluent samples from Series One and Series Four testing. The objectives were to evaluate additional passes through the air stripper, and to generate contaminant-free water for reverse osmosis test work, Tests 1002-92A & 92B.

Analytical Summary

Table 3 lists analytical results for the four sets of tests where the water was passed through the air stripper six or seven times. The data show reduction of the methylene chloride to as low a 6.9 µg/L. The methylene chloride values after seven passes at the maximum air flow ranged from 6.9 to 40 µg/L. The trichloroethylene values ranged from 0.6 to 8.6 µg/L. With the methylene chloride removed, it was possible to detect other components in the effluent. Some of the final effluent samples showed trace amounts of carbon tetrachloride, chloroform, 1,2-dichloroethylene, and 1,1,2-trichloroethylene.

A composite of the final effluent water from 1002-90A and 90B were submitted for detailed water analyses. The values found are listed in Table 4. Other than the iron reduction due to precipitation, there was little change in the inorganic analyses. The organics all were reduced significantly. The major organics found in the final effluents were acetone and 2-butanone. Acetone and 2-butanone are inefficient strippers, although 98% of the acetone was removed. Acetone levels in drinking water are not established, but levels of 1 mg/L have been acceptable in some cases.

Data Evaluation

The mass transfer coefficients for methylene chloride from the water phase into the air phases were calculated for most data points. Table 5 shows formula for the calculations and the values used in those formulae.

The effect of the air flow on the stripping efficiency (mass transfer coefficient) is tabulated in Table 6 and plotted in Figure 1. The mass transfer coefficients increased

Table 3

SUMMARY OF ANALYTICAL VALUES

Sample No.	Air Flow cu m/sq m/sec	Liquid Flow kg/sq m/sec	Column Height m	Methylene Chloride µg/L	Trichloro ethylene µg/L	Carbon tetrachloride µg/L	Chloro-form µg/L	1,2 Dichloro ethylene µg/L	1,1,2 Trichloro ethane µg/L
1002-88A-0			Feed	2710000					
1002-88A-1	0.396	13.6	1.65	351000					
1002-88A-2	0.396	13.6	3.30	200000					
1002-88A-3	0.396	13.6	4.95	4300					
1002-88A-4	0.396	13.6	6.60	810					
1002-88A-5	0.396	13.6	8.25	74					
1002-90-1	0.396	13.6	9.90	19	5.4				
1002-90-2	0.396	13.6	11.55	6.9	0.6				
1002-88B-0			Feed	4600000					
1002-88B-1	0.396	13.6	1.65	1073000					
1002-88B-2	0.396	13.6	3.30	56800					
1002-88B-3	0.396	13.6	4.95	13800					
1002-88B-4	0.396	13.6	6.60	2110					
1002-88B-5	0.396	13.6	8.25	740					
1002-90-3	0.396	13.6	9.90	306	69				
1002-90-4	0.396	13.6	11.55	40	8.6				
1002-79-0			Feed	2380000					
1002-79-5	0.161	13.6	1.65	1300000					
1002-79-10	0.161	13.6	3.30	525000					
1002-79-15	0.161	13.6	4.95	139000					
1002-92A-1	0.396	13.6	6.60	27500					
1002-92A-2	0.396	13.6	8.25	5900					
1002-92A-3	0.396	13.6	9.90	1300	11				
1002-92A-4	0.396	13.6	11.55	226	3.4				
1002-87-0		13.6	Feed	2918000					
1002-87-2	0.325	13.6	1.65	151000					
1002-87-4	0.325	13.6	3.30	18000					
1002-87-6	0.325	13.6	4.95	2240	670				
1002-92B-5	0.396	13.6	6.60	1450	41	1	0.5	1.6	0.7
1002-92B-6	0.396	13.6	8.25	340	10	1.1			

Table 4

LONGHORN ARMY AMMUNITION PLANT
Air Stripper Feed and Effluent Analyses

	Stripper Feed Water		Stripper Effluent Water	
	mg/L	Ion Balance meq/L	mg/L	Ion Balance meq/L
Anions				
Chloride	680	19.15	585	16.48
Nitrite	2.2		4.52	0.10
Nitrate	48	0.77	51.5	0.83
Bromide	1.3	0.02	0.85	0.01
Ortho-phosphate	<0.25		<0.25	
Sulfate	5.5	0.11	4.22	0.09
Fluoride	1	0.05	<0.4	
Silica, SiO2	37	1.23	35	1.17
Anion sum		21.34		18.67
Cations				
Barium	3.4	0.05	2.1	0.03
Manganese	1.2	0.04	0.99	0.04
Iron	15.6	0.56	0.2	0.01
Calcium	88	4.40	72	3.60
Magnesium	69	5.68	56	4.61
Sodium	302	13.13	270	11.74
Potassium	3.7	0.09	3.1	0.08
Cation sum		23.96		20.10
Organics				PQL
Bis (2-ethylhexyl) pthalate			0.010	0.053
Benzoic acid		0.56	0.550	0.260
Chloromethane		32	0.001	0.010
Methylene chloride		3,960	0.030	0.005
Acetone		52	<1.000	0.500
Chloroform		6	<0.001	0.005
2-butanone			0.150	0.100
1,1,1-trichloroethane			0.001	0.005
4-methyl-2-pentanone			0.007	0.050
Trichloroethene		90	0.009	0.005
Toluene			0.001	0.005
Xylenes, total		3.4	0.002	0.005

Analyses by Evergreen:
Organics by 8240 and 8270

Table 5

MASS TRANSFER CALCULATION EQUATIONS FOR METHYLENE CHLORIDE

Definitions		Values
Vp	Vapor pressure (atm)	1
S	Solubility in water (g/L)	20
HTU	Height of transfer unit (m)	1.96
NTU	Number of transfer units	6.13
Pt	Operating pressure (1 atm)	1
H	Henry's Constant (atm)	138
L'	Liquid loading rate (kM/sq m/sec	0.76
G	Gas loading rate (kM/sq m/sec)	0.018
Z	Packing height (m)	11.55
C(inf)	Influent concentration (µg/L)	2710000
C(eff)	Effluent concentration (µg/L)	6.9
Kla	Mass Transfer Coefficient (/sec)	0.0072
R	Stripping factor	3.23
Co	Molar density of water (kM/cu m	55.6

$R = (H * G)/(Pt * L)$

$R = 3.23$

$$Kla = \frac{L}{Zt * Co} \; \frac{R}{(R-1)} \ln \left| \frac{(C(inf)/C(eff) * (R-1) + 1}{R} \right|$$

$Kla = 0.0072$

$$NTU = \frac{R}{(R-1)} \ln \left| \frac{(C(inf)/C(eff) * (R-1) + 1}{R} \right|$$

$NTU = 6.13$

$HTU = Z/(NTU)$

$HTU = 1.96$

Table 6

EFFECT OF AIR FLOW ON MASS TRANSFER COEFFICIENT

cu m/sq m/sec	Methylene Chloride, kLa		
Air Flow	Pass 1	Pass 2	Pass 3
0.018	0.0038	0.0055	0.0051
0.036	0.0045	0.0057	0.0064
0.102	0.0062	0.0070	0.0078
0.254	0.0073	0.0092	0.0095
0.396	0.0087	0.0111	0.0115

EFFECT OF AIR FLOW ON MASS TRANSFER COEFFICIENT

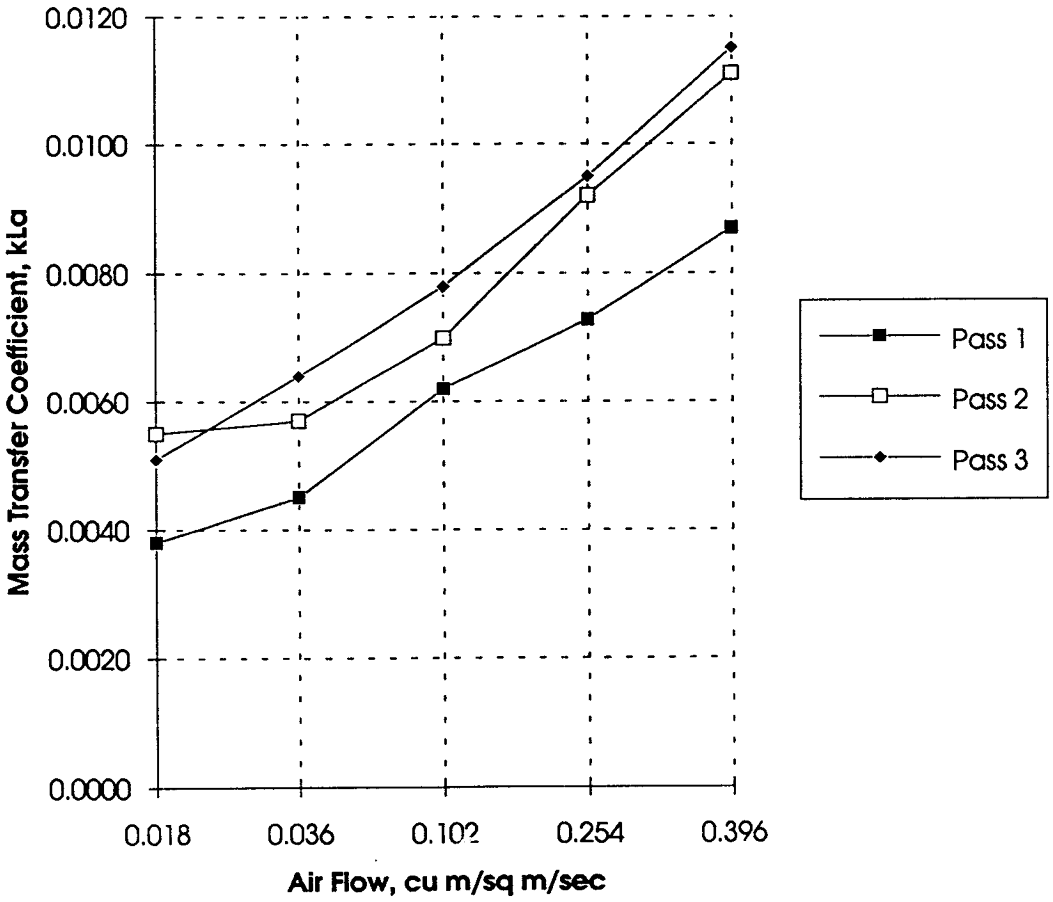

FIGURE 1

rapidly with the increasing air flow. The mass transfer coefficients also increased with each pass of the water through the 1.65-m tall column.

Table 7 summarizes mass transfer numbers for the four series where methylene chloride analyses are available for every pass. Trichloroethylene mass transfer coefficients also were determined where analyses were available. The mass transfer coefficients showed considerable scatter. For those passes using only the high air flow data, the median coefficient was 0.0089.

The do not show any values where the methylene was below the target level of 0.005 mg/L. Achieving this value would require another pass through the laboratory stripping column for a total of eight passes, i.e. a total of 13.2 meters. The deviations in some of the values probably are due to methylene chloride contamination from reusing rinsed and washed containers and ubiquitous methylene chloride in the air being recycled by the air compressor. As it was the stripping efficiency was as high as 99.9997%.

Table 7

SUMMARY OF MASS TRANSFER VALUES

Sample No.	Air Flow kg/sq m/sec	Liquid Flow kg/sq m/sec	Column Height m	Methylene Chloride		Trichloro ethylene	
				µg/L	KlA	µg/L	KlA
1002-88A-0			Feed	2710000			
1002-88A-1	0.365	13.6	1.65	351000	0.0107		
1002-88A-2	0.365	13.6	3.30	200000	0.0059		
1002-88A-3	0.365	13.6	4.95	4300	0.0172		
1002-88A-4	0.365	13.6	6.60	810	0.0940		
1002-88A-5	0.365	13.6	8.25	74	0.0119		
1002-90-1	0.365	13.6	9.90	19	0.0084	5.4	
1002-90-2	0.365	13.6	11.55	6.9	0.0073	0.6	0.0028
7 passes					0.0072		0.0012
1002-88B-0			Feed	4600000			
1002-88B-1	0.365	13.6	1.65	1073000	0.0087		
1002-88B-2	0.365	13.6	3.30	56800	0.0139		
1002-88B-3	0.365	13.6	4.95	13800	0.0086		
1002-88B-4	0.365	13.6	6.60	2110	0.0101		
1002-88B-5	0.365	13.6	8.25	740	0.0074		
1002-90-3	0.365	13.6	9.90	306	0.0068	69	
1002-90-4	0.365	13.6	11.55	40	0.0107	8.6	0.0028
7 passes					0.0066		0.0010
1002-79-0			Feed	2380000			
1002-79-5	0.161	13.6	1.65	1300000	0.0060		
1002-79-10	0.161	13.6	3.30	525000	0.0069		
1002-79-15	0.161	13.6	4.95	139000	0.0083		
1002-92A-1	0.365	13.6	6.60	27500	0.0093		
1002-92A-2	0.365	13.6	8.25	5900	0.0090		
1002-92A-3	0.365	13.6	9.90	1300	0.0089	11	
1002-92A-4	0.365	13.6	11.55	226	0.0097	3.4	0.0022
7 passes					0.0053		0.0011
1002-87-0		13.6	Feed	2918000			
1002-87-2	0.325	13.6	1.65	151000	0.0140		
1002-87-4	0.325	13.6	3.30	18000	0.0110		
1002-87-6	0.325	13.6	4.95	2240	0.0108	670	
1002-92B-5	0.365	13.6	6.60	1450	0.0055	41	0.0032
1002-92B-6	0.365	13.6	8.25	340	0.0087	10	0.0024
5 passes					0.0073		0.0014

AIR STRIPPER SIZING

A major question in the design and cost is the handling of the stripped VOC's. If the flow to treatment is 20 gpm containing 100 mg/L TCE and 4,500 mg/L MEC, approximately 1,000 pounds of VOC's will be stripped per day. Activated carbon or alumina absorption will not be effective for cleaning the off-gas because of the low boiling point (high vapor pressure) of the methylene chloride. The only economic method is catalytic oxidation or incineration followed by scrubbing of the hydrogen chloride and carbon dioxide that are the products of oxidation.

Attempts were made to determine the appropriate packed section heights using either Odna's formulae[1/] or a graphical solution[2/]. In both cases the calculated heights were at least twice that observed in the laboratory program. Three papers evaluated or compared Odna calculations with actual results.[3,4,5/] These comparisons show that the calculations can be off by up to a factor of two. In addition the influent water in the comparisons disccussed in the papers contained contaminants at levels near 1 mg/L not the 3,000-4,500 mg/L requiring treatment.

The laboratory tests all were done at a liquid rate of 20 gpm/ft^2 (13.6 kg/m^2/sec). Our experience with air strippers is that this is the most practical operating flow. It allows for some plugging of the packing due to precipitation without affecting the performance. A lower flow offers no advantages and would increase the cost for the column and packing.

The laboratory test data demonstrate that a stripper having 13-14 meters packed height (42-45 feet), equivalent to eight passes through the test column, will be capable of achieving methylene chloride levels of less than 0.005 mg/L. The other chlorinated contaminants also will be less than 0.005 mg/L.

The maximum air flow used in the pilot testing was 7.8 scfm, the equivalent to 78 scfm full scale. This is the minimum air flow to use for methylene chloride. It gives an air to water volume ratio of 29; whereas ratios of up to 74 have been recommended by others[6/] for methylene chloride.

Design specifications for the air stripper are summarized in Table 7.

Table 7

DESIGN SPECIFICATIONS

WATER FLOW:	10-20 gpm, 37-74 L/m
CONTAMINANT LEVEL:	3000 mg/L methylene chloride 100 mg/L trichloroethylene
REMEDIATED LEVEL:	0.005 mg/L methylene chloride 0.005 mg/L trichloroethylene
EFFICIENCY:	99.9998% for methylene chloride 99.995% for trichloroethylene
OPERATING TEMPERATURES:	WATER 16-26°C, 61-79°F AIR -12-38°C, 10-100°F
AIR FLOW:	100-200 scfm, 3-6 m^3/min
INSTRUMENTATION:	WATER Flow sensitivity ±4% Temperature ±1°C AIR Flow sensitivity ±5% Temperature ±1°C PRESSURE DROP Manometer 0-15 ± 0.3 cm water 0-5 ± 0.1 in water
STRIPPER SIZE:	1 ft^2, (0.1 m^2), 14-inch diameter (36 cm) 43-feet (13.2 m) packing height The stripper should be baffled at 2-m intervals to ensure that water does not run directly down the wall

AIR STRIPPER COST ESTIMATE

The cost for the above air stripper was estimated based on fabrication of the air stripper from purchased pipe, tanks, etc. An estimate for the cost of a catalytic oxidizer handling 100-200 scfm was obtained from a vendor. An estimate for the cost of an appropriate scrubber for the oxidizer off-gas was obtained from a vendor.

The costs to fabricate the air stripper and install at a level site were then estimated. The installations costs do not include the cost for bringing utilities to the site nor any permitting or other administrative type costs. The costs essentially are those to place the system on site in an operable condition.

The instrumentation included with the system is minimal. Liquid flows to the air stripper are metered and totalled. Air flow to the stripper is estimated by pressure. The pressure drop through the stripper is measured. The influent and effluent tanks are fitted the level controls. The electrical system is designed to stop the system when required and then to attempt restarting at periodic intervals. The initial interlocks are that the air blower, the scrubber and catalytic oxidizer are operating and the effluent tank is not full. If the influent tank contains water above the lower level probe the water flow will start until the level decreases to the lower probe, at which time the flow stops until the timer attempts restarting. Treated water from the effluent tank is pumped through a filter to disposal or other treatment based on the level controls. The high level control turns on the pump and the low level control turns the pump off.

Table 8

AIR STRIPPER COST ESTIMATE

Air stripper materials	$ 20,000
Catalytic oxidizer	35,000
Fume scrubber	10,000
Equipment subtotal	65,000
Fabrication, air stripper	5,000
Supports, stands, etc.	5,000
Pipe, valves, fittings	1,000
Electrical supplies	5,000
Fabrication subtotal	16,000
Field installation	
Concrete	3,000
Electrical	6,000
Mechanical	14,000
Installation subtotal	23,000
Detailed engineering, supervision	10,000
Total estimated installed cost	$ 114,000

REFERENCES

1. Lenzo, Frank C. et al, The application of the Odna correlation to packed column air stripper design: theory versus reality, Proceedings Annual Conference American Water Works Association, Part 2, 1990, pages 1301-1321

2. Speece, R. E. et al, Nomograph for air stripping of VOC from water, Journal of Environmental Engineering, Vol 113, 2, pp 434-443, 19987

3. Cordone, Leslie et al, Hanscom AFB, pilot scale air stripping column study, Hazardous and Industrial Waste, 20th, 1988, pages 108-121

4. Lamarche, Philippe and Droste, Ronald L., Air-stripping mass transfer correlations for volatile organics, Journal of the American Water Works Association, 1989, pages 78-89.

5. Staudinger, Jeffery et al, Evaluating the Odna mass transfer correlation for the design of packed-column air stripping, Vol 82, 1, pp 73-79, 1990

6. Gossett, et al, Mass transfer coefficients and Henry's constants for packed tower air stripping of volatile organics: measurements and correlation, Air Force engineering and services center report, ESL-TR-85-18, 1985 (referred to in #2)

008023

MAR 4 1994

CERTIFIED MAIL: RETURN RECEIPT REQUESTED P 104 195 150
151

Lieutenant Colonel Lawrence J. Sowa
Commanding Officer, U.S. Army
Longhorn Army Ammunition Plant
Marshall, Texas 75671-1059

Lynn Muckelrath, Project Manager
Longhorn Army Ammunition Plant
Attn: SMCLO-EN
Marshall, Texas 75671-1059

Dear Colonel and Lynn:

Pursuant to the Federal Facility Agreement (FFA) for the Longhorn Army Ammunition Plant, EPA has received several documents regarding the Longhorn Army Ammunition Plant in the past couple of months. Due to the number of documents received, the volume of information to be reviewed, the complexity of the issues involved, and the schedule of meetings to discuss these various documents, EPA has not and/or will not meet the review times dictated by the Department of the Army.

The documentation describing how background concentrations were determined for soils at Longhorn Army Ammunition Plant was received by EPA on January 28, 1994. EPA will submit written comments and be prepared to discuss EPA's comments at the March 22, 1994, meeting at EPA's office.

The Draft Final Interim Risk Assessment for Burning Ground No. 3 and the Unlined Evaporation Pond (LHAAP 18 & 24) in Longhorn Army Ammunition Plant was received by EPA on January 25, 1994. EPA will submit written comments and be prepared to discuss EPA's comments at the March 22, 1994, meeting at EPA's office.

The Draft Final Field Investigation Summary Report for the Group #2 sites at Longhorn Army Ammunition Plant was received by EPA on February 22, 1994. The letter sent the Department of Army requested comments by March 4, 1994. As the submission of this document was approximately 30 days late and as the FFA allows at least 30 days for EPA review, EPA is not submitting comments on March 4, 1994. EPA will, however, be ready to discuss for scoping purposes initial comments on the Draft Final Field Investigation Summary Report for the Group #2 sites at Longhorn Army Ammunition Plant at the March 23, 1994, meeting at EPA's office. At that time, EPA may be able to submit written comments, however, if additional time is necessary for review and the submission of comments, EPA will formally notify the Department of the Army.

The Draft Final Report Phase I for the Investigations of the 125 Waste Process Sumps and 20 Waste Rack Sumps at Longhorn Army Ammunition Plant was received by EPA on February 22, 1994. The letter sent the Department of Army requested comments by March 4, 1994. Given the enormity of the investigation and the length of the document, EPA is not submitting comments on March 4, 1994. As a meeting to discuss for scoping purposes the Draft Final Report Phase I for the Investigations of the 125 Waste Process Sumps and 20 Waste Rack Sumps at Longhorn Army Ammunition Plant has not been scheduled, EPA will be ready to discuss the document and possibly submit written comments when the meeting takes place.

If you have any questions about this matter or any other matter, please contact me at (214) 655-6744.

Sincerely,

Lisa Marie Price
Remedial Project Manager
Superfund Texas Enforcement

cc: Tulsa District Corps of Engineers <u>VIA FAX</u>
P.O. Box 61
Attn: Mr. Ross Nguyen
CESWT-PP-E
Tulsa, OK 74121-0061

Mike Moore, Superfund <u>VIA FAX</u>
Texas Water Commission
P.O. Box 13087
Capital Station
1700 N. Congress Avenue
Austin, TX 78711-3087

LONGHORN ARMY AMMUNITION PLANT
MEETING AGENDA

MEETING: TECHNICAL REVIEW COMMITTEE (TRC)
& PROGRAM MANAGERS

LOCATION: LONGHORN ARMY AMMUNITION PLANT
MARSHALL, TEXAS - BLDG. 703

DATE / TIME: MARCH 10, 1994 9:30 A.M.

SIGN IN: AT ENTRANCE OF LHAAP THERE IS A GATE HOUSE WHERE YOU SIGN IN. THE GUARD WILL ISSUE A TEMPORARY BADGE. IF YOU BRING A CAMERA PLEASE REQUEST A CAMERA PERMIT.

AGENDA -TRC

I. SCHEDULES - TOTAL PROGRAM
II. RMIS/DERMIS
II. OVERVIEW OF PHASE I DATA - BURNING GROUND SITES 18 & 24

008026

TRC MEETING LHAAP MARCH 10, 1994

LYNN MUCKELRATH	ACC	(903) 679-2980
David Burroughs	Thiokol Corp.	(903) 679-2668
Bud Jones	TNRCC	(903) 595-5466
CYRIL ONEWOKAE	HQ, AMCCOM, AMSMC-EQE	(309) 782-1350
DAVID TOLBERT	ACO-LH	903-679-2928
John Wagner	LCE	918-669-7239
MICHAEL MOORE	TNRCC	(512) 239-2483
LisaMarie Price	EPA	(214) 655-6744
JIM CARTER	US ARMY CORPS OF ENGRS TULSA DISTR, EASTERN AREA OFC	918-676-3355
John Weatherly	US Army, COE Tulsa	918-669-7281
Oscar [illegible], Jr.	Corps of Engineers	918 676-3265
IRA NATHAN	ACO	903-679-2613
Debbie Scheckel	ACOE	918-~~2~~669-7481
CPT Nguyen	Tulsa District, CE	918-669-7480
JONNA POLK	TULSA DISTRICT, CCE	918/669-7046
RANDALL L. KRATCHER	TULSA DISTRICT COE	918-669-7505
Cliff Warren	Tulsa Dist. COE	918-669-7505
[illegible]	HQ [illegible]	301-349-6640

LONGHORN ARMY AMMUNITION PLANT
TRC MEETING

10 MARCH 1994

LONGHORN ARMY AMMUNITION PLANT

IR ACCOMPLISHMENT SINCE DEC 93

- Completed Phase I Group #1 FSR.
- Completed Phase I Site 1A field work.
- Phase I Group #2 FSR is under review by Regulators.
- Phase I 145 sumps FSR is under review by Regulators.
- Completed Phase I (IRA) field work.
- Completed Phase II (IRA-Pilot Study) Project Plan.
- Started Phase II (IRA-Pilot Study) field work.
- Interim Risk Assessment for LHAAP 18 & 24 is under review by Regulators.
- Revised the Installation Action Plan.
- Classified, labelled, and stored IDWs from Sites 1, 11, 13, 14, 16, and 17. (Estimate completion date is 20 Apr 94)

LONGHORN ARMY AMMUNITION PLANT

IR ACTIVITIES IN THE NEXT 3 MONTHS

- Award Phase II Group #1.
- Prepare Draft Work Plan for Phase II Group #1.
- Develop scope for Phase II Group #2.
- Develop scope for Phase II 145 sumps.
- Prepare Draft Work Plan for Phase II 145 Sumps.
- Prepare Draft RI Report for Group #3.
- Complete Phase II (IRA-Pilot Study) field work.
- Revise the Generic Waste Management Plan.

008030

MAR 2 2 1994

CERTIFIED MAIL: RETURN RECEIPT REQUESTED P435 988060

Lieutenant Colonel Lawrence J. Sowa
Commanding Officer, U.S. Army
Longhorn Army Ammunition Plant
Marshall, Texas 75671-1059

Lynn Muckelrath, Project Manager
Longhorn Army Ammunition Plant
Attn: SMCLO-EN
Marshall, Texas 75671-1059

Dear Colonel and Lynn:

Pursuant to the Federal Facility Agreement for the Longhorn Army Ammunition Plant (LHAAP), EPA is submitting comments on the Draft Final Interim Risk Assessment for Burning Ground 3 and Unlined Evaporation Pond (Sites LHAAP 18 & 24) dated January 1994. EPA's comments are include as an enclosure to this letter and in the enclosed letter from Metcalf & Eddy.

If you have any questions about EPA's comments or any other matter, please contact me at (214) 655-6744.

Sincerely,

original LMP

Lisa Marie Price
Remedial Project Manager
Superfund Texas Enforcement

cc: Tulsa District Corps of Engineers
P.O. Box 61
Attn: Mr. Ross Nguyen
CESWT-PP-E
Tulsa, OK 74121-0061

Mike Moore, Superfund
Texas Water Commission
P.O. Box 13087
Capital Station
1700 N. Congress Avenue
Austin, TX 78711-3087

6H-ET
Hitt 3/21/94

EPA's Comments on
Draft Final Interim Risk Assessment for
Burning Ground No. 3 and
Unlined Evaporation Pond,
Longhorn Army Ammunition Plant

General Comments:

The Army's conclusion in this draft final risk assessment for the Interim Remedial Action (IRA) for the Unlined Evaporation Pond and Burning Ground No. 3 (UEP/BG3) is that no imminent or near-future threat exists, therefore, an IRA is not warranted. However, in conversations with the Army subsequent to the submission of this document to EPA and the Texas Natural Resource Conservation Commission (TNRCC), the Army now supports the implementation of the IRA at UEP/BG3, and is moving forward with pilot study for the IRA and with the financial commitment necessary for the implementation of the IRA.

EPA's conclusion after reviewing this draft risk assessment is that additional data must be collected to more fully characterize the nature and extent of contamination in soil, groundwater, surface water, and in sediments in order to provide a qualitative and quantitative assessment of risk. However, EPA continues to contend that an IRA is warranted and necessary at the UEP/Burning Ground No. 3 in order to prevent or at least minimize further harm the environment.

Consequently, EPA recommends that this Draft Final Interim Risk Assessment for Burning Ground 3 and Unlined Evaporation Pond (Sites LHAAP 18 & 24) not be finalized. EPA makes this recommendation not only because of the commitment for the IRA at UEP/BG3 in contradiction with the conclusions of the draft final risk assessment but also due to the uncertainties associated with the information used in developing this risk assessment, as acknowledged in the Draft Final Interim Risk Assessment for Burning Ground 3 and Unlined Evaporation Pond (Sites LHAAP 18 & 24).

Specific Comments:

Data Gaps and Limitations

Page 1, last paragraph and Page 2, 1st paragraph: It was reported that the objective of this risk assessment is to provide a screening-level analysis of potential imminent risks to human health and is not intended to serve as the final baseline risk assessment for LHAAP sites 18 and 24.

Page 16, 1st paragraph: It was reported that surface soils data (0 to 6-inch depth) were not available and that surrogate values from samples collected from a depth of 0 to 5 feet below ground were used. Data validation and QA/QC were not readily available.

Due to the above limitation (i.e., the objective of the risk assessment and type of available data), the use of an RME value and "proxy" concentration for non-detect, as mentioned on page 26 of the risk assessment, is not acceptable. The exposure point concentration should be the maximum detected concentration as suggested on page 5-24 of the U.S. EPA's Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) (RAGS/HHEM), Section 5.95 "*Use a Concentration-Toxicity Screen*".

Surface Water and Groundwater

It has been acknowledged by the Army, TNRCC and EPA, that adequate information does not exist, therefore, there is no clear understanding of the hydrogeology at the UEP/BG3 site or for the entire facility. In order to better determine the risk to human health and the environment, a thorough investigation into the hydrogeology for the entire facility must be conducted during the phase II field investigation for the RI.

Furthermore, there must be a better understanding of surface water and sediment contamination and the associated risks. Although the risk assessment assumed that the impact of the groundwater contaminant plume and surface water runoff on Harrison Bayou and Saunders Branch and its collective impact on the lake is negligible, EPA feels that until such time as an adequate investigation of the groundwater and surface water (including sediments), and of the relationship between groundwater releases to surface water has been conducted, such assumptions cannot be made.

Chemicals of Potential Concern

Monitoring well MW-2 had a concentration of 576 μg/l for 1,3,5-TNB (page B-48, Appendices). This chemical was not tested for in previous sampling events, therefore, there is no way to evaluate concentrations through time and there is no way to determine its possible impact on Caddo Lake. Consequently, include 1,3,5-TNB as a chemical of concern.

Land Use and Exposure Pathways

Page 22 and Table 23, page 23: RAGS/HHEM states that with respect to the determination of future land use in the baseline risk assessment professional judgement is critical, and that the selection of any alternate future land use should be supported with a logical, reasonable argument in the exposure assessment chapter of the risk assessment (Section 6.2.2, page 6-7).

The U.S. Government currently owns the land occupied by the LHAAP facility, however, the continuing mission of the facility appears to be in question. Therefore, to state that no changes in land use are anticipated seems biased and premature. Given that the facility is currently utilized for commercial/industrial purposes and the facility is located on the only natural lake in the State of Texas and that several recreational areas are located in close proximity to the facility, future commercial/industrial and future recreational land use scenarios seem logical. Therefore, EPA requests that the Army include a future commercial/indutrial scenario and a future recreational land use scenario in the baseline risk assessment conducted for the facility.

Input Parameters for Intake Equations

Pages 43 through 46: Use RAGS/HHEM Supplemental Guidance: "Standard Default Exposure Factors" OSWER Directive 9285.6-03, and the Dermal Exposure Assessment: Principles and Applications document (EPA/600/8-91/011B) for dermal contact with water and soil.

Dermal Toxicity Values

Page 50, 2nd paragraph: It was not clear if toxicity values based on administered dose were adjusted for the absorption rate before toxicity values for dermal contact exposure were used. Adjustments for absorption efficiency should be followed according to RAGS/HHEM Appendix A.

Chemicals for Which No EPA Toxicity Values Are Available, Section 4.4, page 61

Arsenic: It was reported that a slope factor was not available for arsenic. The Integrated Risk Information System (IRIS) reports both inhalation and ingestion unit risks. Cancer risk due to ingestion of soil contaminated with arsenic was lacking and should be evaluated. The oral unit risk of 5E-5/µ/l was proposed and was recommended to be adopted. The unit risk can be adjusted by assuming a body weight of 70 kg and ingestion rate of 2 liters and reported as per mg/kg/day.

Trichloroethylene (TCE): It was reported that EPA has withdrawn its carcinogenicity assessment for TCE and that the cancer risk for this chemical was not evaluated. TCE is the only other chemical of concern in groundwater besides methylene chloride. Eliminating the chemical from carcinogenic evaluation will minimize the actual risk from the site. Health Effects Assessment Summary Tables (HEAST) recommends contacting the Environmental Criteria and Assessment Office (ECAO) for the toxicity value for TCE. ECAO was contacted and the following were the toxicity values provided:

ORAL: Unit Risk = 3.3E-7 per µg/l
Slope Factor = 1.1E-2 per mg/kg/day

INHALATION: Unit Risk = 1.7E-6 per µg/cu.m.
Slope Factor = 6.0E-3 per mg/kg/day

Tetrachloroethylene (PERC): Same as TCE. Use the following toxicity values:

ORAL: Unit Risk = 1.5E-6 per µg/l
Slope Factor = 5.2E-2 per mg/kg/day

INHALATION: Unit Risk = range from 2.9E-7 to 9.5E-7 with a
geometric mean of 5.8E-7 per µg/cu.m.
Slope Factor = 2.0E-3 per mg/kg/day

Toxicity Information for Carcinogenic Effects

Slope factors for carcinogens should be reported as per mg/kg/day.

Inhalation of Air

It was reported that the Burning Ground (BG3) is still active. Evaluation of direct inhalation and indirect exposure of the products or chemicals emitted during the burning process should be evaluated.

Models Used

Air Model: Turner (1970) model was used to determine the exposure concentrations in air within specified dispersion distances from the source. The model seems to be very old and newer models should have been evaluated. EPA recommends that the T-Screen Dispersion model be used, as it will more accurately model dispersion. Also the dispersion distances were arbitrary set at 100, 500, 1,000, and 1,500 meters from the UEP/BG3 perimeter. The Burning Ground (BG3) is still active and an evaluation should have been done for shorter distances. Regardless, even at the 100 meters distance the cancer risk was evaluated to be 4E-3 from release point (page 65) using only two chemicals of concern. The cancer risk will be much higher if shorter distances were assumed and more chemicals (TCE & PERC) are included in the evaluation.

Water Model: The Simplified Lake and Stream Analysis (SLSA) was used to predict water contaminant concentrations in Lake Caddo. This model is a rough screening model and seems to be inadequate for the purpose of a risk assessment.

Threshold Limit Values-Time Weighted Averages (TLVs-TWAs)

Inhalation exposure concentrations were compared to TLVs-TWAs (page 68) and the conclusion reached that risks to on-site receptors (site workers) are not anticipated. This conclusion was stated even though the risk assessment indicated a cancer risk of 4E-3 to workers.

The use of TLVs and TWAs is inappropriate for the purposes of a risk assessment. The Superfund program follows the risk assessment evaluation of the effect of combined chemicals. i.e., cumulative risk. Risks greater than EPA's acceptable excess cancer risk range of 1E-4 to 1E-6, pursuant to the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), are unacceptable.

Off-site/Caddo Lake Risk

Although the ingestion of water via water supply was evaluated, the inhalation of volatiles during showering should also be evaluated.

Ingestion of Caddo Lake fish by a child was evaluated, however, the concentrations of contaminants in the fish was based on too many models and assumptions.

Ecological Assessment

Page 85: In the first paragraph, it is stated that the interim assessment represents a screening-level estimate of potential ecological impacts resulting from contaminant release from Sites 18 and 24. Clarification is needed to describe how the definitive ecological risk assessment will differ from the interim ecological risk assessment. A problem formulation and ecological site conceptual model (including sources of contaminants, exposure pathways and routes, and ecological receptors) need to be provided for the definitive ecological risk assessment. The purpose of the model is to provide the rationale and focus for assessment and measurement endpoints for the definitive ecological risk assessment. In the third paragraph, references for EPA guidance are provided. EPA's document entitled Framework for Ecological Risk Assessment (EPA/630/R-92/001, February 1992) should be added.
Information about the problem formulation step and ecological site conceptual model can be found in this reference.

Page 87, Identification of Chemicals of Potential Concern section: Explanation needs to be provided to justify whether it is appropriate that the list of contaminants for human health is the same as the list of contaminants for ecological risk assessment. The cross referenced sections in the human health section were not sufficiently detailed. More detail needs to be provided for the methodology. Charts need to be included that specify all contaminants detected, frequencies of detection, details on any other criteria used to eliminate contaminants from the list for risk assessment, and specific rationales used to eliminate contaminants. Clarification is needed for the purposes of ecological risk assessment about whether contaminants that were eliminated for the human health risk assessment should have been retained for the ecological risk assessment. Also, it is unclear whether other media besides current groundwater and site surface soils and future surface water should have been evaluated.

Page 88: In the third paragraph, how was it determined that there are no permanent surface waters on the site? Given the close proximity of Harrison Bayou and Saunders Branch and the site's drainage patterns, these may possibly represent "permanent" surface water for the purposes of this ecological risk assessment. In the last paragraph, it is mentioned that a fence most likely limits movement of large mammals onto the site. The discussion about the fence (or language about restriction of wildlife movement) is inappropriate in the ecological risk assessment and should be removed from page 88 and elsewhere in the document.

Page 89: A more specific biological inventory of species expected to be present should be provided. For example, what terrestrial species of small mammals and raptors and what aquatic species are expected to be supportable by the habitat? In order to select ecological receptors of concern from an inventory of supportable species, justification needs to be provided about likely sensitivity and exposure of species to site-related contaminants, which can be identified from literature searches for mechanisms of toxicity for the site-related contaminants, ecotoxicological values, and life history requirements.

Table 15, Threatened and Endangered Species: The list is for Harrison County. There needs to be a determination of whether the threatened and endangered species are expected to utilize habitat on the site or be affected by off-site migration of contaminants, and if so, the rationale about how the threatened and endangered species will be assessed in the ecological risk assessment needs to be provided.

Page 90: In the first paragraph, potential ecological exposure pathways are mentioned. Discussion should be provided about how each of the exposure pathways will be assessed.

Page 96: In the first paragraph, it is stated that, chemical-specific intakes for assessment of ecological risk were not calculated due to complexity of ecosystem composition and scarcity of species-specific intake rates and toxicity data. From these statements, it appears that no attempts were made to inventory and characterize ecological species (their life history requirements and their sensitivity to site-related contaminants), to identify food web relationships, or to compile from the available literature species-specific intake rates and toxicity data. The speculations made about the complexity of the ecosystem and the scarcity of literature data are inadequate to justify no effort to obtain the information. The ecosystem needs to be characterized, and the literature needs to be thoroughly searched to obtain what data is available for ecotoxicological values, mechanisms of toxicity, and life history requirements (dietary percentages, daily ingestion rates, body weight, home range sizes). Not assessing bioaccumulation would only be appropriate for site-related contaminants that are not bioaccumulative. The contaminants which are bioaccumulative need to be identified. For those contaminants that are bioaccumulative, tissue residue analyses would be recommended to be planned for the definitive ecological risk assessment.

Page 96, Identification of Contaminant-Specific Criteria section: In the second paragraph, it is stated that risk characterization for on-site organisms exposed to site surface soils was qualitative, not quantitative, because of lack of developed numerical soils contaminant criteria. The Superfund program in Region 6 uses ecotoxicological literature values for terrestrial biota in the absence of EPA-published soil criteria. It seems that the literature was not and needs to be thoroughly searched to obtain those ecotoxicological values available for the site-related contaminants that could be used to represent site ecological receptors. The risk characterization for the screening ecological risk assessment needs to be as quantitative as possible with the results summarized on page 99.

Page 97: Both acute and chronic EPA aquatic life freshwater criteria should have been used. In the last paragraph, the complete list of site-related contaminants that did not have EPA aquatic life freshwater criteria should be provided.

Table 17: Was the 50 mg/l hardness used for the aquatic criteria a site-specific value? If not, a site-specific hardness value should be used in the calculation of the criteria for hardness-dependent metals. Also, was the list of contaminants the full list of aquatic site-related contaminants?

Page 99, Ecological Risk Characterization section: In the first paragraph, which describes the risk characterization in general, a statement should be added that the purpose of risk characterization is to quantify ecologically protective residual concentrations for site-related contaminants. In the second paragraph, the conclusions about ecological risk for terrestrial ecological receptors are qualitative, speculative, unconvincing, and reflect an inadequate amount of effort dedicated to the ecological risk assessment. For the terrestrial assessment, there is no resultant information that can be used to determine ecologically protective residual concentrations for site-related contaminants. In the third paragraph regarding conclusions about the aquatic risk characterization, clarification needs to be provided for whether EPA aquatic life freshwater criteria were available for all of the contaminants (estimated by modeling to discharge to surface waters). If there were contaminants for which EPA criteria were not available, the literature should be searched for ecotoxicological values that could be used in the risk characterization.

Page 102: The first sentence of the second paragraph needs to be reworded once a more quantitative assessment is conducted.

REVIEW COMMENTS FOR THE DRAFT FINAL REPORT INTERIM RISK ASSESSMENT FOR BURNING GROUND 3 AND UNLINED EVAPORATION POND (SITES 18 & 24) LONGHORN ARMY AMMUNITION PLANT KARNACK, TEXAS

JANUARY 1994

Metcalf and Eddy (M&E) risk assessors have reviewed the Draft Final Interim Risk Assessment Report for Burning Ground 3 and Unlined Evaporation Pond (Sites 18 & 24) at the Longhorn Army Ammunition Plant in Karnack, Texas. In general, the structure and approach taken in this Interim Risk Assessment are consistent with existing guidance. However, M&E's review revealed a number of issues and deficiencies which should be resolved in subsequent versions of this document. Guidance documents used in the human health risk assessment review included U.S. EPA's Risk Assessment Guidance for Superfund (RAGS) Volume I Human Health Evaluation Manual (HHEM) (Part A); RAGS HHEM Supplemental Guidance "Standard Default Exposure Factors" OSWER Directive 9285.6-03, Dermal Exposure Assessment: Principles and Applications (U.S. EPA 1992); and U.S. EPA Region VI's Draft Supplemental Risk Assessment guidance (April 14, 1992). A review of the ecological assessment was also performed. Comments for the ecological review follow the human health risk assessment review comments.

HUMAN HEALTH RISK ASSESSMENT

GENERAL COMMENTS

1. Overall, the risk assessment involves a reasonable approach for deciding whether an immediate threat to human health could be associated with what is known of current site conditions. The most feasible, maximally exposed existing receptors were identified and relevant exposures, for the most part were characterized. The report is beneficial in that data gaps are identified which could potentially impact the performance of a reliable or valid Remedial Investigation/Feasibility Study (RI/FS) for the sites. The major conclusion which can be drawn for the report is that additional data must be collected to more fully characterize the nature and extent of contamination in soil, groundwater, surface water, and sediments.

2. The significance of Caddo Lake and Big Cypress Bayou being in close proximity to the site should be given further attention. Since drinking water supply and recreation are associated with the bodies of water, it would seem worth the effort to sample the surface water and sediment at

points potentially impacted by surface water runoff or migration of groundwater. It seems that surface water runoff from the active burning grounds/UEP could reach Harrison Bayou which drains to Caddo Lake. Figure 2 shows Harrison Bayou within 1000 feet of contaminated soil and groundwater. This surface water runoff route is not included in the modeling of future contamination to Caddo Lake. This seems inadequate when looking at the potential for surface water runoff and possibly groundwater recharge to Harrison Bayou. Sampling of the sediment and surface water in this tributary and other water bodies would eliminate much of the uncertainty involved with modeling potential impacts.

3. Although inhalation of volatiles detected in soil was evaluated, the contribution of fugitive dusts containing metals and semi-volatiles was omitted. The contribution of these analytes to total inhalation Risk/Hazard via fugitive dust inhalation should be evaluated.

4. Additional justification for not evaluating a future residential scenario may be required for the sites for the baseline risk assessment for the RI/FS.

SPECIFIC COMMENTS

<u>Section 1.2, page 5</u>: The discussion focuses on the lack of groundwater wells on the installation. However, no information regarding wells off-site is provided. Additional details should be included concerning whether private wells exist in the vicinity of the installation.

<u>Section 2.0, pages 8-16</u>: Although the text gives reference to a data summary report that describes past sampling events and analyses, a brief description of past sampling and analyses, especially for soil and groundwater, may provide a better understanding of the chemical release trends that have occurred in groundwater. For instance, it has been stated that the November 1992 groundwater sampling results will be used for the interim assessment due to data collection, data quality, and current contamination trends. It would be helpful to see a presentation of past sampling results, data, trends, etc. in order to provide the overall picture for the site assessment.

It has been assumed that the site will remain unchanged in the future, and that workers on site are the main receptors of concern for the soil exposure pathway. Therefore, future redevelopment of the area is not expected to occur. Subsurface soil would not be expected to be exposed. Because surface soil data (0-6 inches) does not exist for the site, maybe a qualitative analysis can be included in the assessment to provide a comparison of how surface soil and soil collected at depth (1-5 feet) may differ in chemical composition and concentration.

<u>Section 2.4, page 16</u>: Chemicals were not considered to be of concern if they were detected infrequently and/or below background concentrations. However, according to a draft supplemental risk assessment guidance provided by Region VI (April 14, 1992), chemicals of concern should have included; 1) chemicals detected in at least one CLP sample; 2) compounds considered common laboratory contaminants that exceed 10 times the maximum concentration in blank samples, and chemicals not considered common laboratory contaminants that exceed 5 times the maximum blank sample concentration. According to U.S. EPA Region VI 's guidelines, organic chemicals or naturally occurring hazardous metals, should not be eliminated by comparison to background concentrations because omission of these chemicals may result in a loss to the overall risk characterization. Chemicals that could be eliminated are essential nutrients, excluding arsenic.

Chemicals that were eliminated from further study based on the reasons listed above, but that should be potentially included as chemicals of concern are thallium, acetone, tetrachloroethene, toluene, vinyl chloride, and xylene in groundwater, and vinyl chloride in soil.

<u>Section 2.4, Table 1, page 17</u>: There appear to be some discrepancies between Table B-2 and Table 1. Table 1 states that vinyl chloride was detected 2/31

times at 21 and 25 μg/l. However, Table B-2 lists the following vinyl chloride concentrations in groundwater.

MW-1 = 30 μg/l
MW-22 = 25 μg/l
BH-7 = 880 μg/l
MW-4 = 21 μg/l
BH-4 = 18 and 90 μg/l
BH-8 = 120 μg/l

An explanation should be provided for the exclusion of these data points from MW-1, BH-4, BH-7, and BH-8.

Section 2.4, page 18:

If chemicals are eliminated based on minimal relative contribution to risk, it is necessary to provide documentation of comparative calculations such as those provided in RAGS Section 5.9.5. Given the toxicity of tetrachloroethylene, a qualitative comparison of relative risk contribution is insufficient without corresponding quantitative comparisons. However, U.S. EPA Region VI guidance states the Concentration-Toxicity Screening procedure should not be used unless the data set consist of more than 80 chemicals

In addition, the purpose of using frequency of detection as a method of eliminating chemicals is to prevent evaluating chemicals which may not be site related. Chemicals removed from further consideration in groundwater were also detected in soil. Based on past site activities and the presence of tetrachloroethylene, toluene, and vinyl chloride in soil as well as groundwater, it is clear that these chemicals are most likely site related. According to RAGS section 5.9.3, chemicals expected to be present should not be eliminated from further consideration based on frequency of detection.

Section 2.4, page 18:

According to summary table C-2 there were four locations where vinyl chloride was detected in soil borings.

8A-900 @ 8 ft = 785 μg/kg
8A-904 @ 4 ft = 51 μg/kg
8A-907 @ 4 ft = 51 μg/kg
8A-977 @ 10 ft = 56 μg/kg

Even though two of these samples are below the level at which occupational exposure would normally occur, the samples do provide evidence that vinyl chloride is site related. Since vinyl chloride is most likely site related, it should not be removed from further consideration in soil based on frequency of detection. Therefore, vinyl chloride should be included in the risk assessment evaluation. The source of the value of 42 μg/kg vinyl chloride in Table 2 is unclear based on available data.

Section 2.4, Table 2, page 19: The location and individual concentrations of each background soil sample should be provided so that the 95% upper confidence level calculations can be checked for accuracy.

In addition, if chemicals are going to be removed based on comparison to background, an effort must be made to demonstrate that the site specific background concentrations truly represent background conditions. Although the soil background concentrations listed appear comparable to those presented in *Elements in North American Soils*, by James Dragun and Andrew Chiasson (1991), it is necessary to include data from literature sources to qualify site-specific soil and groundwater background samples.

Section 3.1, page 22: Although the facility is located on land owned by the government and land use or ownership is not expected to change, a potential for future development should probably be considered. Perhaps additional information concerning zoning designations of the areas surrounding the facility could be added to the text. Further, relevant governmental policies/regulations regarding site investigations in the event of a change in ownership should be described.

Section 3.2, page 22:

A conceptual site model showing the sources of contamination, transport media, routes of exposure and human receptors at exposure points could be developed and included in the report.

In addition, the potential for a future residential scenario should be discussed in the risk assessment in order to provide the range of potential risk which could feasibly be expected for the site.

Section 3.2, page 24:

A qualitative evaluation of potential groundwater contamination was included for residents serviced by the community water supply well. As a conservative measure, a quantitative assessment could be included to evaluate the groundwater concentrations detected on-site.

Section 3.2, page 25:

Exposure via inhalation of fugitive dust particles was not included in the risk assessment because of the presence of a grass covering. However, exposure may be likely if the grass covering does not remain lush and healthy such as during dry seasons. If dry seasons are common in the site vicinity, an exposure scenario that includes inhalation of fugitive dusts probably should be included.

Section 3.3, page 35:

Modeling may not adequately represent water quality conditions in Harrison Bayou and Caddo Lake. Actual sampling of surface water and sediment in Harrison Bayou and Caddo Lake would give a clear indication of present conditions. Although it may be necessary to model the extent of contamination into the future, the current extent should be accurately defined by sampling data.

Section 3.4, Table 8, page 41:

Please provide more information regarding the actual calculation of the 95% upper confidence levels. It is difficult to distinguish exactly what values were incorporated into the calculations. For example, Table 2 on page 19 states that arsenic was detected 21/42 times. However, based on table C-1, it appears that, disregarding the E.P. toxicity samples 8A-916 through 8A-921, arsenic was detected 25/49 times in samples 5 feet deep or less. It is impossible to check the calculations if it is not clear which values were included in the calculations. It would also be appropriate to document the formulas used in the calculations such as sample standard deviation and 95% upper confidence level.

Section 3.4, page 43:

According to U.S. EPA Region VI guidelines, as well as HHEM Supplemental Guidance, the exposure frequency for workers is 250 days (assuming 5 days per week, 50 weeks per year) and exposure duration for workers is 25 years. The appropriate exposure parameter values should be incorporated in all intake equations.

Section 3.4, pages 43 through 46:

Some of the exposure parameters listed do not appear to be good estimates of reasonable maximum exposure.

- A 15 year exposure duration for an occupational scenario is significantly less than the 25 year exposure duration recommended in RAGS/HHEM.
- A 25 Kg child body weight is significantly above the 15.1 Kg child body weight recommended in RAGS/HHEM.

Section 3.4, page 44:

The value of 1 for an absorption value is very conservative. U.S. EPA Region VI recommends using 0.1 for organics and 0.01 for metals.

Section 3.4, page 46:

The dermal permeability constant used in the intake equation for dermal exposure to water is chemical-specific. It appears as though the default constant of 8.4E-04 was used for each of the chemicals. The *Dermal Exposure Assessment Principles and Applications (U.S. EPA 1992)* guidance provides chemical-specific permeability constants. Please include a table listing the values used for each of the chemicals of concern.

<u>Section 4.2, page 56</u>:	The Health Effects Assessment Summary Tables (HEAST) lists an RfC of 3.0 mg/m^3 for methylene chloride (HEAST, March 1993).
<u>Section 4.3, page 59</u>:	The unit risk value of 5E-5 µg/L may be converted to an oral slope factor of 1.8 (mg/kg-day)$^{-1}$ by assuming 2 liters per day and 70 kg body weight as per the guidance of the Environmental Criteria and Assessment Office (ECAO). The ECAO is part of the U.S. EPA 's Office of Health and Environmental Assessment and is responsible for the development of the HEAST.
<u>Section 4.3, page 60</u>:	The chemical cis-1,2-dichloroethene is classified as group D (IRIS October 1993). No carcinogenic toxicity values exist for this chemical. Although this chemical was listed in the carcinogenic toxicity section, cis-1,2-dichloroethene was not included in the risk calculations.
<u>Section 4.3, page 61</u>:	According to the March 1993 edition of HEAST, the carcinogenic toxicity values for trichloroethene have been removed and the ECAO should be contacted. The ECAO has developed provisional toxicity values for the oral and inhalation exposure pathways. The ECAO and also U.S. EPA Region VI personnel should be contacted for guidance. In addition, contact should be made with U.S. EPA Region VI personnel and ECAO concerning guidance as to the assessment of other chemicals of concern which lack toxicity values.
<u>Section 4.3, page 61</u>:	Applicable or Relevant and Appropriate Requirements (ARARs) such as maximum contaminant levels (MCLs) for groundwater, and ambient water quality standards (AWQS) for surface water

	were not included in the risk assessment. The chemical-specific ARARs should be provided for the media of concern.
	Toxicity values for lead have not been developed for use in the risk and hazard calculations, but exposure to lead can be evaluated with U.S. EPA's Lead Biokinetic Model.
Section 4.4, page 61:	A slope factor is available for arsenic. A slope factor is not available for cis-1,2-dichloroethene.
Section 5.3, page 72, Table 13:	The hazard quotients for the ingestion of site soils (worker) for nickel and zinc are incorrect. The correct values are 4E-4 and 10E-5, respectively. No significant changes to the total worker soil ingestion hazard would result based on these corrections.
Section 5.3, page 74:	Intuitively, an HI exceeding 1.0 based on dermal absorption of arsenic and cadmium from soil does not make much sense, especially given the relatively low concentration of arsenic (<3.0 mg/kg) in soil. Furthermore, carcinogenic risk for the dermal pathway is 3E-7, and 3E-9 for ingestion of soil. According to RAGS HHEM Part A, Appendix A, the assessment of dermal exposure to contaminants in soil or water may require an adjustment of the oral toxicity value from an administered dose to an absorbed dose. This is accomplished by taking the oral toxicity value and multiplying it by the chemical-specific oral absorption factor for noncarcinogenic values. Carcinogenic toxicity values are divided by the oral absorption factors. The adjusted oral toxicity value, or "dermal" toxicity value, is then used as the toxicity value in the risk and hazard calculations.
Section 5.3, page 78, Table 14:	The reference concentration for methylene chloride is 3.0 mg/m^3. Therefore, a hazard quotient can be computed for methylene chloride for the exposure pathway for inhalation of organic vapors from Caddo Lake.

ECOLOGICAL RISK ASSESSMENT

GENERAL COMMENTS

1. U.S. EPA Region VI has a *Region 6 Standardized Ecological Risk Assessment Format*. The format identifies the five sections which make up the Ecological Risk Assessment. This report contains only two of these sections (Exposure Assessment, Risk Characterization). Some of the information necessary in the other sections is provided, but these are deficiencies. All components of an ecological risk assessment must be provided.

2. A hazard identification is a necessary part of the Ecological Risk Assessment. This section identifies a site description and a description of stressors. The site description includes the distribution of contaminants throughout the media. While this is done to some degree, the lateral and vertical extent of contamination in the soil is not presented.

   The description of stressors should include a discussion of bioavailability and potential adverse effects on biota. This information was not provided.

3. The receptor characterization and endpoints are necessary. An on-site and near-site survey to: (1) describe the communities and species making up the communities; (2) identify the presence or potential presence of Federal and State Threatened and Endangered Species; and (3) identify sensitive habitats such as wetlands was not performed and needs to be. Also, site-specific endpoints were not measured. For example, no toxicity testing or tissue analysis were performed.

4. No surrogate species were established for this risk assessment. Surrogate species need to be developed for different media and

trophic levels. These surrogates are then carried through the risk assessment process to show the presence or absence of potential risk.

5. The ecological risk assessment is too qualitative to allow conclusions to be drawn. According to the Region VI Format for Ecological Risk Assessments, the objectives of the risk characterization are to: (1) determine if there is a significant ecological risk; (2) evaluate a need to remediate; and (3) develop potential remediation goals. A qualitative attempt was made to determine objectives 1 and 2. Discussion of objective 3 should also be provided.

SPECIFIC COMMENTS

Section 9.0, page 89, ¶5: State-listed Threatened and Endangered Species should be included. Also, sensitive habitats, especially wetlands that are potentially impacted, need to be identified and investigated.

Section 9.2, page 90, ¶1: It appears that surface runoff from the sites drains to Harrison Bayou. The concern by the authors for potential aquatic impacts suggests that sediment is also a medium where exposure is possible. This pathway was not explored, but should be considered, or an explanation offered for why sediment samples were not collected.

Section 9.3, page 91,¶2: Please explain why modeling was performed instead of collecting actual surface water data.

Section 9.3, page 91, ¶4: Since surface runoff was not included in the model, the authors should not say the methods were "extremely conservative". Surface runoff should be considered as a component of the model, unless objective data are collected to confirm or negate this potential source of site-related constituents.

Section 10.2, page 96 ¶1:	While no Federal standards exist for soils, the NOAA guidelines are commonly used as benchmarks. Using these benchmarks, it appears that barium and cadmium exceed the benchmarks and may be of ecological concern. Benchmarks for the organic contaminants are not available at this time.
Section 10.3, page 97, ¶2:	It is unclear what "sources" of information were used. If a database was used, it should be referenced. If a database was not used, the AQUIRE database is recommended by U.S. EPA. Also, literature values should be used when they are lower than ambient water quality standards. LOELs should be used whenever possible.
Section 10.1, page 96, ¶1:	If available, State of Texas criteria should be incorporated into this section or in other appropriate sections of this report.
Section 10.2, page 96, ¶1:	In Section 10.3, literature values for water contaminants are used whenever Federal criteria are not available. This process should be used for terrestrial plants and animals also. Information on many, if not all, contaminants of concern are available for terrestrial species.
Section 11.1, page 99, ¶1:	As noted earlier, "criteria" are available to allow quantification or semi-quantification of risk. The authors need to collect enough information to allow a more quantitative assessment of risk. This can be in the form of additional sampling and/or a more complete literature search and development of "criteria".
Section 11.2, page 99, ¶1:	The authors apparently feel that there may be unacceptable risk to the terrestrial biota at the site. Further definition of this risk is appropriate. Additionally, it is unclear if the risk is acute, chronic, and/or food chain effects. All these types of risk need to be considered and addressed.

Section 11.3, page 99, ¶1:

Surface water sampling is recommended to allow a much more accurate comparison of criteria to surface water concentrations. Also, "criteria" for sediments were not developed, and consequently, no risk characterization of sediment was performed. Since a risk characterization of surface water was conducted, the sediment should be addressed also. It would also be appropriate to address the potential for food chain effects in this section.

Section 12.0, page 102, ¶1:

The Ecological Risk Assessment should address current and future potential impact.

Appendix C:

According to Section 2.3 of the Risk Assessment, soil samples were taken at discrete depths. Composite interval sampling and continuous sampling were apparently not conducted. In most cases, soil samples were not collected until a depth of 2 or 4 feet had been drilled. After the 2 or 4 foot sample, another sample was not collected until the 7 or 10 foot depth. These samples essentially missed all the ecologically important portions of the soil. More sampling from shallow soils would be appropriate to characterize the potential risk to terrestrial biota. Also, since no surficial samples (0-6 inches) were taken, it is difficult to determine the potential risk to non-burrowing species and shallow rooted plants. Exposures associated with sediment cannot be evaluated without characterizing surficial soil contaminants which may be translocated into Harrison Bayou and Caddo Lake.

APR 1 2 1994

CERTIFIED MAIL: RETURN RECEIPT REQUESTED P104 195 152

David Tolbert, Project Manager
Longhorn Army Ammunition Plant
Attn: SMCLO-EN
Marshall, Texas 75671-1059

Re: Review of the Statistical Methods Used for Calculation of Background Levels at Longhorn Army Ammunition Plant

Dear David:

Pursuant to the Federal Facility Agreement for the Longhorn Army Ammunition Plant, EPA is submitting comments on the document titled Review of the Statistical Methods Used for Calculation of Background Levels at Longhorn Army Ammunition Plant.

Comment #1

As we discussed during the March 22, 1994, meeting held at EPA's office in Dallas, the equations used for calculation of background levels appear appropriate and in accordance with EPA methods. However, it is EPA's position that the background issue has not been resolved.

The intention of identifying background sample locations for each of the 13 sites during the scoping of the approved RI/FS Work Plan dated June 1992, and for the 145 sumps was only to determine what constituents (naturally occurring and man-made/induced) existed at the site under investigation and what constituents possibly were emanating or migrating from other site(s) in close proximity to the site under investigation. The background sample locations and the information generated from the locations were never intended to be used to characterize "background" for the Longhorn Army Ammunition Plant facility.

Background samples are to be collected from areas on the facility not affected by contamination but that do have the same basic characteristics. Proper identification of ground and surface water flow direction and wind direction are key and determination of the proper background sample population size is essential. At this point in the investigations, these key elements in determining background sample locations have not been taken into account, therefore, samples from the appropriate background locations have not been collected.

Comment #2
The determination of the 95% Upper Confidence Limit (UCL) when detection limits are in question is inappropriate. Refer to the Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Final Guidance, April 1989 (EPA/530-SW-89-026); and Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Addendum to Interim Final Guidance, July 1992. In both of these documents, the statistical analysis method when dealing with nondetects is identified and discussed.

If you have any questions about EPA's comments or any other matter, please contact me at (214) 655-6744.

Sincerely,

Lisa Marie Price
Remedial Project Manager
Superfund Texas Enforcement

cc: Lieutenant Colonel Lawrence J. Sowa
Commanding Officer, U.S. Army
Longhorn Army Ammunition Plant
Marshall, Texas 75671-1059

Tulsa District Corps of Engineers
P.O. Box 61
Attn: Mr. Ross Nguyen
CESWT-PP-E
Tulsa, OK 74121-0061

Mike Moore, Superfund
Texas Water Commission
P.O. Box 13087
Capital Station
1700 N. Congress Avenue
Austin, TX 78711-3087

DEPARTMENT OF THE ARMY
LONGHORN/LOUISIANA ARMY AMMUNITION PLANTS
MARSHALL, TEXAS 75671-1059

REPLY TO
ATTENTION OF

RECEIVED
REGION VI
1994 APR 15 AM 9 [illegible]
SUPERFUND BRANCH

April 14, 1994

Environmental Office

Ms. Lisa Price
Superfund Reinforcement
U.S. Environmental Protection Agency
1445 Ross Avenue
Dallas, Texas 75202

Dear Ms. Price:

Enclosed are two copies of the Defense Environmental Restoration Program Management Information System (DERPMIS)/Restoration Management Information System (RMIS) resolution document for Longhorn Army Ammunition Plant, Karnack, Texas.

Sincerely,

Lawrence J. Sowa
Lieutenant Colonel, U.S. Army
Commanding Officer

APR 19 1994

CERTIFIED MAIL: RETURN RECEIPT REQUESTED

P 435 988 062

David Tolbert, Project Manager
Longhorn Army Ammunition Plant
Attn: SMCLO-EN
Marshall, Texas 75671-1059

Re: Draft Final Report Phase I Investigations of
125 Waste Process Sumps and 20 Waste Rack Sumps at
Longhorn Army Ammunition Plant

Dear David:

Pursuant to the Federal Facility Agreement for the Longhorn Army Ammunition Plant, EPA is submitting comments on the document titled Draft Final Report Phase I Investigations of 125 Waste Process Sumps and 20 Waste Rack Sumps at Longhorn Army Ammunition Plant.

If you have any questions about EPA's comments or any other matter, please contact me at (214) 655-6744.

Sincerely,

Lisa Marie Price
Remedial Project Manager
Superfund Texas Enforcement

cc: Lieutenant Colonel Lawrence J. Sowa
Commanding Officer, U.S. Army
Longhorn Army Ammunition Plant
Marshall, Texas 75671-1059

Tulsa District Corps of Engineers
P.O. Box 61
Attn: Mr. Ross Nguyen
CESWT-PP-E
Tulsa, OK 74121-0061

Mike Moore, Superfund
Texas Natural Resource Conservation Commission
P.O. Box 13087
Capital Station
1700 N. Congress Avenue
Austin, TX 78711-3087

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5H 4/19/94

General Comments:

#1 The essence of the investigation of the waste process and waste rack sumps was to determine if a release had occurred, and if a release had occurred to get some indication of the impact of the release. However, it appears that the premise under which the data from the investigation was interpreted and under which this document was prepared is faulty.

> *The chemical data generated during the investigations were evaluated with respect to applicable or relevant and appropriate requirements (ARARs) to determine if the media sampled were contaminated... Background levels were established... Soil sample analytical results were compared to the background concentration levels and also to the [TNRCC] Risk Reduction Standard #2 clean up levels. Data exceeding both the background levels and Risk Reduction Standard #2 clean up levels, were considered to be evidence of contamination.* Section 5.2 **Data Evaluation**, page 29
>
> *Of the 141 [sumps] investigated, 130 sumps showed contamination and 11 sumps contained contaminants of concern which did not exceed applicable cleanup levels.* Executive Summary
>
> *It is recommended that no further investigation be implemented for [11] Sumps..., since none of the constituents of concern exceeded applicable soil cleanup levels.* Section 8.0 **RECOMMENDATIONS**, page 202

Regarding the issue of ARARs, not only was EPA was not involved in any discussion of ARARs specifically for the sumps, but the final determination of ARARs and use of ARARs to determine what is and is not contaminated during the initial investigation phase of the project is completely inappropriate, a point EPA would have made if consulted on the matter.

As early as November 1993 (refer to Longhorn AAP Project Coordinators meeting minutes dated November 16, 1993), EPA has expressed concern about the adequate characterization of background soil concentrations. Again in EPA's December 15, 1993, letter regarding the draft Field Investigation Summary Report for the Group #1 Sites, EPA raised the question of the adequacy of background data compiled for the Corps of Engineers (COE). During the March 22, 1994, meeting held with representatives from the Army, EPA, TNRCC, and COE, the issue of background was again discussed with the same reservation expressed by EPA and TNRCC regarding the issue of the characterization of background soil concentrations. Furthermore, in formal comments submitted by EPA on April 11, 1994, for the document titled Review of the Statistical Methods Used for Calculation of Background Levels at Longhorn Army Ammunition Plant, EPA stated that it did not believe the issue of background had been resolved.

Risk Reduction Standard #2 of the TNRCC Final Risk Reduction Rules appears to accompanied with a caveat for Superfund sites that a site-specific risk assessment must be conducted. Consequently, the Media Specific Concentrations associated with the Risk Reduction Standards are not to be arbitrarily applied.

Therefore, to make the determination after the first phase of the investigation of the waste process and waste rack sumps which sumps are or are not contaminated with constituents of concerns or no concern that exceed or don't exceed some arbitrarily established clean up level is completely inappropriate. Consequently, the document should contain an evaluation of all contaminants detected at that sump sites and report all concentrations detected.

Specific Comments:

#2 Page 16: What kind of safety concerns prevented investigation for this sump?

#3 Table 5-4, page 41: The determination of the 95% Upper Confidence Limit (UCL) when detection limits (i.e., nondetects and percentage of nondetects) are in question is inappropriate. Refer to the Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Final Guidance, April 1989 (EPA/530-SW-89-026); and Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Addendum to Interim Final Guidance, July 1992. In both of these documents, the statistical analysis method when dealing with nondetects is identified and discussed.

008058

APR 19 1994

CERTIFIED MAIL: RETURN RECEIPT REQUESTED

P435 988 061

David Tolbert, Project Manager
Longhorn Army Ammunition Plant
Attn: SMCLO-EN
Marshall, Texas 75671-1059

Re: Draft Final Field Investigation Summary Report for
Group #2 Sites at Longhorn Army Ammunition Plant

Dear David:

Pursuant to the Federal Facility Agreement for the Longhorn Army Ammunition Plant, EPA is submitting comments on the Draft Final Field Investigation Summary Report for Group #2 Sites at Longhorn Army Ammunition Plant. EPA's comments are include as an enclosure to this letter and in the enclosed letter from Metcalf & Eddy.

If you have any questions about EPA's comments or any other matter, please contact me at (214) 655-6744.

Sincerely,

Lisa Marie Price
Remedial Project Manager
Superfund Texas Enforcement

Enclosure

cc: Lieutenant Colonel Lawrence J. Sowa
Commanding Officer, U.S. Army
Longhorn Army Ammunition Plant
Marshall, Texas 75671-1059

Tulsa District Corps of Engineers
P.O. Box 61
Attn: Mr. Ross Nguyen
CESWT-PP-E
Tulsa, OK 74121-0061

Mike Moore, Superfund
Texas Natural Resource Conservation Commission
P.O. Box 13087
Capital Station
1700 N. Congress Avenue
Austin, TX 78711-3087

a boring within that former burn pit.

#20 4-10, paragraph 2: Any guesses as to what the obstruction was that was encountered in 16-SB-04?

#21 Figure 4-4: Well 16-WW-05 is not identified on the figure.

#22 Figure 4-5: Explain the presence of the sand "*amoeba*"?

#23 5-2, paragraph 5: The Unlined Evaporation Pond and Burning Ground No. 3 sites are located DOWNgradient from Burning Ground No. 2 (Site 17). Also Figure 5-2 which depicts the potentiometric surface is questionable given the limited data.

#24 Sites 18 and 24: Figures need to indicate location and distances to Harrison Bayou and Saunders Branch and distance to Caddo Lake.

#25 6-10 paragraph 2: What were the results of the surface water sampling in Harrison Bayou that was conducted? "*A report addressing these results was never prepared. However, the raw data were compiled into a [1989] document...*"

#26 6-30, paragraph 2: "*...the contamination may have been stabilized by the interim remedial action at the UEP.*" Change "*interim remedial action*" to "*RCRA closure*".

#27 Site 29: Figures need to indicate location and distances to surface water features.

#28 7-8, paragraph 1: Indicate how the line was "*closed*" after samples were collected.

RECOMMENDATIONS

General Recommendations:

Great care must be take in the construction of wells, using the state-of-the-art procedures in order to prevent downgradient migration or cross-contamination between units.

Monitoring wells should be logged so that valuable stratigraphic information is passed over.

Specific Recommendations:

Site 12
* Closure of wells 12-WW-03, 12-WW-04, 12-WW-07, 12-121, 12-103
* Confirmation sampling of the 9 site wells; analysis for VOA, explosives and metals
* 18 direct push technology locations for stratigraphic information and ground water sample collection; field screening for VOAs with samples collected for offsite analysis for target metals and explosives analysis

* Based on results of direct push technology, 3 downgradient shallow (<40 feet) monitoring wells (1 well in the plume, 2 at the edge); analysis for VOA, explosives and metals
* Based on results of direct push technology, 1 deep well (>100 feet) monitoring well to be located at the highest concentration detected with the direct push technology; analysis for VOA, metals and explosives
* Installation and monitoring of piezometers in the ditch
* Approximately 6 surface water and sediment sampling in Central Creek and the unnamed Creek for purposes of risk assessing

<u>Site 16</u>
* Confirmation sampling of the 12 site wells; analysis for VOA, explosives and metals
* 15 direct push technology locations for stratigraphic information and ground water sample collection; field screening for VOAs with samples collected for offsite analysis for target metals and explosives analysis
* Based on results of direct push technology, 3 downgradient shallow (<40 feet) monitoring wells (1 well in the plume, 2 at the edge); analysis for VOA, explosives and metals
* Based on results of direct push technology, 1 deep well (>100 feet) monitoring well to be located at the highest concentration detected with the direct push technology; analysis for VOA, metals and explosives

<u>Site 17</u>
* Collection of 20 surface (0 to 6") on and offsite soil samples; locations to be determined based on runoff and/or air depositional patterns; analysis for VOA, explosives and metals
* Confirmation sampling of the monitoring wells 17-WW-01 and 17-130; analysis for VOA, explosives and metals
* 16 direct push technology locations for stratigraphic information and ground water sample collection; field screening for VOAs with samples collected for offsite for target metals, explosives, anions analysis
* Based on results of direct push technology, 3 downgradient shallow (<40 feet) monitoring wells (1 well in the plume, 2 at the edge); analysis for VOA, explosives, metals, and anions
* Based on results of direct push technology, 1 deep well (>100 feet) monitoring well to be located at the highest concentration detected with the direct push technology; analysis for VOA, metals and explosives
* Collection of surface water and sediment samples for the purpose of assessing risk

<u>Sites 18 and 24</u>
* Collection of 25 surface (0 to 6") soil samples; locations to be determined based on runoff and/or air depositional patterns; analysis for VOA, explosives and metals
* 30 direct push technology locations (10 north, 10 south, 10 west) for stratigraphic information and ground water sample collection; field screening for VOAs
* Installation of 5 wells at the Wilcox/Midway contact (at C4A, near MW16, C8 areas, north of C5 and C6, and south of C7 and C10); stratigraphic information will also be collected
* Based on results of direct push technology, 8 shallow (<40 feet) monitoring wells (3

north, 2 west, 3 south, and some maybe east); analysis for VOA, explosives and metals
* Collection of 7 surface water and 7 sediment samples in Harrison Bayou and Saunders Branch
* Assessment of the existing monitoring wells will be conducted to determine which wells should be removed, which should be replaced, and which can remain

Site 29
* Confirmation sampling and analysis of the monitoring well 29-116 for explosives, 29-118 for selenium and mercury, 29-119 for cadmium
* Collection of 4 surface (0 to 6") and 4 shallow subsurface (0 to 5') soil samples from each of the 6 production areas; analysis for explosives and metals
* Collection surface water and sediment samples for the purpose of assessing risk

Production Area
* 16 direct push technology locations for stratigraphic information and ground water sample collection: analysis for explosives and metals
* Based on results of direct push technology, 3 downgradient shallow (<40 feet) monitoring wells (1 well in the plume, 2 at the edge); analysis for explosives and metals
* Based on results of direct push technology, 1 deep well (>100 feet) monitoring well to be located at the highest concentration detected with the direct push technology; analysis for explosives and metals

Cooling Ditch Area
* 17 direct push technology locations for stratigraphic information and ground water sample collection: analysis for explosives and metals
* Based on results of direct push technology, 3 downgradient shallow (<40 feet) monitoring wells (1 well in the plume, 2 at the edge); analysis for explosives and metals
* Based on results of direct push technology, 1 deep well (>100 feet) monitoring well to be located at the highest concentration detected with the direct push technology; analysis for explosives and metals

Site 32
* Collection surface water and sediment samples for the purpose of assessing risk
* Direct push technology locations for stratigraphic information and ground water sample collection: analysis for VOA, explosives and metals
* Based on results of direct push technology if necessary, installation of downgradient wells

Texas Natural Resource Conservation Commission

INTEROFFICE MEMORANDUM

Date: 19 Apr 94

To: Michael Moore, Project Manager, Superfund Investigation Section

From: Allison Jenkins, Toxicologist, Superfund Investigation Section

Subject: Review of Interim Risk Assessment, Longhorn Army Ammunition Plant

I have only a few comments on the above document. Comments regarding the limitations of the risk assessment that we discussed earlier and those limitations that were mentioned in the report are not included. In addition, I reviewed both EPA Region VI and Metcalf and Eddy Comments on the above document.

1. Page 17. Selection of chemicals of concern for groundwater.

Because only 6 contaminants were not included as chemicals of concern, including PCE, toluene, and xylene (all found in soil) and vinyl chloride, it would be conservative to add those as chemicals of concern. These appear to be site-related.

2. Page 23

Ingestion of groundwater should be included as an exposure pathway for future use of the site, if it is potable (≤ 10,000 ppm total dissolved solids) and transmits a useable quantity of water.

3. Page 24. Inhalation of contaminated dust at burning grounds.

Discuss the deletion of this pathway further.

4. Page 45. Body weight of child should be 15 kg. Exposure duration of a worker should be 25 years.

5. Page 59. Arsenic oral slope factor: 1.75 $(mg/kg/day)^{-1}$

6. Page 68

Threshold Limit Values (TLVs) and Time Weighted Averages (TWAs) are not appropriate for use in this risk assessment.

7. Page 100. Include reference for freshwater criteria.

Allison Jenkins

Allison Jenkins

DEPARTMENT OF THE ARMY
LONGHORN/LOUISIANA ARMY AMMUNITION PLANTS
MARSHALL, TEXAS 75671-1059

April 21, 1994

REPLY TO
ATTENTION OF

Engineering Division

Ms.Lisa Price
Superfund Reinforcement
U.S. Environmental Protection Agency
1445 Ross Avenue
Dallas, Texas 75202

Dear Ms. Price:

Enclosed are updates of the deadlines for the Primary and Secondary Documents for Groups #1, #2, and #3 for Longhorn Army Ammunition Plant.

If there are any questions, please contact Mr. David Tolbert at (903)679-2728.

Sincerely,

Lawrence J. Sowa
Lieutenant Colonel, U.S. Army
Commanding Officer

LONGHORN ARMY AMMUNITION PLANT

ASSUMPTIONS ON DEADLINES

- Funding is available and remedial activities will not be delayed because of lack of funding.
- For Group #1 & 2, additional field work will not be required after Phase II field investigation.
- Phase II field work for Group #2 is 120 days or less.
- For Group #3, public will concur with our no-action recommendation.
- All reviews will be completed and all comments can be resolved within the scheduled amount of time.
- No significant delays due to active burning.
- No significant weather delays.
- No significant changed site conditions (such as large buried debris or munitions).

18 Apr 94

LONGHORN ARMY AMMUNITION PLANT

DEADLINES FOR PRIMARY AND SECONDARY DOCUMENTS OF GROUP #1 & 2

TASK NAME	GROUP #1 (1,11, XX,27)	GROUP #2 (12,16 17,18,24,29)
Phase II Work Plan (S)		
Submitted	18 Jul 94	28 Oct 94
Phase II Field Investigations (S)		
Data Results	19 Feb 95	31 Jul 95
Site Characterization Summary (S)		
Submitted	9 Jun 95	18 Nov 95
Risk Assessment (P)		
Draft submitted	17 Aug 95	26 Jan 96
Final	13 Oct 95	23 Mar 96
RI Report (P)		
Draft submitted	19 Nov 95	29 Apr 96
Final	15 Jan 96	25 Jun 96

18 Apr 94

LONGHORN ARMY AMMUNITION PLANT

DEADLINES FOR PRIMARY DOCUMENTS OF GROUP #3

TASK NAME	GROUP #3 (13 & 14)
RI/FS Report (P)	
Draft submitted	29 Jul 94
Final	24 Sep 94
Proposed Plan (P)	
Draft submitted	9 Nov 94
Final	5 Jan 95
Public Meeting	6 Jan 95
Final Public Comment	5 Feb 95
Responsiveness Summary (P)	
Draft submitted	5 May 95
Final	1 Jul 95
Record of Decision (P)	
Draft submitted	31 Aug 95
Final	27 Oct 95

18 Apr 94

DEPARTMENT OF THE ARMY
LONGHORN/LOUISIANA ARMY AMMUNITION PLANTS
MARSHALL, TEXAS 75671-1059

April 21, 1994

REPLY TO
ATTENTION OF

Engineering Division

Ms. Lisa Price
Superfund Reinforcement
U.S. Enironmental Protection Agency
1445 Ross Avenue
Dallas, Texas 75202

Dear Ms. Price:

Enclosed are the Primary and Secondary Documents of:

a. Group #4 (waste sumps)
b. The IRA of the burning #3 and UEP
c. The IRA of the landfill caps (sites 12 & 16).

These documents are for planning purposes only. Group #4 assumes no additional phases beyond phase II.

If there are any questions, please contact Mr. David Tolbert at (903)679-2728.

Sincerely,

Lawrence J. Sowa
Lieutenant Colonel, U.S. Army
Commanding Officer

LONGHORN ARMY AMMUNITION PLANT

PRIMARY AND SECONDARY DOCUMENTS OF GROUP #4 (WASTE SUMPS)

TASK NAME	GROUP #4 (125+20) WASTE SUMPS
Phase II Work Plan (S)	
Submitted	10 Jul 94
Phase II Field Investigation (S)	
Data Results	11 Jun 95
Site Characterization Summary (S)	
Submitted	29 Sep 95
Risk Assessment (P)	
Draft submitted	7 Dec 95
Final	2 Feb 96
RI Report (P)	
Draft submitted	10 Mar 96
Final	6 May 96

(as of 18 Apr 94)

LONGHORN ARMY AMMUNITION PLANT

PRIMARY AND SECONDARY DOCUMENTS OF IRA AT BURNING GROUND #3 & UEP

TASK NAME	IRA (18 & 24)
Phase II (Pilot Study) Field Investigation (S)	
Data Results	1 Aug 94
Submitted FISR	27 Sep 94
Proposed Plan (P)	
Draft submitted	9 Oct 94
Final	5 Dec 94
Public Meeting	6 Dec 94
Final Public Comment	5 Jan 95
Responsiveness Summary (P)	
Draft submitted	26 Mar 95
Final	22 May 95
Record of Decision (P)	
Draft submitted	26 Mar 95
Final	22 May 95
IRA Work Plan (P)	
Draft submitted	3 Nov 95
Final	30 Dec 95
IRA begin	14 Jan 96

(as of 18 Apr 94)

LONGHORN ARMY AMMUNITION PLANT

PRIMARY AND SECONDARY DOCUMENTS FOR LANDFILL CAPS

TASK NAME	IRA (12 & 16)
Remedial Design Work Plan (P)	
Draft submitted	19 Jun 94
Final	15 Aug 94
Decision Document (P)	
Draft submitted	26 Jan 95
Final	24 Mar 95
Plans & Specs (P)	
Draft submitted	19 Mar 95
Final	15 Jun 95
IRA Work Plan (P)	
Draft submitted	13 Oct 95
Final	9 Dec 95
IRA begin	24 Dec 95

(as of 18 Apr 94)