

**LONGHORN ARMY
AMMUNITION PLANT**

KARNACK, TEXAS

**ADMINISTRATIVE
RECORD**

VOLUME 1 of 2

Year - 2000

**Bate Stamp Numbers
024659 - 024920**

Prepared for:

**Department of the Army
Longhorn Army Ammunition Plant**

**LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS
ADMINISTRATIVE RECORD - CHRONOLOGICAL INDEX**

VOLUME 1 of 2

Year - 2000

- A: Title: Letter - Subject: Perchlorate Sampling Results from samples taken by the Texas Natural Resource Conservation Commission (TNRCC) for the Longhorn Army Ammunition Plant (LHAAP), Karnack, Texas
Author: James S.H. Sher, P.E., Project Manager, Superfund Cleanup Section, TNRCC, Austin, Texas
Recipient: James A. McPherson, Commander's Representative, LHAAP
copied to: Chris Villarreal, US Environmental Protection Agency (EPA)
Date: 07 February 2000
Bate Stamp: 024659 – 024660
- B: Title: Meeting Agenda – Technical Review Committee Meeting, Longhorn Army Ammunition Plant (LHAAP), Karnack, Texas
Recipient: All Parties
Date: 15 March 2000
Bate Stamp: 024661 – 024674
- C: Title: Letter & Report - Subject: Caddo Lake Storm Water Sampling Analytical Results for samples collected for the Longhorn Army Ammunition Plant (LHAAP), Karnack, TX
Author: Chris Villarreal, US Environmental Protection Agency (EPA), Dallas, Texas
Recipient: James S.H. Sher, P.E., Texas Natural Resource Conservation Commission (TNRCC)
copied to: James A. McPherson, Commander's Representative, LHAAP,
Jonna Polk, Tulsa District, U.S. Army Corps of Engineers (USACE),
& Dan Wall, U.S. Fish & Wildlife Service
Date: 01 May 2000
Bate Stamp: 024675 – 024729
- D: Title: Meeting Agenda – Monthly Manager's Meeting, Longhorn Army Ammunition Plant (LHAAP), Karnack, Texas
Recipient: All Parties
Date: 15 June 2000
Bate Stamp: 024730 – 024745
- E: Title: Fax/Letter - Subject: Texas Risk Reduction Program - Ref: Request by the Longhorn Army Ammunition Plant (LHAAP), Karnack, Texas to be grandfathered under the Risk Reduction Rules
Author: James S.H. Sher, P.E., Project Manager, Superfund Cleanup Section, Texas Natural Resource Conservation Commission (TNRCC)
Recipient: David Tolbert, Commander's Representative, LHAAP
copied to: Chris Villarreal, US Environmental Protection Agency (EPA)
Date: 07 August 2000
Bate Stamp: 024746

**LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS
ADMINISTRATIVE RECORD - CHRONOLOGICAL INDEX**

VOLUME 1 of 2 (continued)

Year - 2000

- F: Title: Meeting Agenda – Technical Review Committee Meeting, Longhorn Army
 Ammunition Plant (LHAAP), Karnack, Texas
 Recipient: All Parties
 Date: 14 September 2000
 Bate Stamp: 024747 – 024756
- G: Title: Final Report - Remedial Investigation Report - Volume 1: Report
 for Site 16 Landfill Remedial Investigation and Feasibility Study at the Longhorn Army
 Ammunition Plant (LHAAP), Karnack, Texas
 Author: Jacobs Engineering Group, Inc., St. Louis, Missouri
 Recipient: U.S. Army Corps of Engineers (USACE), Tulsa District
 Date: October, 2000
 Bate Stamp: 024757 – 024888
- H: Title: Final Report - Remedial Investigation Report - Volume 2: Appendix I - Figures for Site
 16 Landfill Remedial Investigation and Feasibility Study at the Longhorn Army
 Ammunition Plant (LHAAP), Karnack, Texas
 Author: Jacobs Engineering Group, Inc., St. Louis, Missouri
 Recipient: U.S. Army Corps of Engineers (USACE), Tulsa District
 Date: October, 2000
 Bate Stamp: 024889 – 024920

Robert J. Huston, *Chairman*
R. B. "Ralph" Marquez, *Commissioner*
John M. Baker, *Commissioner*
Jeffrey A. Saitas, *Executive Director*



024659

TEXAS NATURAL RESOURCE CONSERVATION COMMISSION

Protecting Texas by Reducing and Preventing Pollution

February 7, 2000

HAND DELIVERED

James A. McPherson, Commander's Representative

Longhorn/Louisiana Army Ammunition Plant
Attn: SIOLH-CR
P.O. Box 658
Doyline, LA 71023-0658

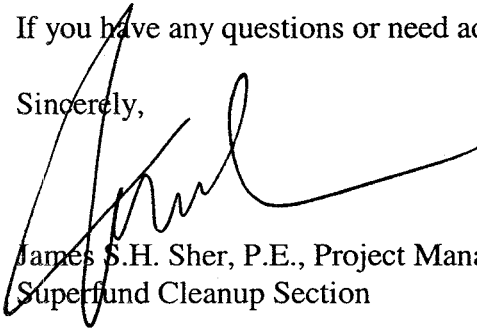
Re: Longhorn Army Ammunition Plant (LHAAP)
TNRCC Perchlorate Sampling Results

Dear Mr. McPherson:

The Texas Natural Resource Conservation Commission collected groundwater and surface water samples on August 24-25, 1999. On December 13, 1999 the TNRCC collected stormwater samples. Based on laboratory reports, all samples indicated that no perchlorate was detected above a practical quantitation limit of 4 ppb. Please see Enclosure A for lists of the sampling locations for both sampling events.

If you have any questions or need additional information please call me at: (512) 239-2444.

Sincerely,



James S.H. Sher, P.E., Project Manager
Superfund Cleanup Section

RC/JS/mwm

cc: Mr. Chris Villarreal, EPA Region 6 (6SF-AP)

ENCLOSURE A

August 24-25, 1999 Sampling Locations

Goose Prairie at Channel Marker F48
Goose Prairie at Channel Marker F51
Caddo Lake in the vicinity of Harrison Bayou
Caddo Lake on Louisiana side of border
Caddo Lake in the vicinity of the Mouth of Harrison Bayou
Caddo Lake in the vicinity of Central Creek
Caddo Lake at Rag Island Point
Caddo Lake in the vicinity of Harrison Bayou
Caddo Lake in the vicinity of Saunders Branch
Caddo Lake at TNRCC Reg IX designated sampling site south of Millers Point
Big Cypress Bayou at old PDWS surface water intake for the LHAAP
Mill Pond in Caddo Lake State Park
Clinton Lake (designated control site)
LHAAP PDWS well G1020025A
LHAAP PDWS well G1020025B
Big Cypress Bayou at the PDWS surface water intake for the City of Marshall
Caddo Lake Water Supply Corporation PDWS wells G1020019A, B, & C
Karnack Water Supply Corporation PDWS well G1020016A
Caddo Lake State Park PDWS well G1020001A

December 13, 1999 Sampling Locations

Mid Lake
Goose Prairie Central Area
Harrison Bayou near mouth
Harrison Bayou Lake Area

**Longhorn Army Ammunition Plant
Technical Review Committee Meeting**

**15 March 2000
10:30 a.m.**

Agenda

Executive Summary

Quarterly Perimeter Well Data Summary

Perchlorate Status Update

Adjourn

**LONGHORN ARMY AMMUNITION PLANT
IRP STATUS SUMMARY**

As Of 15 March, 2000

PROJECT NAME	PROJECT PHASE	PROJECT STATUS	NEXT MAJOR MILESTONE(S)
Group # 2 (Sites 12, 17, 18, 24, 29, and 32)	Remedial Investigation/ Feasibility Study	- Phase III RI field work completed week of 26 October 98. - Perimeter well sampling (including perchlorates) completed 8 Jan 00. - Harrison Bayou sampling completed 4 Feb 00. - SCS submitted to team 1 Feb 00. - Perimeter well sampling results submitted 16 Feb 00.	- Preliminary Harrison Bayou sampling data available 15 March 00. - Perimeter well and Harrison Bayou sampling scheduled for early April.
Group # 4 Wastewater Sumps And Sites 50 & 60	Remedial Investigation/ Feasibility Study	- Phase III RI field work completed 17 December 98. - Goose Prairie Creek sampling completed 4 Feb 00. - Letter submitted to Army for Caddo Lake sampling for risk assessment parameters on 16 Feb 00 (Groups 2 and 4). - SCS submitted to team 28 February 00.	- Preliminary Goose Prairie Creek sampling data available 15 March 00. - Goose Prairie Creek sampling scheduled for early April.
Burning Ground #3 (Sites 18 and 24)	Interim Remedial Action	- Wells sampled in June 99. - Radian completed the startup of the Groundwater Treatment Plant on 31 March 99. A one year operating contract began 1 Jun 99.	- Contracting actions have begun for a new GWTP operating contract.
Landfill Caps (Sites 12 and 16)	Interim Remedial Action	- Landfill caps and final inspections completed November 98. - Cap repair and reseeded work was completed 8 June 99. - Landfill caps inspected for erosion on 9 March 00.	

024662

LONGHORN ARMY AMMUNITION PLANT IRP STATUS SUMMARY

As Of 15 March, 2000

PROJECT NAME	PROJECT PHASE	PROJECT STATUS	NEXT MAJOR MILESTONE(S)
Perchlorates		- Perchlorates have been detected in soil, groundwater, and surface water at Building 25C. - Perchlorates detected in groundwater treatment plant effluent and downgradient surface waters of Harrison Bayou. - All Burning Ground extraction sumps sampled for perchlorates. - Toxicity testing conducted for groundwater treatment plant effluent. - Conceptual plan (memo) to address perchlorates sent to TNRCC and EPA on 24 June 99. - Letter from TNRCC sent 9 July requesting sampling of Caddo Lake for perchlorates. Army response provided 14 July. - Letter from TNRCC received 7 September. Letter forwarded to Army officials on 7 September. - 1 December meeting in Austin, TX held to discuss perchlorate plans. - LHAAP, IOC and COE personnel met with Navy's McGregor staff and attended RAB meeting on 9	- Investigation scoping document to be presented at the 24 February meeting.

**LONGHORN ARMY AMMUNITION PLANT
IRP STATUS SUMMARY**

As Of 15 March, 2000

PROJECT NAME	PROJECT PHASE	PROJECT STATUS	NEXT MAJOR MILESTONE(S)
		December. - Building 25C covered with liner in November 99. - Schedules for investigation and treatability study presented at 19 January 00 meeting. Comments provided during the meeting, and revised schedules submitted 1 Feb 00. - Building 25-C sampling data provided to team on 1 Feb 00. - Army approval received in Jan 00 to sample beyond property boundaries in Caddo Lake. - Funding received for contract with Envirogen for GWTP Bench Scale study. - LHAAP team met on 25 February and finalized perchlorate investigation scoping. Contracting action underway.	
Landfill Site 16 Accelerated RI	RI/FS	- Phase III RI field work complete. - RI Report under Army review. - RI Report to team in October 99.	- RA Report to Team for review on 31 March 00.

**LONGHORN ARMY AMMUNITION PLANT
IRP STATUS SUMMARY**

As Of 15 March, 2000

SCHEDULED MEETINGS AND VISITS TO LHAAP		
Date / Time	Purpose of Meeting / Visit	Location
15 March/10:30	TRC Meeting	LHAAP

01	Inert Burning Grounds	24	Washout & Unlined Evaporation Pond	60	Former Storage Bldg. 411 & 714
11	Suspected TNT Burial Grounds at Ave P&Q	27	South Test Area	XX(54)	Ground Signal Test Area
12	Landfill 12	29	Former TNT Production Area	52	Magazine Area
16	Landfill 16	32	Former TNT Disposal Area	63	Burial Pits
17	Burning Ground 2/Flashing Area	35	Process Wastewater Sumps		
18	Burning Ground 3	50	Former Waste Disposal Facility		

024665

**Longhorn Army Ammunition Plant
Perchlorate Scoping Meeting
February 24, 2000**

The following comments were provided during the perchlorate scoping meeting on 24 February, 2000. The comments will be incorporated into the Perchlorate Investigation Work Plan.

1. Information added to the Executive Summary to identify when perchlorate was used at the Plant.
2. Executive Summary, 1st paragraph, line 8, change "impacted" to "been released to".
3. Add a quarterly team review of groundwater sampling data.
4. Page 0-5, line 3, change to "analysis. Following the evaluation of the sampling data, monitoring wells...".
5. Provide rationale for not sampling wells.
6. Add sampling of well 27WW04, and 1 boring location at site 27.
7. Site 54 – Ira Nathan will provide perchlorate data from rocket motor sampling, and this data will be incorporated into the Work Plan.
8. Site 12 – Add 2 surface (0-6") samples on cap and 2 surface samples in the drainage area (one sample per location).
9. Site 17 – Add statement regarding potential for release in initial area.
10. Site 18 – Add language to address future soil concerns.
11. Site 29 – Delete sampling of well 17, and add sampling of well 16.
12. Site 35C – Add two borings in the drainage area from the INF pond (depths of 0-6" and 1-2'), one boring close to the initial drainage area, then one further downgradient from that point. Add historical information to Work Plan to explain why soil samples are not collected in other areas.
13. Pilot WWTP – Add two soil borings (2 depths) and sample one well.

LONGHORN ARMY AMMUNITION PLANT
PERIMETER WELL SAMPLING
6-7 JANUARY 2000

The perimeter wells (wells 108, 110, 111, 112, 133, and 134) at Longhorn Army Ammunition Plant were sampled on 6-7 January 2000. Wells 110, 111, 112, and 133 were sampled 6 January 2000. Wells 108 and 134 were sampled 7 January. The groundwater samples collected were analyzed for metals, volatile organic compounds (method 8260B), semi-volatile organic compounds (method 8270), high explosives (method 8330), and anions including perchlorate (method 300).

The analytical results for the metals (inorganics) and anions are presented on the following two pages. Analytical detection limits are presented with the results. There were no detections of volatile organic compounds, semi-volatile organic compounds or high explosives. The detection limits for the compounds analyzed by those methods are presented on following pages.

At the time of sampling, water quality parameters (pH, conductivity, turbidity and dissolved oxygen (DO) were recorded. The table below provides those measurements.

Well Number	Sample Date/Time	Temperature (°C)	pH	Conductivity (mS/cm)	Turbidity (NTU)	DO (mg/L)
108	7 Jan 00/ 1600	17.0	6.12	10.9	>999	6.64
110	6 Jan 00/ 1405	16.1	6.54	5.91	14	3.16
111	6 Jan 00/ 1530	17.4	6.08	0.592	784	7.60
112	6 Jan 00/ 1255	16.9	6.61	4.42	24	3.69
133	6 Jan 00/ 1640	16.4	5.81	0.158	28	6.30
134	7 Jan 00/ 1415	17.9	5.24	0.093	52	5.26

Longhorn Army Ammunition Plant
Perimeter Wells (January 2000)
Inorganic Data Summary (mg/L)

Sample Date	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Mg	Mn	Ni	Pb	Sb	Se	Sr	Ti	V	Zn
PW-MW-108																							
7 Jan 2000	30	300	15	30	6	600	3	15	15	30	150	0.2	1200	300	15	15	15	18	30	10	6	30	30
	<30	844	9.6J	53.6	<6	227000	<3	234	9.2J	14.7J	6400	0.16J	4300	185000	8250	121	10.3J	<18	<30	7630	<6	3.0J	74.8
PW-MW-110																							
6 Jan 2000	30	300	15	30	6	600	3	15	15	30	150	0.2	1200	300	15	15	15	18	30	10	6	30	30
	<30	<300	<15	23.3J	<6	225000	<3	9.5J	5.9J	15.5J	822	<0.2	3240	147000	4570	29.7	10.4J	<18	<30	6680	<6	<30	<30
PW-MW-111																							
6 Jan 2000	10	100	5	10	2	200	1	5	5	10	50	0.2	400	100	5	5	5	6	10	10	2	10	10
	<10	3630	<5	151.0	0.46J	23700	<1	11.3	9	13.2	7650	0.20J	1270	24000	455	21.1	7.3	<6	<10	887	<2	11.2	48.1
PW-MW-112																							
6 Jan 2000	20	200	10	20	4	400	2	10	10	20	100	0.2	800	200	10	10	10	12	20	10	4	20	20
	<20	628	<10	39.8	<4	230000	<2	28	6.6J	14.8J	2070	<0.2	3310	283000	2920	25.1	7.7J	<12	<20	7070	<4	<20	15.8J
PW-MW-133																							
6 Jan 2000	10	100	5	10	2	200	1	5	5	10	50	0.2	400	100	5	5	5	6	10	10	2	10	10
	<10	2800	3.7J	71.6	<2	9140	<1	8.3	7.6	14.4	5600	0.18J	2010	3290	265	10.3	11.5	<6	<10	133	<2	7.4J	41.7
PW-MW-134																							
7 Jan 2000	10	100	5	10	2	200	1	5	5	10	50	0.2	400	100	5	5	5	6	10	10	2	10	10
	<10	231	<5	44.6	<2	5790	<1	1.5J	6.3	4.6J	647	0.18J	1590	2320	52.7	4.7J	3.2J	<6	<10	111	<2	1.1J	14.4

3/14/00

Longhorn Army Ammunition Plant Perimeter Wells Total Dissolved Solids Data Summary (mg/L)		Chloride	Nitrite	Nitrate	Sulfate	Perchlorate, Low Level
PW-MW-108		Reporting Limit				
		100	0.05	0.04	0.5	0.032
	7 Jan. 2000	2020	<0.05	<0.04	885	<0.032
PW-MW-110		Reporting Limit				
		50	0.05	0.04	0.5	0.032
	6 Jan. 2000	1370	<0.05	<0.04	1600	<0.032
PW-MW-111		Reporting Limit				
		5	0.05	0.04	0.5	0.004
	6 Jan. 2000	139	<0.05	<0.04	77.8	<0.004
PW-MW-112		Reporting Limit				
		50	0.05	0.04	0.5	0.024
	6 Jan. 2000	1140	<0.05	<0.04	852	<0.024
PW-MW-133		Reporting Limit				
		0.4	0.05	0.04	0.5	0.004
	6 Jan. 2000	10.5	0.12	2.18	9	<0.004
PW-MW-134		Reporting Limit				
		0.2	0.05	0.04	0.5	0.004
	7 Jan. 2000	4.23	<0.05	2.31	2.5	<0.004

Longhorn Army Ammunition Plant
Perimeter Wells
Jan 6-7, 2000
Volatiles Reporting Limit Summary (µg/L)

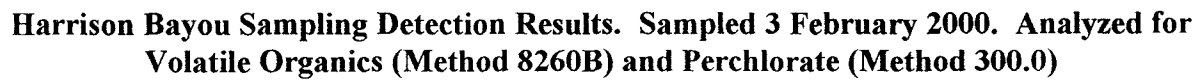
ACETONE	20	IODOMETHANE	1
ACETONITRILE	50	P-CYME (P-ISOPROPYLTOLUENE)	1
ACROLEIN	20	METHYLENE CHLORIDE	10
ACRYLONITRILE	20	METHYL ISOBUTYL KETONE	5
BENZENE	1	TERT-BUTYL METHYL ETHER	5
BROMOBENZENE	1	NAPHTHALENE	1
BROMOCHLOROMETHANE	1	N-PROPYLBENZENE	1
BROMODICHLOROMETHANE	1	STYRENE	1
BROMOFORM	1	1,1,1,2-TETRACHLOROETHANE	1
BROMOMETHANE	1	1,1,2,2-TETRACHLOROETHANE	1
METHYL ETHYL KETONE	20	TETRACHLOROETHYLENE(PCE)	1
N-BUTYLBENZENE	1	TOLUENE	1
SEC-BUTYLBENZENE	1	1,2,3-TRICHLOROBENZENE	1
T-BUTYLBENZENE	1	1,2,4-TRICHLOROBENZENE	1
CARBON DISULFIDE	1	1,1,1-TRICHLOROETHANE	1
CARBON TETRACHLORIDE	1	1,1,2-TRICHLOROETHANE	1
CHLOROBENZENE	1	TRICHLOROETHYLENE (TCE)	1
DIBROMOCHLOROMETHANE	1	TRICHLOROFLUOROMETHANE	1
CHLOROETHANE	1	1,2,3-TRICHLOROPROPANE	1
2-CHLOROETHYL VINYL ETHER	5	1,2,4-TRIMETHYLBENZENE	1
CHLOROFORM	1	1,3,5-TRIMETHYLBENZENE	1
CHLOROMETHANE	1	VINYL ACETATE	10
2-CHLOROTOLUENE	1	VINYL CHLORIDE	1
4-CHLOROTOLUENE	1	O-XYLENE	1
1,2-DIBROMO-3-CHLOROPROPANE	5	M,P-XYLENE	2
1,2-DIBROMOETHANE	1		
DIBROMOMETHANE	1		
1,2-DICHLOROBENZENE	1		
1,3-DICHLOROBENZENE	1		
1,4-DICHLOROBENZENE	1		
DICHLORODIFLUOROMETHANE	1		
1,1-DICHLOROETHANE	1		
1,2-DICHLOROETHANE	1		
1,1-DICHLOROETHENE	1		
CIS-1,2-DICHLOROETHYLENE	1		
TRANS-1,2-DICHLOROETHENE	1		
1,2-DICHLOROPROPANE	1		
1,3-DICHLOROPROPANE	1		
2,2-DICHLOROPROPANE	1		
1,1-DICHLOROPROPENE	1		
CIS-1,3-DICHLOROPROPENE	1		
TRANS-1,3-DICHLOROPROPENE	1		
ETHYL ACETATE	10		
ETHYLBENZENE	1		
HEXACHLOROBUTADIENE	1		
ISOPROPYLBENZENE (CUMENE)	1		
2-HEXANONE (MEK)	5		

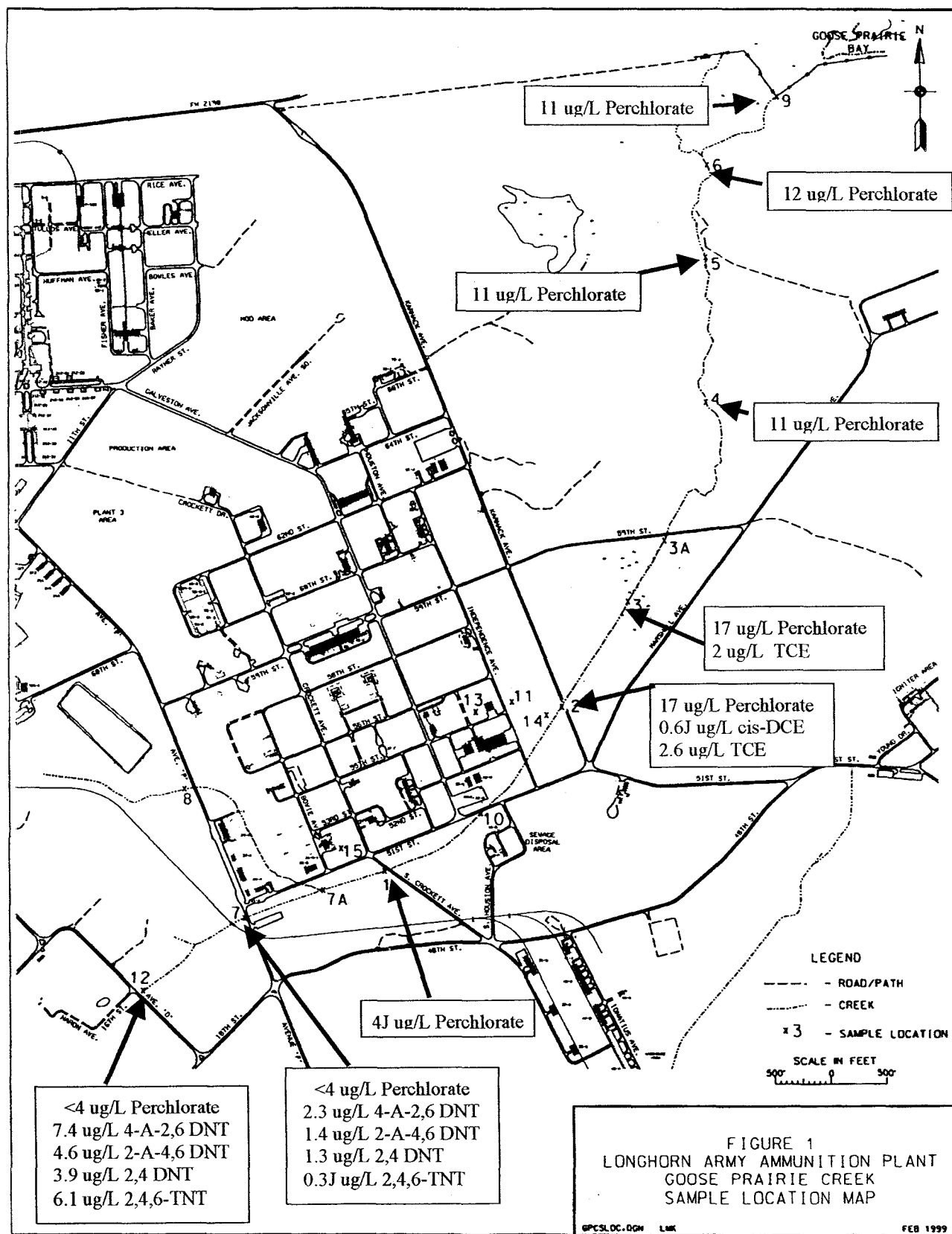
**Longhorn Army Ammunition Plant
Perimeter Wells
Jan 6-7, 2000
Semi-volatile Reporting Limit Summary (µg/L)**

ACENAPHTHENE	2	2,6-DINITROTOLUENE	5
ACETOPHENONE	5	3,3'-DIMETHYLBENZIDINE	10
ACENAPHTHYLENE	2	1,3-DINITROBENZENE	5
ANILINE	5	DIPHENYLAMINE	10
ANTHRACENE	2	FLUORANTHENE	2
BENZO(A)ANTHRACENE	2	FLUORENE	2
BENZIDINE	20	HEXACHLOROBENZENE	5
BENZO(A)PYRENE	2	HEXACHLOROBUTADIENE	5
BENZO(B)FLUORANTHENE	2	HEXACHLOROCYCLOPENTADIENE	5
BENZO(G,H,I)PERYLENE	2	HEXACHLOROETHANE	5
BENZO(K)FLUORANTHENE	2	INDENO(1,2,3-C,D)PYRENE	2
BENZOIC ACID	50	ISOPHORONE	5
BENZYL ALCOHOL	10	2-METHYLNAPHTHALENE	2
BIS(2-CHLOROETHOXY) METHANE	5	3-METHYLPHENOL	5
BIS(2-CHLOROETHYL) ETHER	5	4-METHYLPHENOL (P-CRESOL)	5
BIS(2-CHLOROISOPROPYL) ETHER	5	2-METHYLPHENOL (O-CRESOL)	5
BIS(2-ETHYLHEXYL) PHTHALATE	10	NAPHTHALENE	2
4-BROMOPHENYL PHENYL ETHER	5	2-NITROANILINE	5
BENZYL BUTYL PHTHALATE	5	3-NITROANILINE	10
CARBAZOLE	5	4-NITROANILINE	5
4-CHLORO-3-METHYLPHENOL	5	NITROBENZENE	5
4-CHLOROANILINE	5	2-NITROPHENOL	5
2-CHLORONAPHTHALENE	2	4-NITROPHENOL	5
2-CHLOROPHENOL	5	N-NITROSODI-N-PROPYLAMINE	5
4-CHLOROPHENYL PHENYL ETHER	5	N-NITROSO-DI-N-BUTYLAMINE	5
CHRYSENE	2	N-NITROSO-DIETHYLAMINE	5
DI-N-BUTYL PHTHALATE	5	N-NITROSODIMETHYLAMINE	5
DI-N-OCTYLPHTHALATE	5	N-NITROSODIPHENYLAMINE	10
DIBENZ(A,H)ANTHRACENE	2	PENTACHLOROPHENOL	10
DIBENZOFURAN	5	PHENANTHRENE	2
1,2-DICHLOROBENZENE	5	PHENOL	5
1,3-DICHLOROBENZENE	5	PYRENE	2
1,4-DICHLOROBENZENE	5	PYRIDINE	10
3,3'-DICHLOROBENZIDINE	10	1,2,4,5-TETRACHLOROBENZENE	5
2,4-DICHLOROPHENOL	5	2,3,4,6-TETRACHLOROPHENOL	5
2,6-DICHLOROPHENOL	5	1,2,4-TRICHLOROBENZENE	5
DIETHYL PHTHALATE	5	2,4,5-TRICHLOROPHENOL	5
DIMETHYL PHTHALATE	5	2,4,6-TRICHLOROPHENOL	5
2,4-DIMETHYLPHENOL	5	1,3,5-TRINITROBENZENE	10
4,6-DINITRO-2-METHYLPHENOL	10		
2,4-DINITROPHENOL	50		
2,4-DINITROTOLUENE	5		

**Longhorn Army Ammunition Plant
Perimeter Wells
Jan 6-7, 2000
Explosives Reporting Limit Summary
($\mu\text{g/L}$)**

4-AMINO-2,6-DINITROTOLUENE	0.5
2-AMINO-4,6-DINITROTOLUENE	0.5
1,3-DINITROBENZENE	0.5
2,4-DINITROTOLUENE	0.5
2,6-DINITROTOLUENE	0.5
HMX	0.5
NITROBENZENE	0.5
3-NITROTOLUENE	0.5
RDX	0.5
TETRYL	0.5
1,3,5-TRINITROBENZENE	0.5
2,4,6-TRINITROTOLUENE	0.5
2-NITROTOLUENE	0.5
4-NITROTOLUENE	0.5





f:\army\longhorn\gpsloc.dgn Feb. 28, 2001 13:33:41

Goose Prairie Creek Sampling Detection Results. Sampled 4 February 2000.
Analyzed for Explosives (Method 8330), Volatile Organics (Method 8260B), and
Perchlorate (Method 300.0)



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 6
1445 ROSS AVENUE, SUITE 1200
DALLAS, TX 75202-2733

024676
RECEIVED
MAY 05 2000
HTRW DESIGN CENTER

May 1, 2000

Mr. James S. H. Sher, P.E.
Texas Natural Resource Conservation Commission
Superfund Engineering Section
Pollution Cleanup Division
Mail Code: MC - 144
P.O. Box 13087
Austin, Texas 78711 - 3087

Re: Longhorn Army Ammunition Plant
Analytical Sampling Results - Caddo Lake Storm Water Sampling

Dear Mr. Sher:

Enclosed for your information are copies of the volatile and semi-volatile analytical reports for the Caddo Lake surface water samples collected on March 14, 2000. If you have any questions, please feel free to get me call at (214) 665 - 6758.

Sincerely,

Chris Villarreal
Chris Villarreal
Remedial Project Manager

Enclosures

cc: James A. McPherson, Commander's Representative
Longhorn Army ammunition Plant

Jonna Polk, U.S. Army Corps of Engineers, Tulsa District

Dan Wall, U.S. Fish and Wildlife Service



United States Environmental Protection Agency
Region 6 Environmental Services Branch Laboratory
10625 Fallstone, Houston, Texas 77099

024676
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AR/CL/11/11/11

Final Analytical Report

Site Name LONGHORN ARMY AMMUNITIONS PLANT (CADDO LAKE)

CERCLIS Number TX6213820529

Sample Collection Date March 14, 2000

Laboratory Sample Identification OT5BEW24

Contact Chris Villareal (6SF-AP)

Report Date April 20, 2000

Report Narrative:

Standard procedures for quality assurance and quality control were followed in the analysis and reporting of the sample results. The results apply only to the samples tested. This final report should only be reproduced in full.

The laboratory routinely disposes of samples 90 days after all analysis has been completed. If you have a need to hold these samples in custody longer than 90 days, please send an e-mail to Larry Streck Streck.Larry@epa.gov within the next 30 days briefly stating your need to hold these samples in custody.

Report Approvals:

David Stockton
Deputy Branch Chief (Acting)

Douglas A. Lipka
Region 6 Laboratory Branch Chief



United States Environmental Protection Agency
 Region 6 Environmental Services Branch Laboratory
 10625 Fallstone, Houston, Texas 77099

024677

Final Analytical Report

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024678

U. S. Environmental Protection Agency
Region 6 Houston Laboratory

Report For Sample Number OT5BEW2401

Source: LONGHORN ARMY AMMUNITIONS PLANT (CADDO LAKE)

Site Description: HB-1DS

Date/Time Received: 3/16/2000 11:55 AM

Date Completed 4/20/2000

Date/Time Collected: 3/14/2000 10:50 AM

Sample Type: LIQUID

Comments:

Parameter
LABN

LOW LEVEL ABN

Description

024679

ORGANIC ANALYSIS DATA

Sample NO: OT5BEW24-01

Date Analyzed: 27-Mar-00

Sample Type: Liquid

SEMI-VOLATILE COMPOUNDS BY METHOD 625

(continuous extractor)

units: ug/L

units: ug/L

Compound Name	Results*	Det Limits	Compound Name	Results*	Det Limits
Acenaphthene	ND	2	2,4-Dinitrophenol	ND	30
Acenaphthylene	ND	2	2,4-Dinitrotoluene	ND	6
Anthracene	ND	2	2,6-Dinitrotoluene	ND	6
Benzoic Acid	ND	10	4,6-Dinitro-2-Methylphenol	ND	20
Benzo(a)Anthracene	ND	8	Di-n-Butylphthalate	ND	2
Benzo(a)Pyrene	ND	0.2	Di-n-Octyl Phthalate	ND	4
Benzo(b)Fluoranthene	ND	8	Fluoranthene	ND	2
Benzo(g,h,i)Perylene	ND	8	Fluorene	ND	2
Benzo(k)Fluoranthene	ND	8	Hexachlorobenzene	ND	1
Benzyl Alcohol	ND	4	Hexachlorobutadiene	ND	5
bis(2-Chloroethoxy)Methane	ND	2	Hexachlorocyclopentadiene	ND	10
bis(2-Chloroethyl) Ether	ND	2	Hexachloroethane	ND	3
bis(2-chloroisopropyl)Ether	ND	2	Indeno(1,2,3-cd) Pyrene	ND	8
bis-(2-Ethylhexyl)Phthalate	ND	4	Isophorone	ND	4
4-Bromophenylphenyl Ether	ND	8	2-Methylnaphthalene	ND	2
Butylbenzylphthalate	ND	4	2-Methylphenol	ND	6
Carbazole	ND	2	4-Methylphenol	ND	6
4-Chloroaniline	ND	4	Naphthalene	ND	2
2-Chloronaphthalene	ND	2	2-Nitroaniline	ND	8
2-Chlorophenol	ND	4	3-Nitroaniline	ND	8
4-Chlorophenylphenyl Ether	ND	8	4-Nitroaniline	ND	8
4-Chloro-3-Methylphenol	ND	8	Nitrobenzene	ND	2
Chrysene	ND	8	2-Nitrophenol	ND	10
Dibenzofuran	ND	2	4-Nitrophenol	ND	13
Dibenzo(a,h)Anthracene	ND	8	N-Nitrosodiphenylamine	ND	4
1,2-Dichlorobenzene	ND	3	N-Nitroso-Di-n-Propylamine	ND	6
1,3-Dichlorobenzene	ND	3	Pentachlorophenol	ND	1
1,4-Dichlorobenzene	ND	3	Phenanthrene	ND	2
3,3'-Dichlorobenzidine	ND	10	Phenol	ND	4
2,4-Dichlorophenol	ND	6	Pyrene	ND	2
Diethylphthalate	ND	2	1,2,4-Trichlorobenzene	ND	3
2,4-Dimethylphenol	ND	6	2,4,5-Trichlorophenol	ND	6
DimethylPhthalate	ND	2	2,4,6-Trichlorophenol	ND	6

(*) ND = Not detected above the listed detection limit.

(*) ND = Not detected above the listed detection limit.

Analyst Notes: none



024681

U. S. Environmental Protection Agency**Region 6 Houston Laboratory****Report For Sample Number 0T5BEW2402****Source:** LONGHORN ARMY AMMUNITIONS PLANT (CADDO LAKE)**Site Description:** HB-3S**Date/Time Received:** 3/16/2000 11:55 AM**Date Completed** 4/20/2000**Date/Time Collected:** 3/14/2000 10:55 AM**Sample Type:** LIQUID**Comments:**

Parameter

Description

LABN

LOW LEVEL ABN

024682

ORGANIC ANALYSIS DATA

Sample NO: OT5BEW24-02

Date Analyzed: 27-Mar-00

Sample Type: Liquid

SEMI-VOLATILE COMPOUNDS BY METHOD 625

(continuous extractor)

units: ug/L

units: ug/L

Compound Name	Results*	Det Limits	Compound Name	Results*	Det Limits
Acenaphthene	ND	2	2,4-Dinitrophenol	ND	30
Acenaphthylene	ND	2	2,4-Dinitrotoluene	ND	6
Anthracene	ND	2	2,6-Dinitrotoluene	ND	6
Benzoic Acid	ND	10	4,6-Dinitro-2-Methylphenol	ND	20
Benzo(a)Anthracene	ND	8	Di-n-Butylphthalate	ND	2
Benzo(a)Pyrene	ND	0.2	Di-n-Octyl Phthalate	ND	4
Benzo(b)Fluoranthene	ND	8	Fluoranthene	ND	2
Benzo(g,h,i)Perylene	ND	8	Fluorene	ND	2
Benzo(k)Fluoranthene	ND	8	Hexachlorobenzene	ND	1
Benzyl Alcohol	ND	4	Hexachlorobutadiene	ND	5
bis(2-Chloroethoxy)Methane	ND	2	Hexachlorocyclopentadiene	ND	10
bis(2-Chloroethyl) Ether	ND	2	Hexachloroethane	ND	3
bis(2-chloroisopropyl)Ether	ND	2	Indeno(1,2,3-cd) Pyrene	ND	8
bis-(2-Ethylhexyl)Phthalate	ND	4	Isophorone	ND	4
4-Bromophenylphenyl Ether	ND	8	2-Methylnaphthalene	ND	2
Butylbenzylphthalate	ND	4	2-Methylphenol	ND	6
Carbazole	ND	2	4-Methylphenol	ND	6
4-Chloroaniline	ND	4	Naphthalene	ND	2
2-Chloronaphthalene	ND	2	2-Nitroaniline	ND	8
2-Chlorophenol	ND	4	3-Nitroaniline	ND	8
4-Chlorophenylphenyl Ether	ND	8	4-Nitroaniline	ND	8
4-Chloro-3-Methylphenol	ND	8	Nitrobenzene	ND	2
Chrysene	ND	8	2-Nitrophenol	ND	10
Dibenzofuran	ND	2	4-Nitrophenol	ND	13
Dibenzo(a,h)Anthracene	ND	8	N-Nitrosodiphenylamine	ND	4
1,2-Dichlorobenzene	ND	3	N-Nitroso-Di-n-Propylamine	ND	6
1,3-Dichlorobenzene	ND	3	Pentachlorophenol	ND	1
1,4-Dichlorobenzene	ND	3	Phenanthrene	ND	2
3,3'-Dichlorobenzidine	ND	10	Phenol	ND	4
2,4-Dichlorophenol	ND	6	Pyrene	ND	2
Diethylphthalate	ND	2	1,2,4-Trichlorobenzene	ND	3
2,4-Dimethylphenol	ND	6	2,4,5-Trichlorophenol	ND	6
DimethylPhthalate	ND	2	2,4,6-Trichlorophenol	ND	6

(*) ND = Not detected above the listed detection limit.

(*) ND = Not detected above the listed detection limit.

Analyst Notes: none

Sample Type: Liquid

TENTATIVELY IDENTIFIED SEMI-VOLATILE COMPOUNDS BY METHOD 625

units: ug/L

[illegible]



024684

U. S. Environmental Protection Agency
Region 6 Houston Laboratory

Report For Sample Number 0T5BEW2403

Source: LONGHORN ARMY AMMUNITIONS PLANT (CADDO LAKE)

Site Description: GP-3S

Date/Time Received: 3/16/2000 11:55 AM

Date Completed 4/20/2000

Date/Time Collected: 3/14/2000 01:20 PM

Sample Type: LIQUID

Comments: _____

Parameter

Description

LABN

LOW LEVEL ABN

024685

ORGANIC ANALYSIS DATA

Sample NO: OT5BEW24-03

Date Analyzed: 27-Mar-00

Sample Type: Liquid

SEMI-VOLATILE COMPOUNDS BY METHOD 625

(continuous extractor)

units: ug/L

units: ug/L

Compound Name	Results*	Det Limits	Compound Name	Results*	Det Limits
Acenaphthene	ND	2	2,4-Dinitrophenol	ND	30
Acenaphthylene	ND	2	2,4-Dinitrotoluene	ND	6
Anthracene	ND	2	2,6-Dinitrotoluene	ND	6
Benzoic Acid	ND	10	4,6-Dinitro-2-Methylphenol	ND	20
Benzo(a)Anthracene	ND	8	Di-n-Butylphthalate	ND	2
Benzo(a)Pyrene	ND	0.2	Di-n-Octyl Phthalate	ND	4
Benzo(b)Fluoranthene	ND	8	Fluoranthene	ND	2
Benzo(g,h,i)Perylene	ND	8	Fluorene	ND	2
Benzo(k)Fluoranthene	ND	8	Hexachlorobenzene	ND	1
Benzyl Alcohol	ND	4	Hexachlorobutadiene	ND	5
bis(2-Chloroethoxy)Methane	ND	2	Hexachlorocyclopentadiene	ND	10
bis(2-Chloroethyl) Ether	ND	2	Hexachloroethane	ND	3
bis(2-chloroisopropyl)Ether	ND	2	Indeno(1,2,3-cd) Pyrene	ND	8
bis-(2-Ethylhexyl)Phthalate	ND	4	Isophorone	ND	4
4-Bromophenylphenyl Ether	ND	8	2-Methylnaphthalene	ND	2
Butylbenzylphthalate	ND	4	2-Methylphenol	ND	6
Carbazole	ND	2	4-Methylphenol	ND	6
4-Chloroaniline	ND	4	Naphthalene	ND	2
2-Chloronaphthalene	ND	2	2-Nitroaniline	ND	8
2-Chlorophenol	ND	4	3-Nitroaniline	ND	8
4-Chlorophenylphenyl Ether	ND	8	4-Nitroaniline	ND	8
4-Chloro-3-Methylphenol	ND	8	Nitrobenzene	ND	2
Chrysene	ND	8	2-Nitrophenol	ND	10
Dibenzofuran	ND	2	4-Nitrophenol	ND	13
Dibenzo(a,h)Anthracene	ND	8	N-Nitrosodiphenylamine	ND	4
1,2-Dichlorobenzene	ND	3	N-Nitroso-Di-n-Propylamine	ND	6
1,3-Dichlorobenzene	ND	3	Pentachlorophenol	ND	1
1,4-Dichlorobenzene	ND	3	Phenanthrene	ND	2
3,3'-Dichlorobenzidine	ND	10	Phenol	ND	4
2,4-Dichlorophenol	ND	6	Pyrene	ND	2
Diethylphthalate	ND	2	1,2,4-Trichlorobenzene	ND	3
2,4-Dimethylphenol	ND	6	2,4,5-Trichlorophenol	ND	6
DimethylPhthalate	ND	2	2,4,6-Trichlorophenol	ND	6

(*) ND = Not detected above the listed detection limit.

(*) ND = Not detected above the listed detection limit.

Analyst Notes: none

024687

**U. S. Environmental Protection Agency****Region 6 Houston Laboratory****Report For Sample Number 0T5BEW2404****Source:** LONGHORN ARMY AMMUNITIONS PLANT (CADDO LAKE)**Site Description:** GP-1S**Date/Time Received:** 3/16/2000 11:55 AM**Date Completed** 4/20/2000**Date/Time Collected:** 3/14/2000 01:00 PM**Sample Type:** LIQUID**Comments:**

Parameter

Description

LABN

LOW LEVEL ABN

024088

ORGANIC ANALYSIS DATA

Sample NO: OT5BEW24-04

Date Analyzed: 27-Mar-00

Sample Type: Liquid

SEMI-VOLATILE COMPOUNDS BY METHOD 625

(continuous extractor)

units: ug/L

units: ug/L

Compound Name	Results*	Det Limits	Compound Name	Results*	Det Limits
Acenaphthene	ND	2	2,4-Dinitrophenol	ND	30
Acenaphthylene	ND	2	2,4-Dinitrotoluene	ND	6
Anthracene	ND	2	2,6-Dinitrotoluene	ND	6
Benzoic Acid	ND	10	4,6-Dinitro-2-Methylphenol	ND	20
Benzo(a)Anthracene	ND	8	Di-n-Butylphthalate	ND	2
Benzo(a)Pyrene	ND	0.2	Di-n-Octyl Phthalate	ND	4
Benzo(b)Fluoranthene	ND	8	Fluoranthene	ND	2
Benzo(g,h,i)Perylene	ND	8	Fluorene	ND	2
Benzo(k)Fluoranthene	ND	8	Hexachlorobenzene	ND	1
Benzyl Alcohol	ND	4	Hexachlorobutadiene	ND	5
bis(2-Chloroethoxy)Methane	ND	2	Hexachlorocyclopentadiene	ND	10
bis(2-Chloroethyl) Ether	ND	2	Hexachloroethane	ND	3
bis(2-chloroisopropyl)Ether	ND	2	Indeno(1,2,3-cd) Pyrene	ND	8
bis-(2-Ethylhexyl)Phthalate	ND	4	Isophorone	ND	4
4-Bromophenylphenyl Ether	ND	8	2-Methylnaphthalene	ND	2
Butylbenzylphthalate	ND	4	2-Methylphenol	ND	6
Carbazole	ND	2	4-Methylphenol	ND	6
4-Chloroaniline	ND	4	Naphthalene	ND	2
2-Chloronaphthalene	ND	2	2-Nitroaniline	ND	8
2-Chlorophenol	ND	4	3-Nitroaniline	ND	8
4-Chlorophenylphenyl Ether	ND	8	4-Nitroaniline	ND	8
4-Chloro-3-Methylphenol	ND	8	Nitrobenzene	ND	2
Chrysene	ND	8	2-Nitrophenol	ND	10
Dibenzofuran	ND	2	4-Nitrophenol	ND	13
Dibenzo(a,h)Anthracene	ND	8	N-Nitrosodiphenylamine	ND	4
1,2-Dichlorobenzene	ND	3	N-Nitroso-Di-n-Propylamine	ND	6
1,3-Dichlorobenzene	ND	3	Pentachlorophenol	ND	1
1,4-Dichlorobenzene	ND	3	Phenanthrene	ND	2
3,3'-Dichlorobenzidine	ND	10	Phenol	ND	4
2,4-Dichlorophenol	ND	6	Pyrene	ND	2
Diethylphthalate	ND	2	1,2,4-Trichlorobenzene	ND	3
2,4-Dimethylphenol	ND	6	2,4,5-Trichlorophenol	ND	6
DimethylPhthalate	ND	2	2,4,6-Trichlorophenol	ND	6

(*) ND = Not detected above the listed detection limit.

(*) ND = Not detected above the listed detection limit.

lyst Notes: none



024690

U. S. Environmental Protection Agency
Region 6 Houston Laboratory

Report For Sample Number 0T5BEW2405

Source: LONGHORN ARMY AMMUNITIONS PLANT (CADDO LAKE)

Site Description: HB-1S

Date/Time Received: 3/16/2000 11:55 AM

Date Completed 4/20/2000

Date/Time Collected: 3/14/2000 10:50 AM

Sample Type: LIQUID

Comments: _____

Parameter

Description

LABN

LOW LEVEL ABN

024691

ORGANIC ANALYSIS DATA

Sample NO: 0T5BEW24-05

Date Analyzed: 27-Mar-00

Sample Type: Liquid

SEMI-VOLATILE COMPOUNDS BY METHOD 625

(continuous extractor)

units: ug/L

units: ug/L

Compound Name	Results*	Det Limits	Compound Name	Results*	Det Limits
Acenaphthene	ND	2	2,4-Dinitrophenol	ND	30
Acenaphthylene	ND	2	2,4-Dinitrotoluene	ND	6
Anthracene	ND	2	2,6-Dinitrotoluene	ND	6
Benzoic Acid	ND	10	4,6-Dinitro-2-Methylphenol	ND	20
Benzo(a)Anthracene	ND	8	Di-n-Butylphthalate	ND	2
Benzo(a)Pyrene	ND	0.2	Di-n-Octyl Phthalate	ND	4
Benzo(b)Fluoranthene	ND	8	Fluoranthene	ND	2
Benzo(g,h,i)Perylene	ND	8	Fluorene	ND	2
Benzo(k)Fluoranthene	ND	8	Hexachlorobenzene	ND	1
Benzyl Alcohol	ND	4	Hexachlorobutadiene	ND	5
bis(2-Chloroethoxy)Methane	ND	2	Hexachlorocyclopentadiene	ND	10
bis(2-Chloroethyl) Ether	ND	2	Hexachloroethane	ND	3
is(2-chloroisopropyl)Ether	ND	2	Indeno(1,2,3-cd) Pyrene	ND	8
is-(2-Ethylhexyl)Phthalate	ND	4	Isophorone	ND	4
4-Bromophenylphenyl Ether	ND	8	2-Methylnaphthalene	ND	2
Butylbenzylphthalate	ND	4	2-Methylphenol	ND	6
Carbazole	ND	2	4-Methylphenol	ND	6
4-Chloroaniline	ND	4	Naphthalene	ND	2
2-Chloronaphthalene	ND	2	2-Nitroaniline	ND	8
2-Chlorophenol	ND	4	3-Nitroaniline	ND	8
4-Chlorophenylphenyl Ether	ND	8	4-Nitroaniline	ND	8
4-Chloro-3-Methylphenol	ND	8	Nitrobenzene	ND	2
Chrysene	ND	8	2-Nitrophenol	ND	10
Dibenzofuran	ND	2	4-Nitrophenol	ND	13
Dibenzo(a,h)Anthracene	ND	8	N-Nitrosodiphenylamine	ND	4
1,2-Dichlorobenzene	ND	3	N-Nitroso-Di-n-Propylamine	ND	6
1,3-Dichlorobenzene	ND	3	Pentachlorophenol	ND	1
1,4-Dichlorobenzene	ND	3	Phenanthrene	ND	2
3,3'-Dichlorobenzidine	ND	10	Phenol	ND	4
2,4-Dichlorophenol	ND	6	Pyrene	ND	2
Diethylphthalate	ND	2	1,2,4-Trichlorobenzene	ND	3
2,4-Dimethylphenol	ND	6	2,4,5-Trichlorophenol	ND	6
DimethylPhthalate	ND	2	2,4,6-Trichlorophenol	ND	6

(*) ND = Not detected above the listed detection limit.

(*) ND = Not detected above the listed detection limit.

Analyst Notes: none

Sample Type: Liquid

TENTATIVELY IDENTIFIED SEMI-VOLATILE COMPOUNDS BY METHOD 625

units: ug/L

(**) Estimated concentration is based on a Response Factor of 1.0 to the nearest internal standard.



024693

U. S. Environmental Protection Agency
Region 6 Houston Laboratory

Report For Sample Number OT5BEW2406

Source: LONGHORN ARMY AMMUNITIONS PLANT (CADDO LAKE)

Site Description: HB-2S

Date/Time Received: 3/16/2000 11:55 AM

Date Completed 4/20/2000

Date/Time Collected: 3/14/2000 11:10 AM

Sample Type: LIQUID

Comments:

Parameter

Description

LABN

LOW LEVEL ABN

024694

ORGANIC ANALYSIS DATA

Sample NO: OT5BEW24-06

Date Analyzed: 27-Mar-00

Sample Type: Liquid

SEMI-VOLATILE COMPOUNDS BY METHOD 625

(continuous extractor)

units: ug/L

units: ug/L

Compound Name	Results*	Det Limits	Compound Name	Results*	Det Limits
Acenaphthene	ND	2	2,4-Dinitrophenol	ND	30
Acenaphthylene	ND	2	2,4-Dinitrotoluene	ND	6
Anthracene	ND	2	2,6-Dinitrotoluene	ND	6
Benzoic Acid	ND	10	4,6-Dinitro-2-Methylphenol	ND	20
Benzo(a)Anthracene	ND	8	Di-n-Butylphthalate	ND	2
Benzo(a)Pyrene	ND	0.2	Di-n-Octyl Phthalate	ND	4
Benzo(b)Fluoranthene	ND	8	Fluoranthene	ND	2
Benzo(g,h,i)Perylene	ND	8	Fluorene	ND	2
Benzo(k)Fluoranthene	ND	8	Hexachlorobenzene	ND	1
Benzyl Alcohol	ND	4	Hexachlorobutadiene	ND	5
bis(2-Chloroethoxy)Methane	ND	2	Hexachlorocyclopentadiene	ND	10
bis(2-Chloroethyl) Ether	ND	2	Hexachloroethane	ND	3
Is(2-chloroisopropyl)Ether	ND	2	Indeno(1,2,3-cd) Pyrene	ND	8
ois-(2-Ethylhexyl)Phthalate	ND	4	Isophorone	ND	4
4-Bromophenylphenyl Ether	ND	8	2-Methylnaphthalene	ND	2
Butylbenzylphthalate	ND	4	2-Methylphenol	ND	6
Carbazole	ND	2	4-Methylphenol	ND	6
4-Chloroaniline	ND	4	Naphthalene	ND	2
2-Chloronaphthalene	ND	2	2-Nitroaniline	ND	8
2-Chlorophenol	ND	4	3-Nitroaniline	ND	8
4-Chlorophenylphenyl Ether	ND	8	4-Nitroaniline	ND	8
4-Chloro-3-Methylphenol	ND	8	Nitrobenzene	ND	2
Chrysene	ND	8	2-Nitrophenol	ND	10
Dibenzofuran	ND	2	4-Nitrophenol	ND	13
Dibenzo(a,h)Anthracene	ND	8	N-Nitrosodiphenylamine	ND	4
1,2-Dichlorobenzene	ND	3	N-Nitroso-Di-n-Propylamine	ND	6
1,3-Dichlorobenzene	ND	3	Pentachlorophenol	ND	1
1,4-Dichlorobenzene	ND	3	Phenanthrene	ND	2
3,3'-Dichlorobenzidine	ND	10	Phenol	ND	4
2,4-Dichlorophenol	ND	6	Pyrene	ND	2
Diethylphthalate	ND	2	1,2,4-Trichlorobenzene	ND	3
2,4-Dimethylphenol	ND	6	2,4,5-Trichlorophenol	ND	6
DimethylPhthalate	ND	2	2,4,6-Trichlorophenol	ND	6

(*) ND = Not detected above the listed detection limit.

(*) ND = Not detected above the listed detection limit.

Analyst Notes: none

Sample Type: Liquid

TENTATIVELY IDENTIFIED SEMI-VOLATILE COMPOUNDS BY METHOD 625

units: ug/L

(**) Estimated concentration is based on a Response Factor of 1.0 to the nearest internal standard.

024696



U. S. Environmental Protection Agency
Region 6 Houston Laboratory

Report For Sample Number 0T5BEW2407

Source: LONGHORN ARMY AMMUNITIONS PLANT (CADDO LAKE)

Site Description: GP-2S

Date/Time Received: 3/16/2000 11:55 AM

Date Completed 4/20/2000

Date/Time Collected: 3/14/2000 12:57 PM

Sample Type: LIQUID

Comments:

Parameter
LABN

LOW LEVEL ABN

Description

024697

ORGANIC ANALYSIS DATA

Sample NO: OT5BEW24-07

Date Analyzed: 27-Mar-00

Sample Type: Liquid

SEMI-VOLATILE COMPOUNDS BY METHOD 625
(continuous extractor)

units: ug/L

units: ug/L

Compound Name	Results*	Det Limits	Compound Name	Results*	Det Limits
Acenaphthene	ND	2	2,4-Dinitrophenol	ND	30
Acenaphthylene	ND	2	2,4-Dinitrotoluene	ND	6
Anthracene	ND	2	2,6-Dinitrotoluene	ND	6
Benzoic Acid	ND	10	4,6-Dinitro-2-Methylphenol	ND	20
Benzo(a)Anthracene	ND	8	Di-n-Butylphthalate	ND	2
Benzo(a)Pyrene	ND	0.2	Di-n-Octyl Phthalate	ND	4
Benzo(b)Fluoranthene	ND	8	Fluoranthene	ND	2
Benzo(g,h,i)Perylene	ND	8	Fluorene	ND	2
Benzo(k)Fluoranthene	ND	8	Hexachlorobenzene	ND	1
Benzyl Alcohol	ND	4	Hexachlorobutadiene	ND	5
bis(2-Chloroethoxy)Methane	ND	2	Hexachlorocyclopentadiene	ND	10
bis(2-Chloroethyl) Ether	ND	2	Hexachloroethane	ND	3
bis(2-chloroisopropyl)Ether	ND	2	Indeno(1,2,3-cd) Pyrene	ND	8
bis-(2-Ethylhexyl)Phthalate	ND	4	Isophorone	ND	4
4-Bromophenylphenyl Ether	ND	8	2-Methylnaphthalene	ND	2
Butylbenzylphthalate	ND	4	2-Methylphenol	ND	6
Carbazole	ND	2	4-Methylphenol	ND	6
4-Chloroaniline	ND	4	Naphthalene	ND	2
2-Chloronaphthalene	ND	2	2-Nitroaniline	ND	8
2-Chlorophenol	ND	4	3-Nitroaniline	ND	8
4-Chlorophenylphenyl Ether	ND	8	4-Nitroaniline	ND	8
4-Chloro-3-Methylphenol	ND	8	Nitrobenzene	ND	2
Chrysene	ND	8	2-Nitrophenol	ND	10
Dibenzofuran	ND	2	4-Nitrophenol	ND	13
Dibenzo(a,h)Anthracene	ND	8	N-Nitrosodiphenylamine	ND	4
1,2-Dichlorobenzene	ND	3	N-Nitroso-Di-n-Propylamine	ND	6
1,3-Dichlorobenzene	ND	3	Pentachlorophenol	ND	1
1,4-Dichlorobenzene	ND	3	Phenanthrene	ND	2
3,3'-Dichlorobenzidine	ND	10	Phenol	ND	4
2,4-Dichlorophenol	ND	6	Pyrene	ND	2
Diethylphthalate	ND	2	1,2,4-Trichlorobenzene	ND	3
2,4-Dimethylphenol	ND	6	2,4,5-Trichlorophenol	ND	6
DimethylPhthalate	ND	2	2,4,6-Trichlorophenol	ND	6

(*) ND = Not detected above the listed detection limit.

(*) ND = Not detected above the listed detection limit.

Analyst Notes: none

024699



U. S. Environmental Protection Agency
Region 6 Houston Laboratory

Report For Sample Number 0T5BEW2408

Source: LONGHORN ARMY AMMUNITIONS PLANT (CADDO LAKE)

Site Description: GP-2V

Date/Time Received: 3/16/2000 11:55 AM

Date Completed 4/20/2000

Date/Time Collected: 3/14/2000 01:00 PM

Sample Type: LIQUID

Comments:

Parameter

Description

LVOA

LOW LEVEL VOA

Volatile Organic Compounds
Method CLP SOW OLM03.1 (low level)

021700

Sample Number: OT5BEW24-08

Date Extracted: not extracted

Sample Type: LIQUID

Date Analyzed: 22-Mar-00

Compound	page 1 of 1	results*	(µg/l)	detection limits
Chloromethane		ND		1
Bromomethane		ND		1
Vinyl Chloride		ND		1
Chloroethane		ND		1
Methylene Chloride		ND		2
Acetone		ND		5
Carbon Disulfide		ND		1
1,1-Dichloroethene		ND		1
1,1-Dichloroethane		ND		1
trans-1,2-Dichloroethene		ND		1
cis-1,2-Dichloroethene		ND		1
Chloroform		ND		1
1,2-Dichloroethane		ND		1
2-Butanone		ND		5
1,1,1-Trichloroethane		ND		1
Carbon Tetrachloride		ND		1
Bromodichloromethane		ND		1
1,2-Dichloropropane		ND		1
cis-1,3-Dichloropropene		ND		1
Trichloroethene		ND		1
Benzene		ND		1
Dibromochloromethane		ND		1
trans-1,3-Dichloropropene		ND		1
1,1,2-Trichloroethane		ND		1
Bromoform		ND		1
4-Methyl-2-Pentanone		ND		5
2-Hexanone		ND		5
Tetrachloroethene		ND		1
1,1,2,2-Tetrachloroethane		ND		1
Toluene		ND		1
Chlorobenzene		ND		1
Ethylbenzene		ND		1
Styrene		ND		1
o-xylene		ND		1
m/p-xylene		ND		1

* "ND" means not detected at the corresponding detection limit.

Tentatively Identified Volatile Organic Compounds**Method CLP SOW OLM03.1 (low level)****024701**

Sample Number: OT5BEW24-08

Date Extracted: not extracted

Sample Type: LIQUID

Date Analyzed: 22-Mar-00

Number TICs found: 0

TIC NO.	CAS NO.	COMPOUND NAME*	RT min.	EST.** CONC. µg/l
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* The compounds listed are tentatively identified by the best match with the NIST/Wiley mass spectral database and/or by manual interpretation.

** An estimated concentration is obtained by quantitation using the nearest internal standard. Since no standard was used for confirmation nor quantitation, a response factor of 1.0 is assumed.

024702



U. S. Environmental Protection Agency
Region 6 Houston Laboratory

Report For Sample Number OT5BEW2409

Source: LONGHORN ARMY AMMUNITIONS PLANT (CADDO LAKE)

Site Description: HB-3V

Date/Time Received: 3/16/2000 11:55 AM

Date Completed 4/20/2000

Date/Time Collected: 3/14/2000 11:00 AM

Sample Type: LIQUID

Comments:

Parameter

Description

LVOA

LOW LEVEL VOA

Volatile Organic Compounds
Method CLP SOW OLM03.1 (low level)

024703

Sample Number: OT5BEW24-09

Date Extracted: not extracted

Sample Type: LIQUID

Date Analyzed: 22-Mar-00

Compound	page 1 of 1	results* (µg/l)	detection limits
Chloromethane		ND	1
Bromomethane		ND	1
Vinyl Chloride		ND	1
Chloroethane		ND	1
Methylene Chloride		ND	1
Acetone		ND	2
Carbon Disulfide		ND	5
1,1-Dichloroethene		ND	1
1,1-Dichloroethane		ND	1
trans-1,2-Dichloroethene		ND	1
cis-1,2-Dichloroethene		ND	1
Chloroform		ND	1
1,2-Dichloroethane		ND	1
2-Butanone		ND	1
1,1,1-Trichloroethane		ND	5
Carbon Tetrachloride		ND	1
Bromodichloromethane		ND	1
1,2-Dichloropropane		ND	1
cis-1,3-Dichloropropene		ND	1
Trichloroethene		ND	1
Benzene		ND	1
Dibromochloromethane		ND	1
trans-1,3-Dichloropropene		ND	1
1,1,2-Trichloroethane		ND	1
Bromoform		ND	1
4-Methyl-2-Pentanone		ND	1
2-Hexanone		ND	5
Tetrachloroethene		ND	5
1,1,2,2-Tetrachloroethane		ND	1
Toluene		ND	1
Chlorobenzene		ND	1
Ethylbenzene		ND	1
Styrene		ND	1
o-xylene		ND	1
m/p-xylene		ND	1

* "ND" means not detected at the corresponding detection limit.

Tentatively Identified Volatile Organic Compounds
Method CLP SOW OLM03.1 (low level)

024704

Sample Number: OT5BEW24-09

Date Extracted: not extracted

Sample Type: LIQUID

Date Analyzed: 22-Mar-00

Number TICs found: 0

TIC NO.	CAS NO.	COMPOUND NAME*	RT min.	EST.** CONC. µg/l
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* The compounds listed are tentatively identified by the best match with the NIST/Wiley mass spectral database and/or by manual interpretation.

** An estimated concentration is obtained by quantitation using the nearest internal standard. Since no standard was used for confirmation nor quantitation, a response factor of 1.0 is assumed.

021705



U. S. Environmental Protection Agency
Region 6 Houston Laboratory

Report For Sample Number 0T5BEW2410

Source: LONGHORN ARMY AMMUNITIONS PLANT (CADDO LAKE)

Site Description: HB-1V

Date/Time Received: 3/16/2000 11:55 AM

Date Completed 4/20/2000

Date/Time Collected: 3/14/2000 10:40 AM

Sample Type: LIQUID

Comments:

Parameter

LVOA

LOW LEVEL VOA

Description

Volatile Organic Compounds
Method CLP SOW OLM03.1 (low level)

024706

Sample Number: OT5BEW24-10

Date Extracted: not extracted

Sample Type: LIQUID

Date Analyzed: 22-Mar-00

Compound	page 1 of 1	results* (µg/l)	detection limits
Chloromethane		ND	1
Bromomethane		ND	1
Vinyl Chloride		ND	1
Chloroethane		ND	1
Methylene Chloride		ND	2
Acetone		8.2	5
Carbon Disulfide		2.6	1
1,1-Dichloroethene		ND	1
1,1-Dichloroethane		ND	1
trans-1,2-Dichloroethene		ND	1
cis-1,2-Dichloroethene		ND	1
Chloroform		ND	1
1,2-Dichloroethane		ND	1
2-Butanone		ND	5
1,1,1-Trichloroethane		ND	1
Carbon Tetrachloride		ND	1
Bromodichloromethane		ND	1
1,2-Dichloropropane		ND	1
cis-1,3-Dichloropropene		ND	1
Trichloroethene		ND	1
Benzene		ND	1
Dibromochloromethane		ND	1
trans-1,3-Dichloropropene		ND	1
1,1,2-Trichloroethane		ND	1
Bromoform		ND	1
4-Methyl-2-Pentanone		ND	5
2-Hexanone		ND	5
Tetrachloroethene		ND	1
1,1,2,2-Tetrachloroethane		ND	1
Toluene		ND	1
Chlorobenzene		ND	1
Ethylbenzene		ND	1
Styrene		ND	1
o-xylene		ND	1
m/p-xylene		ND	1

* "ND" means not detected at the corresponding detection limit.

Tentatively Identified Volatile Organic Compounds
Method CLP SOW OLM03.1 (low level)

OT5BEW24 Page 32

024707

Sample Number: OT5BEW24-10

Date Extracted: not extracted

Sample Type: LIQUID

Date Analyzed: 22-Mar-00

Number TICs found: 0

TIC NO.	CAS NO.	COMPOUND NAME*	RT min.	EST.** CONC. µg/l
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* The compounds listed are tentatively identified by the best match with the NIST/Wiley mass spectral database and/or by manual interpretation.

** An estimated concentration is obtained by quantitation using the nearest internal standard. Since no standard was used for confirmation nor quantitation, a response factor of 1.0 is assumed.

024708



U. S. Environmental Protection Agency
Region 6 Houston Laboratory

Report For Sample Number OT5BEW2411

Source: LONGHORN ARMY AMMUNITIONS PLANT (CADDO LAKE)

Site Description: GP-1V

Date/Time Received: 3/16/2000 11:55 AM

Date Completed 4/20/2000

Date/Time Collected: 3/14/2000 12:55 PM

Sample Type: LIQUID

Comments:

Parameter
LVOA

LOW LEVEL VOA

Description

Volatile Organic Compounds
Method CLP SOW OLM03.1 (low level)

024709

Sample Number: OT5BEW24-11

Date Extracted: not extracted

Sample Type: LIQUID

Date Analyzed: 23-Mar-00

Compound	page 1 of 1	results* (µg/l)	detection limits
Chloromethane		ND	1
Bromomethane		ND	1
Vinyl Chloride		ND	1
Chloroethane		ND	1
Methylene Chloride		ND	2
Acetone		9.8	5
Carbon Disulfide		ND	1
1,1-Dichloroethene		ND	1
1,1-Dichloroethane		ND	1
trans-1,2-Dichloroethene		ND	1
cis-1,2-Dichloroethene		ND	1
Chloroform		ND	1
1,2-Dichloroethane		ND	1
2-Butanone		ND	5
1,1,1-Trichloroethane		ND	1
Carbon Tetrachloride		ND	1
Bromodichloromethane		ND	1
1,2-Dichloropropane		ND	1
cis-1,3-Dichloropropene		ND	1
Trichloroethene		ND	1
Benzene		ND	1
Dibromochloromethane		ND	1
trans-1,3-Dichloropropene		ND	1
1,1,2-Trichloroethane		ND	1
Bromoform		ND	1
4-Methyl-2-Pentanone		ND	5
2-Hexanone		ND	5
Tetrachloroethene		ND	1
1,1,2,2-Tetrachloroethane		ND	1
Toluene		ND	1
Chlorobenzene		ND	1
Ethylbenzene		ND	1
Styrene		ND	1
o-xylene		ND	1
m/p-xylene		ND	1

* "ND" means not detected at the corresponding detection limit.

Tentatively Identified Volatile Organic Compounds
Method CLP SOW OLM03.1 (low level)

024710

Sample Number: OT5BEW24-11

Date Extracted: not extracted

Sample Type: LIQUID

Date Analyzed: 23-Mar-00

Number TICs found: 0

TIC NO.	CAS NO.	COMPOUND NAME*	RT min.	EST.** CONC. µg/l
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* The compounds listed are tentatively identified by the best match with the NIST/Wiley mass spectral database and/or by manual interpretation.

** An estimated concentration is obtained by quantitation using the nearest internal standard. Since no standard was used for confirmation nor quantitation, a response factor of 1.0 is assumed.

024711

U. S. Environmental Protection Agency
Region 6 Houston Laboratory

Report For Sample Number 0T5BEW2412

Source: LONGHORN ARMY AMMUNITIONS PLANT (CADDO LAKE)

Site Description: HB-2V

Date/Time Received: 3/16/2000 11:55 AM

Date Completed 4/20/2000

Date/Time Collected: 3/14/2000 11:05 AM

Sample Type: LIQUID

Comments:

Parameter

LVOA

LOW LEVEL VOA

Description

Volatile Organic Compounds
Method CLP SOW OLM03.1 (low level)

024712

Sample Number: OT5BEW24-12

Date Extracted: not extracted

Sample Type: LIQUID

Date Analyzed: 23-Mar-00

Compound	page 1 of 1	results* (µg/l)	detection limits
Chloromethane		ND	1
Bromomethane		ND	1
Vinyl Chloride		ND	1
Chloroethane		ND	1
Methylene Chloride		ND	2
Acetone		ND	5
Carbon Disulfide		ND	1
1,1-Dichloroethene		ND	1
1,1-Dichloroethane		ND	1
trans-1,2-Dichloroethene		ND	1
cis-1,2-Dichloroethene		ND	1
Chloroform		ND	1
1,2-Dichloroethane		ND	1
2-Butanone		ND	5
1,1,1-Trichloroethane		ND	1
Carbon Tetrachloride		ND	1
Bromodichloromethane		ND	1
1,2-Dichloropropane		ND	1
cis-1,3-Dichloropropene		ND	1
Trichloroethene		ND	1
Benzene		ND	1
Dibromochloromethane		ND	1
trans-1,3-Dichloropropene		ND	1
1,1,2-Trichloroethane		ND	1
Bromoform		ND	1
4-Methyl-2-Pentanone		ND	5
2-Hexanone		ND	5
Tetrachloroethene		ND	1
1,1,2,2-Tetrachloroethane		ND	1
Toluene		ND	1
Chlorobenzene		ND	1
Ethylbenzene		ND	1
Styrene		ND	1
o-xylene		ND	1
m/p-xylene		ND	1

* "ND" means not detected at the corresponding detection limit.

Tentatively Identified Volatile Organic Compounds
Method CLP SOW OLM03.1 (low level)**024713**

Sample Number: OT5BEW24-12

Date Extracted: not extracted

Sample Type: LIQUID

Date Analyzed: 23-Mar-00

Number TICs found: 0

TIC NO.	CAS NO.	COMPOUND NAME*	RT min.	EST.** CONC. µg/l
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* The compounds listed are tentatively identified by the best match with the NIST/Wiley mass spectral database and/or by manual interpretation.

** An estimated concentration is obtained by quantitation using the nearest internal standard. Since no standard was used for confirmation nor quantitation, a response factor of 1.0 is assumed.

024714

U. S. Environmental Protection Agency
Region 6 Houston Laboratory

Report For Sample Number 0T5BEW2413

Source: LONGHORN ARMY AMMUNITIONS PLANT (CADDO LAKE)

Site Description: HB-1VD

Date/Time Received: 3/16/2000 11:55 AM

Date Completed 4/20/2000

Date/Time Collected: 3/14/2000 10:40 AM

Sample Type: LIQUID

Comments: _____

Parameter

Description

LVOA

LOW LEVEL VOA

Volatile Organic Compounds
Method CLP SOW OLM03.1 (low level)

024715

Sample Number: OT5BEW24-13

Date Extracted: not extracted

Sample Type: LIQUID

Date Analyzed: 23-Mar-00

Compound	page 1 of 1	results* (µg/l)	detection limits
Chloromethane		ND	1
Bromomethane		ND	1
Vinyl Chloride		ND	1
Chloroethane		ND	1
Methylene Chloride		ND	2
Acetone		ND	5
Carbon Disulfide		22.2	1
1,1-Dichloroethene		ND	1
1,1-Dichloroethane		ND	1
trans-1,2-Dichloroethene		ND	1
cis-1,2-Dichloroethene		ND	1
Chloroform		ND	1
1,2-Dichloroethane		ND	1
2-Butanone		ND	5
1,1,1-Trichloroethane		ND	1
Carbon Tetrachloride		ND	1
Bromodichloromethane		ND	1
1,2-Dichloropropane		ND	1
cis-1,3-Dichloropropene		ND	1
Trichloroethene		ND	1
Benzene		ND	1
Dibromochloromethane		ND	1
trans-1,3-Dichloropropene		ND	1
1,1,2-Trichloroethane		ND	1
Bromoform		ND	1
4-Methyl-2-Pentanone		ND	5
2-Hexanone		ND	5
Tetrachloroethene		ND	1
1,1,2,2-Tetrachloroethane		ND	1
Toluene		ND	1
Chlorobenzene		ND	1
Ethylbenzene		ND	1
Styrene		ND	1
o-xylene		ND	1
m/p-xylene		ND	1

* "ND" means not detected at the corresponding detection limit.

Tentatively Identified Volatile Organic Compounds
Method CLP SOW OLM03.1 (low level)

024716

Sample Number: OT5BEW24-13

Date Extracted: not extracted

Sample Type: LIQUID

Date Analyzed: 23-Mar-00

Number TICs found: 0

TIC NO.	CAS NO.	COMPOUND NAME*	RT min.	EST.** CONC. µg/l
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* The compounds listed are tentatively identified by the best match with the NIST/Wiley mass spectral database and/or by manual interpretation.

** An estimated concentration is obtained by quantitation using the nearest internal standard. Since no standard was used for confirmation nor quantitation, a response factor of 1.0 is assumed.

024717



U. S. Environmental Protection Agency
Region 6 Houston Laboratory

Report For Sample Number 0T5BEW2414

Source: LONGHORN ARMY AMMUNITIONS PLANT (CADDO LAKE)

Site Description: TB-2

Date/Time Received: 3/16/2000 11:55 AM

Date Completed 4/20/2000

Date/Time Collected: 3/14/2000 07:52 AM

Sample Type: LIQUID

Comments:

Parameter
LVOA

LOW LEVEL VOA

Description

Volatile Organic Compounds
Method CLP SOW OLM03.1 (low level)

024718

Sample Number: 0T5BEW24-14

Date Extracted: not extracted

Sample Type: LIQUID

Date Analyzed: 23-Mar-00

Compound	page 1 of 1	results* (µg/l)	detection limits
Chloromethane-----		ND	1
Bromomethane-----		ND	1
Vinyl Chloride-----		ND	1
Chloroethane-----		ND	1
Methylene Chloride-----		ND	2
Acetone-----		ND	5
Carbon Disulfide-----		ND	1
1,1-Dichloroethene-----		ND	1
1,1-Dichloroethane-----		ND	1
trans-1,2-Dichloroethene-----		ND	1
cis-1,2-Dichloroethene-----		ND	1
Chloroform-----		ND	1
1,2-Dichloroethane-----		ND	1
2-Butanone-----		ND	5
1,1,1-Trichloroethane-----		ND	1
Carbon Tetrachloride-----		ND	1
Bromodichloromethane-----		ND	1
1,2-Dichloropropane-----		ND	1
cis-1,3-Dichloropropene-----		ND	1
Trichloroethene-----		ND	1
Benzene-----		ND	1
Dibromochloromethane-----		ND	1
trans-1,3-Dichloropropene-----		ND	1
1,1,2-Trichloroethane-----		ND	1
Bromoform-----		ND	1
4-Methyl-2-Pentanone-----		ND	5
2-Hexanone-----		ND	5
Tetrachloroethene-----		ND	1
1,1,2,2-Tetrachloroethane-----		ND	1
Toluene-----		ND	1
Chlorobenzene-----		ND	1
Ethylbenzene-----		ND	1
Styrene-----		ND	1
o-xylene-----		ND	1
m/p-xylene-----		ND	1

* "ND" means not detected at the corresponding detection limit.

Tentatively Identified Volatile Organic Compounds
Method CLP SOW OLM03.1 (low level)

024719

Sample Number: OT5BEW24-14

Date Extracted: not extracted

Sample Type: LIQUID

Date Analyzed: 23-Mar-00

Number TICs found: 0

TIC NO.	CAS NO.	COMPOUND NAME*	RT min.	EST.** CONC. µg/l
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* The compounds listed are tentatively identified by the best match with the NIST/Wiley mass spectral database and/or by manual interpretation.

** An estimated concentration is obtained by quantitation using the nearest internal standard. Since no standard was used for confirmation nor quantitation, a response factor of 1.0 is assumed.



024720

U. S. Environmental Protection Agency
Region 6 Houston Laboratory

Report For Sample Number OT5BEW2415

Source: LONGHORN ARMY AMMUNITIONS PLANT (CADDO LAKE)

Site Description: AB-1

Date/Time Received: 3/16/2000 11:55 AM

Date Completed 4/20/2000

Date/Time Collected: 3/14/2000 07:50 AM

Sample Type: LIQUID

Comments:

Parameter
LVOA

LOW LEVEL VOA

Description

Volatile Organic Compounds
Method CLP SOW OLM03.1 (low level)

024721

Sample Number: OT5BEW24-15

Date Extracted: not extracted

Sample Type: LIQUID

Date Analyzed: 23-Mar-00

Compound	page 1 of 1	results* (µg/l)	detection limits
Chloromethane		ND	1
Bromomethane		ND	1
Vinyl Chloride		ND	1
Chloroethane		ND	1
Methylene Chloride		ND	1
Acetone		ND	2
Carbon Disulfide		ND	5
1,1-Dichloroethene		ND	1
1,1-Dichloroethane		ND	1
trans-1,2-Dichloroethene		ND	1
cis-1,2-Dichloroethene		ND	1
Chloroform		ND	1
1,2-Dichloroethane		ND	1
2-Butanone		ND	1
1,1,1-Trichloroethane		ND	5
Carbon Tetrachloride		ND	1
Bromodichloromethane		ND	1
1,2-Dichloropropane		ND	1
cis-1,3-Dichloropropene		ND	1
Trichloroethene		ND	1
Benzene		ND	1
Dibromochloromethane		ND	1
trans-1,3-Dichloropropene		ND	1
1,1,2-Trichloroethane		ND	1
Bromoform		ND	1
4-Methyl-2-Pentanone		ND	5
2-Hexanone		ND	5
Tetrachloroethene		ND	1
1,1,2,2-Tetrachloroethane		ND	1
Toluene		ND	1
Chlorobenzene		ND	1
Ethylbenzene		ND	1
Styrene		ND	1
o-xylene		ND	1
m/p-xylene		ND	1

* "ND" means not detected at the corresponding detection limit.

Tentatively Identified Volatile Organic Compounds**Method CLP SOW OLM03.1 (low level)****024722**

Sample Number: OT5BEW24-15

Date Extracted: not extracted

Sample Type: LIQUID

Date Analyzed: 23-Mar-00

Number TICs found: 0

TIC NO.	CAS NO.	COMPOUND NAME*	RT min.	EST.** CONC. µg/l
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* The compounds listed are tentatively identified by the best match with the NIST/Wiley mass spectral database and/or by manual interpretation.

** An estimated concentration is obtained by quantitation using the nearest internal standard. Since no standard was used for confirmation nor quantitation, a response factor of 1.0 is assumed.

WATER VOLATILE SYSTEM MONITORING COMPOUND RECOVERY

024723

Instrument ID: SYSTEM 5- HP 5972

Set Number: OT5BEW24

Method: CLP SOW O

Set Name: LONGHORN A

Column Info: 0.25 -HP-624

	EPA SAMPLE NO.	SMC1 (DCE) #	SMC2 (TOL) #	SMC3 (BFB) #	TOT OUT
01	OT5BEW24-DL1	106	96	99	0
02	OT5BEW24-BLK1	105	100	102	0
03	OT5BEW24-08	109	103	104	0
04	OT5BEW24-08 M	104	97	98	0
05	OT5BEW24-08 M	109	99	98	0
06	OT5BEW24-09	104	100	101	0
07	OT5BEW24-10	112	110	107	0
08	OT5BEW24-DL2	95	91	92	0
09	OT5BEW24-BLK2	96	87 *	87	1
10	OT5BEW24-11	97	92	93	0
11	OT5BEW24-12	106	100	99	0
12	OT5BEW24-13	109	100	104	0
13	OT5BEW24-14	92	98	101	0
14	OT5BEW24-15	91	95	99	0

QC LIMITS

SMC1 (DCE)	=	1,2-Dichloroethane-d4	(76-114)
SMC2 (TOL)	=	Toluene-d8	(88-110)
SMC3 (BFB)	=	Bromofluorobenzene	(86-115)

Column to be used to flag recovery values

* Values outside of contract required QC limits

D System Monitoring Compound diluted out

WATER VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

024724

Set Name: LONGHORN ARMY AMMU

Lab File: V50M2208.D

Set Number: OT5BEW24

Method: CLP SOW O

Sample Type: LIQUID

EPA Sample No. OT5BEW24-08

COMPOUND	SPIKE ADDED (µg/l)	SAMPLE CONCENTRATION (µg/l)	MS CONCENTRATION (µg/l)	MS % REC #	QC LIMITS REC.
1,1-Dichloroethene	50	0.0	46	92	61 - 145
Trichloroethene	50	0.0	46	92	71 - 170
Benzene	50	0.0	52	104	76 - 127
Toluene	50	0.0	49	98	76 - 125
Chlorobenzene	50	0.0	48	96	75 - 130

COMPOUND	SPIKE ADDED (µg/l)	MSD CONCENTRATION (µg/l)	MSD % REC #	% RPD #	QC LIMITS	
					RPD	REC.
1,1-Dichloroethene	50	49	98	6	14	61 - 145
Trichloroethene	50	47	94	2	14	71 - 170
Benzene	50	53	106	2	11	76 - 127
Toluene	50	51	102	4	13	76 - 125
Chlorobenzene	50	49	98	2	13	75 - 130

Column to be used to flag recovery and RPD values with an asterisk

* Values outside of QC limits

RPD: 0 out of 5 outside limits

Spike Recovery: 0 out of 10 outside limits

COMMENTS:

2C

WATER SEMIVOLATILE SURROGATE RECOVERY

Lab Name: US EPA REGION 6 LABORATORY Contract: _____

024725

Lab Code: _____ Site Nam Longhorn SAS No.: _____ Act.#: 0TEW24

	Sample No.:	S1 2FP #	S2 PHL #	S3 2CP #	S4 DCB #	S5 NBZ #	S6 FBP #	S7 TBP #	S8 TPH #	TOT OUT
01	EW24-BLK1	91	101	101	102	108	113 *	100	99	1
02	EW24-01	66	75	80	74	88	86	98	78	0
03	EW24-02	80	87	91	85	98	92	101	75	0
04	EW24-03	89	96	98	87	105	98	100	99	0
05	EW24-04	90	95	99	90	104	100	123	90	0
06	EW24-05	80	85	90	85	102	97	107	86	0
07	EW24-06	69	77	80	78	92	86	93	71	0
08	EW24-07	81	84	91	83	101	91	109	81	0
09	EW24-07MS	72	78	83	78	94	86	104	71	0
10	EW24-07MSD	78	86	89	82	100	91	102	69	0
11	EW24-BLK2	83	86	93	96	102	92	105	109	0

QC LIMITS

S1	2FP	=	2-Fluorophenol (surr1)	(30-106)
S2	PHL	=	Phenol-d5 (surr2)	(27-112)
S3	2CP	=	2-Chlorophenol-d4 (surr3)	(39-105)
S4	DCB	=	1,2-Dichlorobenzene-d4 (surr4)	(42-103)
S5	NBZ	=	Nitrobenzene-d5 (surr5)	(29-121)
S6	FBP	=	2-Fluorobiphenyl (surr6)	(36-111)
S7	TBP	=	2,4,6-Tribromophenol (surr7)	(29-129)
S8	TPH	=	d14-Terphenyl (surr8)	(39-135)

Column to be used to flag recovery values

* Values outside of contract required QC limits

D Surrogate diluted out

3C

WATER SEMIVOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

024726

Lab Name: US EPA REGION 6 LABORATORY Contract: _____Lab Code: _____ Site Name Longhorn SAS No.: _____ Act. #: 0TEW24Matrix Spike - Sample No.: EW24-07

COMPOUND	SPIKE ADDED (ug/L)	SAMPLE CONCENTRATION (ug/L)	MS CONCENTRATION (ug/L)	MS % REC #	QC LIMITS REC.
Phenol	10	0.0	7.8	78	40 - 97
2-Chlorophenol	10	0.0	7.5	75	47 - 98
1,4-Dichlorobenzene	5.0	0.0	2.9	58	41 - 94
N-Nitroso-di-propylamine	5.0	0.0	3.6	72	26 - 111
1,2,4-Trichlorobenzene	5.0	0.0	3.4	68	41 - 99
4-Chloro-3-methylphenol	10	0.0	8.8	88	32 - 109
Acenaphthene	5.0	0.0	3.9	78	41 - 104
4-Nitrophenol	10	0.0	8.7	87	32 - 130
2,4-Dinitrotoluene	5.0	0.0	4.3	86	41 - 106
Pentachlorophenol	10	0.0	12	120	40 - 136
Pyrene	5.0	0.0	4.1	82	52 - 122

COMPOUND	SPIKE ADDED (ug/L)	MSD CONCENTRATION (ug/L)	MSD % REC #	% RPD #	QC LIMITS	
					RPD	REC.
Phenol	10	8.4	84	7	29	40 - 97
2-Chlorophenol	10	7.9	79	5	26	47 - 98
1,4-Dichlorobenzene	5.0	3.1	62	7	24	41 - 94
N-Nitroso-di-propylamine	5.0	3.8	76	5	50	26 - 111
1,2,4-Trichlorobenzene	5.0	3.8	76	11	25	41 - 99
4-Chloro-3-methylphenol	10	8.3	83	6	39	32 - 109
Acenaphthene	5.0	3.9	78	0	43	41 - 104
4-Nitrophenol	10	7.8	78	11	33	32 - 130
2,4-Dinitrotoluene	5.0	4.0	80	7	34	41 - 106
Pentachlorophenol	10	11	110	9	30	40 - 136
Pyrene	5.0	4.0	80	2	22	52 - 122

Column to be used to flag recovery and RPD values with an asterisk

* Values outside of QC limits

RPD: 0 out of 11 outside limits

Spike Recovery: 0 out of 22 outside limits

COMMENTS: _____

024727

OFFICIAL
CHAIN OF CUSTODY RECORD

PROJ. NO.		PROJECT NAME		STATION LOCATION		NO. OF CONTAINERS		REMARKS	
Caddo Lake		Caddo Lake		Caddo Lake		Caddo Lake		Caddo Lake	
SAMPLERS: (Signature)		R. Clark		Caddo Lake		Caddo Lake		Caddo Lake	
STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS		REMARKS	
HB-1DS	03/14/2000	10:50		✓	Harrison Bayou #1 / Caddo Lake	2			
HB-3S	↑ 10:55			✓	Harrison Bayou #3 / Caddo Lake	2			
GP-3S	↓ 13:20			✓	Goose Prairie #3 / Caddo Lake	2			
N/A	03/14/2000			✓		1		TEMP BLANK	
Relinquished by: (Signature)		Date / Time		Received by: (Signature)		Date / Time		Received by: (Signature)	
R. Clark		03/15/2000 1600		UPS					
Relinquished by: (Signature)		Date / Time		Received by: (Signature)		Date / Time		Received by: (Signature)	
Relinquished by: (Signature)		Date / Time		Received for Laboratory by: (Signature)		Date / Time		Remarks	
				J. Acosta		3/14/00 11:55 am			
Shipped by:		Airbill Number:							

Distribution: White Accompanies Shipment; Pink to Coordinator Field Files;
Green to Report; Yellow Returns with WarrantEPA 7500-53
(11/96)

Temp Blank = 3°C

6- 11839

[illegible]

Distribution: White Accompanies Shipment; Pink to Coordinator Field Files;
Green to Report; Yellow Returns with Warrant

EPA 7500-53
(11/96)

Temp Blank: 10°C ~~44~~

CHAIN OF CUSTODY

6- 11840

Temp Blank: 1°C

EPA 7500-53
(11/96)

**Longhorn Army Ammunition Plant
Monthly Manager's Meeting**

**15 June 2000
10:30 a.m.**

Agenda

Quarterly Sampling Results

Perchlorate Investigation Update

Perchlorate Treatability Study Update

Meeting Schedule

**LONGHORN ARMY AMMUNITION PLANT
IRP STATUS SUMMARY**

As Of 15 June, 2000

PROJECT NAME	PROJECT PHASE	PROJECT STATUS	NEXT MAJOR MILESTONE(S)
Group # 2 (Sites 12, 17, 18, 24, 29, and 32)	Remedial Investigation/ Feasibility Study	- Phase III RI field work completed week of 26 October 98. - SCS submitted to team 1 Feb 00. - Perimeter well and Harrison Bayou sampling conducted week of 17 April 00. <i>and Goose Prairie Creek.</i>	- Perimeter well and Harrison Bayou quarterly sampling scheduled for July 00.
Group # 4 Wastewater Sumps And Sites 50 & 60	Remedial Investigation/ Feasibility Study	- Phase III RI field work completed 17 December 98. - SCS submitted to team 28 February 00. - Goose Prairie Creek sampling conducted week of 17 April 00.	- Goose Prairie Creek quarterly sampling scheduled for July 00.
Burning Ground #3 (Sites 18 and 24)	Interim Remedial Action	- Contract awarded to Complete Environmental on 31 May 00.	
Landfill Caps (Sites 12 and 16)	Interim Remedial Action	- Landfill caps and final inspections completed November 98. - Cap repair and reseeded work was completed 8 June 99. - Landfill caps inspected for erosion on 9 March 00.	

024731

LONGHORN ARMY AMMUNITION PLANT IRP STATUS SUMMARY

As Of 15 June, 2000

PROJECT NAME	PROJECT PHASE	PROJECT STATUS	NEXT MAJOR MILESTONE(S)
Perchlorates		- Perchlorates have been detected in soil, groundwater, and surface water at Building 25C. - Perchlorates detected in groundwater treatment plant effluent and downgradient surface waters of Harrison Bayou. - All Burning Ground extraction sumps sampled for perchlorates. - Toxicity testing conducted for groundwater treatment plant effluent. - Conceptual plan (memo) to address perchlorates sent to TNRCC and EPA on 24 June 99. - Letter from TNRCC sent 9 July requesting sampling of Caddo Lake for perchlorates. Army response provided 14 July. - Letter from TNRCC received 7 September. Letter forwarded to Army officials on 7 September. - 1 December meeting in Austin, TX held to discuss perchlorate plans. - LHAAP, IOC and COE personnel met with Navy's McGregor staff and attended RAB meeting on 9	- Perchlorate investigation groundwater data summary report to team 19 July 00.

**LONGHORN ARMY AMMUNITION PLANT
IRP STATUS SUMMARY**

As Of 15 June, 2000

PROJECT NAME	PROJECT PHASE	PROJECT STATUS	NEXT MAJOR MILESTONE(S)
		December. - Building 25C covered with liner in November 99. - Schedules for investigation and treatability study presented at 19 January 00 meeting. Comments provided during the meeting, and revised schedules submitted 1 Feb 00. - Building 25-C sampling data provided to team on 1 Feb 00. - Army approval received in Jan 00 to sample beyond property boundaries in Caddo Lake. - Funding received for contract with Envirogen for GWTP Bench Scale study. Contract awarded, and kick-off meeting held 24 April 00. - LHAAP team met on 25 February and finalized perchlorate investigation scoping. Contract awarded. - Investigation Work Plan submitted 21 April 00. - Lake water samples collected at HB-1, 2, 3 on 27 April 00. Additional split samples collected with TNRCC week of 30 May 00.	

024733

**LONGHORN ARMY AMMUNITION PLANT
IRP STATUS SUMMARY**

As Of 15 June, 2000

PROJECT NAME	PROJECT PHASE	PROJECT STATUS	NEXT MAJOR MILESTONE(S)
		- Perchlorate investigation field work completed 8 June 00.	
Landfill Site 16 Accelerated RI	RI/FS	- Phase III RI field work complete. - RI Report to team in October 99. - RA Report to team 31 March 00.	- FS Report to team 14 August 00.

024734

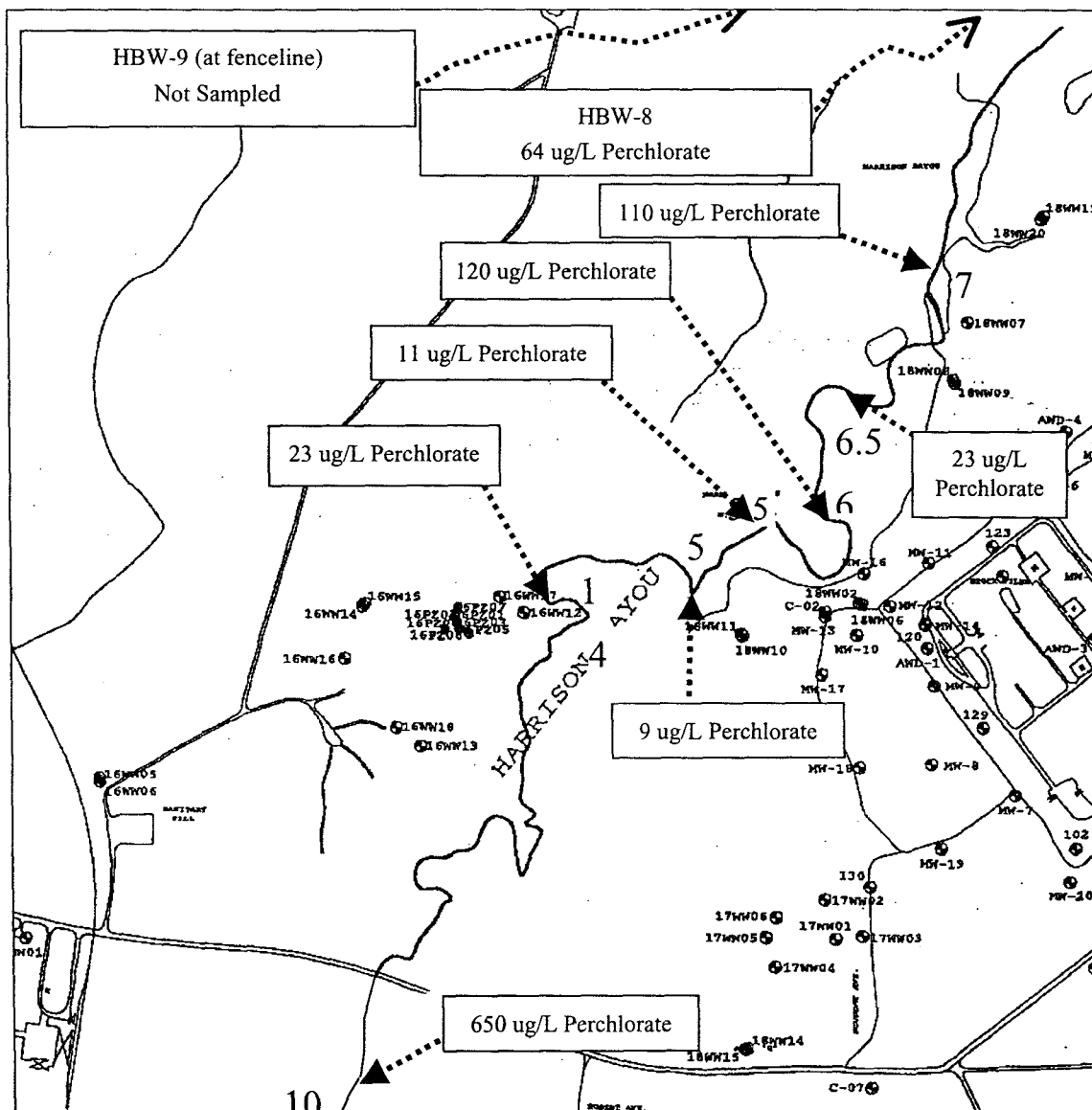
**LONGHORN ARMY AMMUNITION PLANT
IRP STATUS SUMMARY**

As Of 15 June, 2000

SCHEDULED MEETINGS AND VISITS TO LHAAP			
Date / Time	Purpose of Meeting / Visit	Location	
26 July/1:00	Monthly Managers' Meeting	LHAAP	

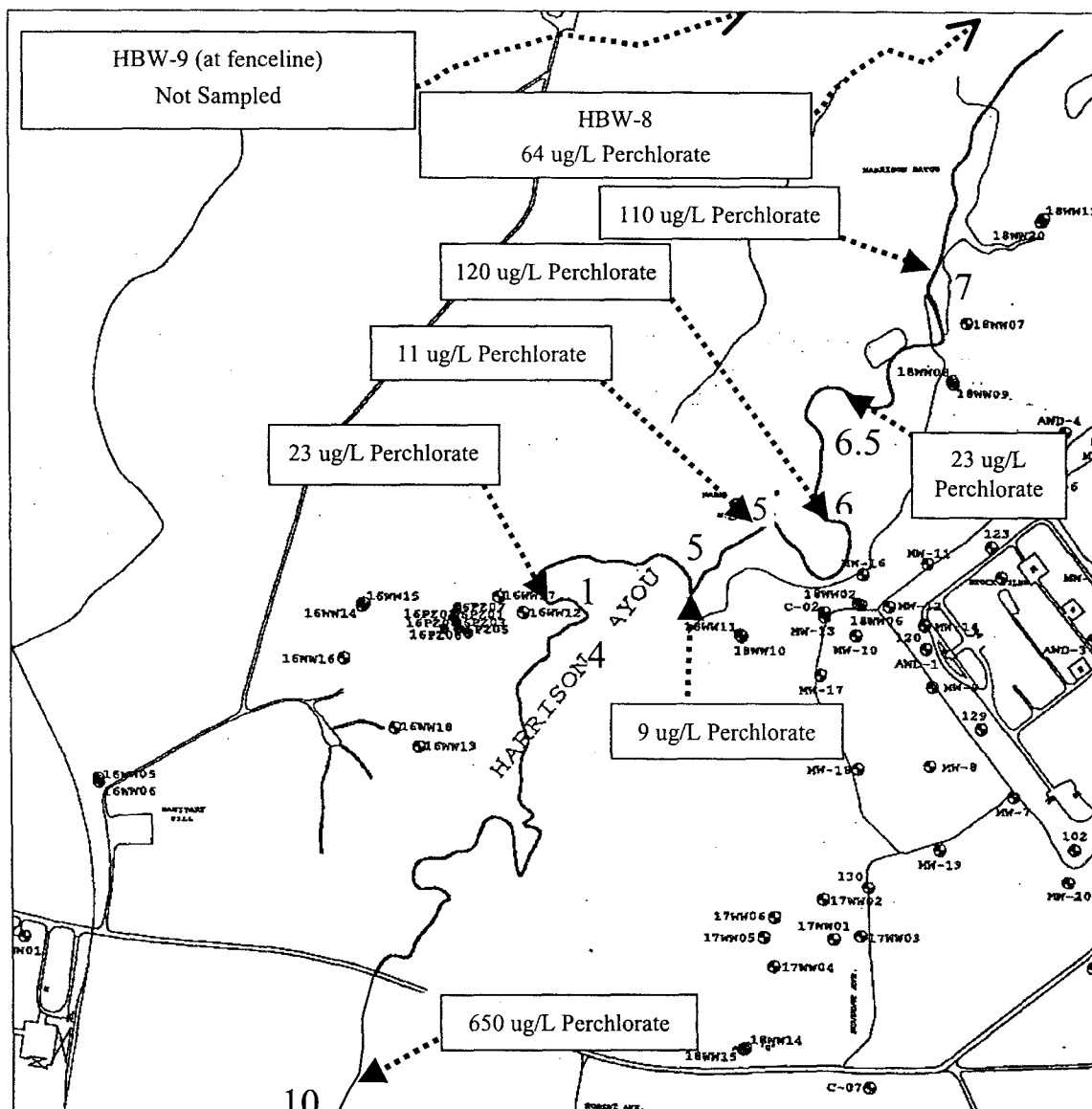
01	Inert Burning Grounds	24	Washout & Unlined Evaporation Pond	60	Former Storage Bldg. 411 & 714
11	Suspected TNT Burial Grounds at Ave P&Q	27	South Test Area	XX(54)	Ground Signal Test Area
12	Landfill 12	29	Former TNT Production Area	52	Magazine Area
16	Landfill 16	32	Former TNT Disposal Area	63	Burial Pits
17	Burning Ground 2/Flashing Area	35	Process Wastewater Sumps		
18	Burning Ground 3	50	Former Waste Disposal Facility		

024735



Harrison Bayou Sampling Detection Results. Sampled 20 & 21 April 2000. Analyzed for Volatile Organics (Method 8260B) and Perchlorate (Method 300.0).

Sample locations HBW-6, 7 & 10 sampled the afternoon of 4/20/00. The remaining locations were sampled the afternoon of 4/21/00.



Harrison Bayou Sampling Detection Results. Sampled 20 & 21 April 2000. Analyzed for Volatile Organics (Method 8260B) and Perchlorate (Method 300.0).

Sample locations HBW-6, 7 & 10 sampled the afternoon of 4/20/00. The remaining locations were sampled the afternoon of 4/21/00.

LONGHORN ARMY AMMUNITION PLANT
PERIMETER WELL SAMPLING
19-20 APRIL 2000

The perimeter wells (wells 108, 110, 111, 112, 133, and 134) at Longhorn Army Ammunition Plant were sampled on 19-20 April 2000. Wells 111, 112, 133, and 134 were sampled on 19 April 2000. Wells 108 and 110 were sampled on 20 April 2000. The groundwater samples collected were analyzed for metals, volatile organic compounds (method 8260B), semi-volatile organic compounds (method 8270), high explosives (method 8330), and anions including perchlorate (method 300).

The analytical results for the metals (inorganics) and anions are presented on the following two pages. Analytical detection limits are presented with the results. There were no detections of volatile organic compounds, semi-volatile organic compounds or high explosives. The detection limits for the compounds analyzed by those methods are presented on the following pages.

At the time of sampling, water quality parameters (pH, conductivity, turbidity and dissolved oxygen (DO)) were recorded. The table below provides those measurements.

Well Number	Sample Date/Time	Temperature (C)	pH	Conductivity (mS/cm)	Turbidity (NTU)	DO (mg/L)
108	20 April 00/	Insufficient Water				
110	20 April 00/ 0920	17.0	6.27	6.89	12	2.25
111	19 April 00/ 1215	19.3	5.44	0.120	36	2.77
112	19 April 00/ 1055	18.2	6.39	5.28	86	3.03
133	19 April 00/ 1215	19.4	5.60	0.092	139	4.20
134	19 April 00/ 0745	19.7	5.89	0.095	20	4.54

Longhorn Army Ammunition Plant Perimeter Wells (April 2000) Inorganic Data Summary (mg/L)																							
Sample Date	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Mg	Mn	Ni	Pb	Sb	Se	Sr	Ti	V	Zn
PW-MW-108	Reporting Limit																						
	10	100	5	10	2	200	1	5	5	10	50	0.2	400	100	5	5	5	6	10	20	2	10	10
	<10	2120	2.8J	37.1	0.22J	30800	<1	63.6	2.1J	4.7J	3230	0.21	1220	23300	1590	24.6	<5	<6	<10	900	2.2	4.8J	38.6
PW-MW-110	Reporting Limit																						
	10	100	5	10	2	200	1	5	5	10	50	0.2	400	100	5	5	5	6	10	50	2	10	10
	<10	260	<5	20.2	<2	228000	<1	11.1	0.66J	3.7J	598	0.15J	4070	134000	4610	28.9	<5	<6	<10	6330	4.9	<10	25.4
PW-MW-111	Reporting Limit																						
	10	100	5	10	2	200	1	5	5	10	50	0.2	400	100	5	5	5	6	10	10	2	10	10
	<10	1350	<5	157	0.86J	4410	<1	13.3	2.0J	7.3J	1610	0.17J	364J	4350	290	12.8	2.9J	<6	<10	133	1.4J	3.8J	49.8
PW-MW-112	Reporting Limit																						
	10	100	5	10	2	200	1	5	5	10	50	0.2	400	100	5	5	5	6	10	50	2	10	10
	<10	737	<5	34	0.28J	199000	<1	21.1	1.6J	7.8J	2970	0.26	3400	251000	2520	21.7	1.5J	<6	<10	6130	4.1	2.2J	41.7
PW-MW-133	Reporting Limit																						
	10	100	5	10	2	200	1	5	5	10	50	0.2	400	100	5	5	5	6	10	10	2	10	10
	<10	1880	3.5J	59.1	0.21J	7950	<1	5.7	5.7	14.9	4070	0.19J	2180	3190	212	7.6	3.9J	<6	<10	129	<2	5.4J	58.3
PW-MW-134	Reporting Limit																						
	10	100	5	10	2	200	1	5	5	10	50	0.2	400	100	5	5	5	6	10	10	2	10	10
	<10	270	<5	38.6	0.14J	5810	<1	1.2J	6.2	4.6J	522	0.11J	1810	2310	47.7	4.9J	<5	<6	<10	106	<2	0.88J	50.6

Longhorn Army Ammunition Plant
Perimeter Wells
April 19-20, 2000
Volatiles Reporting Limit Summary (µg/L)

ACETONE	20	IODOMETHANE	1
ACETONITRILE	50	P-CYMENE (P-ISOPROPYLTOLUENE)	1
ACROLEIN	20	METHYLENE CHLORIDE	10
ACRYLONITRILE	20	METHYL ISOBUTYL KETONE	5
BENZENE	1	TERT-BUTYL METHYL ETHER	5
BROMOBENZENE	1	NAPHTHALENE	1
BROMOCHLOROMETHANE	1	N-PROPYLBENZENE	1
BROMODICHLOROMETHANE	1	STYRENE	1
BROMOFORM	1	1,1,1,2-TETRACHLOROETHANE	1
BROMOMETHANE	1	1,1,2,2-TETRACHLOROETHANE	1
METHYL ETHYL KETONE	20	TETRACHLOROETHYLENE(PCE)	1
N-BUTYLBENZENE	1	TOLUENE	1
SEC-BUTYLBENZENE	1	1,2,3-TRICHLOROBENZENE	1
T-BUTYLBENZENE	1	1,2,4-TRICHLOROBENZENE	1
CARBON DISULFIDE	1	1,1,1-TRICHLOROETHANE	1
CARBON TETRACHLORIDE	1	1,1,2-TRICHLOROETHANE	1
CHLOROBENZENE	1	TRICHLOROETHYLENE (TCE)	1
DIBROMOCHLOROMETHANE	1	TRICHLOROFLUOROMETHANE	1
CHLOROETHANE	1	1,2,3-TRICHLOROPROPANE	1
2-CHLOROETHYL VINYL ETHER	5	1,2,4-TRIMETHYLBENZENE	1
CHLOROFORM	1	1,3,5-TRIMETHYLBENZENE	1
CHLOROMETHANE	1	VINYL ACETATE	10
2-CHLOROTOLUENE	1	VINYL CHLORIDE	1
4-CHLOROTOLUENE	1	O-XYLENE	1
1,2-DIBROMO-3-CHLOROPROPANE	5	M,P-XYLENE	2
1,2-DIBROMOETHANE	1		
DIBROMOMETHANE	1		
1,2-DICHLOROBENZENE	1		
1,3-DICHLOROBENZENE	1		
1,4-DICHLOROBENZENE	1		
DICHLORODIFLUOROMETHANE	1		
1,1-DICHLOROETHANE	1		
1,2-DICHLOROETHANE	1		
1,1-DICHLOROETHENE	1		
CIS-1,2-DICHLOROETHYLENE	1		
TRANS-1,2-DICHLOROETHENE	1		
1,2-DICHLOROPROPANE	1		
1,3-DICHLOROPROPANE	1		
2,2-DICHLOROPROPANE	1		
1,1-DICHLOROPROPENE	1		
CIS-1,3-DICHLOROPROPENE	1		
TRANS-1,3-DICHLOROPROPENE	1		
ETHYL ACETATE	10		
ETHYLBENZENE	1		
HEXACHLOROBUTADIENE	1		
ISOPROPYLBENZENE (CUMENE)	1		
2-HEXANONE (MEK)	5		

Longhorn Army Ammunitions Plant
Perimeter Wells
April 19-20, 2000
Semi-volatile Reporting Limit Summary (µg/L)

ACENAPHTHENE	2	2,6-DINITROTOLUENE	5
ACETOPHENONE	5	3,3'-DIMETHYLBENZIDINE	10
ACENAPHTHYLENE	2	1,3-DINITROBENZENE	5
ANILINE	5	DIPHENYLAMINE	10
ANTHRACENE	2	FLUORANTHENE	2
BENZO(A)ANTHRACENE	2	FLUORENE	2
BENZIDINE	20	HEXACHLOROBENZENE	5
BENZO(A)PYRENE	2	HEXACHLOROBUTADIENE	5
BENZO(B)FLUORANTHENE	2	HEXACHLOROCYCLOPENTADIENE	5
BENZO(G,H,I)PERYLENE	2	HEXACHLOROETHANE	5
BENZO(K)FLUORANTHENE	2	INDENO(1,2,3-C,D)PYRENE	2
BENZOIC ACID	50	ISOPHORONE	5
BENZYL ALCOHOL	10	2-METHYLNAPHTHALENE	2
BIS(2-CHLOROETHOXY) METHANE	5	3-METHYLPHENOL	5
BIS(2-CHLOROETHYL) ETHER	5	4-METHYLPHENOL (P-CRESOL)	5
BIS(2-CHLOROISOPROPYL) ETHER	5	2-METHYLPHENOL (O-CRESOL)	5
BIS(2-ETHYLHEXYL) PHTHALATE	10	NAPHTHALENE	2
4-BROMOPHENYL PHENYL ETHER	5	2-NITROANILINE	5
BENZYL BUTYL PHTHALATE	5	3-NITROANILINE	10
CARBAZOLE	5	4-NITROANILINE	5
4-CHLORO-3-METHYLPHENOL	5	NITROBENZENE	5
4-CHLOROANILINE	5	2-NITROPHENOL	5
2-CHLORONAPHTHALENE	2	4-NITROPHENOL	5
2-CHLOROPHENOL	5	N-NITROSODI-N-PROPYLAMINE	5
4-CHLOROPHENYL PHENYL ETHER	5	N-NITROSO-DI-N-BUTYLAMINE	5
CHRYSENE	2	N-NITROSO-DIETHYLAMINE	5
DI-N-BUTYL PHTHALATE	5	N-NITROSODIMETHYLAMINE	5
DI-N-OCTYLPHTHALATE	5	N-NITROSODIPHENYLAMINE	10
DIBENZ(A,H)ANTHRACENE	2	PENTACHLOROPHENOL	10
DIBENZOFURAN	5	PHENANTHRENE	2
1,2-DICHLOROBENZENE	5	PHENOL	5
1,3-DICHLOROBENZENE	5	PYRENE	2
1,4-DICHLOROBENZENE	5	PYRIDINE	10
3,3'-DICHLOROBENZIDINE	10	1,2,4,5-TETRACHLOROBENZENE	5
2,4-DICHLOROPHENOL	5	2,3,4,6-TETRACHLOROPHENOL	5
2,6-DICHLOROPHENOL	5	1,2,4-TRICHLOROBENZENE	5
DIETHYL PHTHALATE	5	2,4,5-TRICHLOROPHENOL	5
DIMETHYL PHTHALATE	5	2,4,6-TRICHLOROPHENOL	5
2,4-DIMETHYLPHENOL	5	1,3,5-TRINITROBENZENE	10
4,6-DINITRO-2-METHYLPHENOL	10		
2,4-DINITROPHENOL	50		
2,4-DINITROTOLUENE	5		

Longhorn Army Ammunition Plant Perimeter Wells Total Dissolved Solids Data Summary (mg/L)		Chloride	Nitrite	Nitrate	Sulfate	Perchlorate, Low Level
PW-MW-108		Reporting Limit				
		20	5	4	50	0.004
	20 April 2000	310	<5	<4	190	<0.004
PW-MW-110		Reporting Limit				
		50	13	10	130	0.012
	20 April 2000	1370	<13	<10	1500	<0.012
PW-MW-111		Reporting Limit				
		1	0.25	0.2	2.5	0.004
	19 April 2000	14	<0.25	<0.2	26	<0.004
PW-MW-112		Reporting Limit				
		50	13	10	130	0.008
	19 April 2000	1450	<13	<10	850	<0.008
PW-MW-133		Reporting Limit				
		0.4	0.1	0.08	1	0.004
	19 April 2000	11.7	<0.1	2.49	11	<0.004
PW-MW-134		Reporting Limit				
		0.2	0.05	0.04	0.5	0.004
	19 April 2000	4.38	<0.05	2.9	2	<0.004

024743

Longhorn Army Ammunition Plant
Perimeter Wells
April 19-20, 2000
Explosives Reporting Limit Summary
(µg/L)

4-AMINO-2,6-DINITROTOLUENE	0.5
2-AMINO-4,6-DINITROTOLUENE	0.5
1,3-DINITROBENZENE	0.5
2,4-DINITROTOLUENE	0.5
2,6-DINITROTOLUENE	0.5
HMX	0.5
NITROBENZENE	0.5
3-NITROTOLUENE	0.5
RDX	0.5
TETRYL	0.5
1,3,5-TRINITROBENZENE	0.5
2,4,6-TRINITROTOLUENE	0.5
2-NITROTOLUENE	0.5
4-NITROTOLUENE	0.5

**Longhorn Army Ammunition Plant
Technical Review Committee Meeting
15 June 2000**

[illegible]

**Longhorn Army Ammunition Plant
Technical Review Committee Meeting
15 June 2000**

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Loa

Robert J. Huston, *Chairman*
R. B. "Ralph" Marquez, *Commissioner*
John M. Baker, *Commissioner*
Jeffrey A. Saitas, *Executive Director*



TEXAS NATURAL RESOURCE CONSERVATION COMMISSION

Protecting Texas by Reducing and Preventing Pollution

August 7, 2000

VIA E-MAIL, FAX, AND CERTIFIED MAIL

Mr. David Tolbert, Commander's Representative
Longhorn/Louisiana Army Ammunition Plant
Attn: SIOLH-CR
P.O. Box 658
Doyline, LA 71023-0658

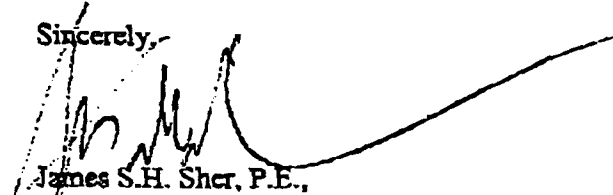
Re: Texas Risk Reduction Program - Grandfathering under the Risk Reduction Rules

This letter is written in response to the August 6, 2000 Longhorn Army Ammunition Plant's (LHAAP) request to be grandfathered under the Risk Reduction Rules (RRR).

In accordance with section 30 Texas Administrative Code (TAC) 350.2 (m) continued response actions under 30 TAC 335.553 (b) Risk Reduction Standard 3 requires the submittal of a Remedial Investigation (RI) report prior to May 1, 2001. Submittal of an RI report after May 1, 2001 requires that response actions proceed according to 30 TAC 350.

If you have any questions, please call me at (512) 239-2444.

Sincerely,


James S.H. Sher, P.E.,
Project Manager
Superfund Cleanup Section

JS/nmmw

cc: Mr. Chris Villareal, EPA Region 6 (6SF-AP)

024747

**Longhorn Army Ammunition Plant
Technical Review Committee Meeting**

**14 September 2000
10:30 a.m.**

Agenda

Executive Summary

Group 2 and 4 Risk Assessment Sampling

Quarterly Sampling Results

Bench Scale Treatability Study Results – Final Report

Meeting Schedule

Adjourn

**LONGHORN ARMY AMMUNITION PLANT
IRP STATUS SUMMARY**

As Of 14 September, 2000

PROJECT NAME	PROJECT PHASE	PROJECT STATUS	NEXT MAJOR MILESTONE(S)
Group # 2 (Sites 12, 17, 18, 24, 29, and 32)	Remedial Investigation/ Feasibility Study	- Phase III RI field work completed week of 26 October 98. - SCS submitted to team 1 Feb 00. - Perimeter well and Harrison Bayou sampling conducted week of 7 August 00. - Quarterly sampling results presented to team during September 2000 TRC.	- Quarterly sampling scheduled for early November 00. - Remedial Investigation Report to team 15 December 00.
Group # 4 (Wastewater Sumps And Sites 50 & 60)	Remedial Investigation/ Feasibility Study	- Phase III RI field work completed 17 December 98. - SCS submitted to team 28 February 00. - Goose Prairie Creek sampling conducted week of 7 August 00. - Quarterly sampling results presented to team during September 2000 TRC.	- Quarterly sampling scheduled for early November 00. - Remedial Investigation Report to team 22 December 00.
Burn Ground #3 (Sites 18 and 24)	Interim Remedial Action	- Contract awarded to Complete Environmental on 31 May 00.	
Landfill Caps (Sites 12 and 16)	Interim Remedial Action	- Landfill caps inspected for erosion on 9 March 00. - Landfill caps mowed week of 10 July 00.	

024748

LONGHORN ARMY AMMUNITION PLANT IRP STATUS SUMMARY

As Of 14 September, 2000

PROJECT NAME	PROJECT PHASE	PROJECT STATUS	NEXT MAJOR MILESTONE(S)
Perchlorate		- Perchlorate has been detected in soil, groundwater, and surface water at Building 25C. - Perchlorate detected in groundwater treatment plant effluent and downgradient surface waters of Harrison Bayou. - All Burning Ground extraction sumps sampled for perchlorate. - Toxicity testing conducted for groundwater treatment plant effluent. - Conceptual plan (memo) to address perchlorate sent to TNRCC and EPA on 24 June 99. - Letter from TNRCC sent 9 July requesting sampling of Caddo Lake for perchlorate. Army response provided 14 July. - Letter from TNRCC received 7 September. Letter forwarded to Army officials on 7 September. - 1 December meeting in Austin, TX held to discuss perchlorate plans. - LHAAP, IOC and COE personnel met with Navy's McGregor staff and attended RAB meeting on 9 December. - Building 25C covered with liner in November 99.	- Second quarter field work in progress. Results to team 25 October 00.

024749

**LONGHORN ARMY AMMUNITION PLANT
IRP STATUS SUMMARY**

As Of 14 September, 2000

PROJECT NAME	PROJECT PHASE	PROJECT STATUS	NEXT MAJOR MILESTONE(S)
		- Schedules for investigation and treatability study presented at 19 January 00 meeting. Comments provided during the meeting, and revised schedules submitted 1 Feb 00. - Building 25-C sampling data provided to team on 1 Feb 00. - Army approval received in Jan 00 to sample beyond property boundaries in Caddo Lake. - Funding received for contract with Envirogen for GWTP Bench Scale study. Contract awarded, and kick-off meeting held 24 April 00. - LHAAP team met on 25 February and finalized perchlorate investigation scoping. Contract awarded. - Investigation Work Plan submitted 21 April 00. - Lake water samples collected at HB-1, 2, 3 on 27 April 00. Additional split samples collected with TNRCC week of 30 May 00. - First quarter investigation field work completed 8 June 00. - First quarter investigation results provided to team for review on 20 July 00.	

024750

**LONGHORN ARMY AMMUNITION PLANT
IRP STATUS SUMMARY**

As Of 14 September, 2000

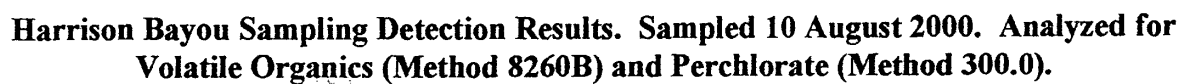
PROJECT NAME	PROJECT PHASE	PROJECT STATUS	NEXT MAJOR MILESTONE(S)
		- Envirogen contract for perchlorate treatment system awarded 4 August, and kickoff meeting held at LHAAP on 7 August 00. - Proposed second quarter investigation plan submitted to team 18 August 00. Agreement reached 23 August 00.	
Transition Management Group		- Transition Management Group met 11 July. Discussion topics included EarthTech contract, interior fencing, real estate transfer progress, and method of transfer achievable by Oct.00.	- Quarterly meeting scheduled for 14 September 00.
Landfill Site 16 Accelerated RI	RI/FS	- Phase III RI field work complete. - RI Report to team in October 99. - RA Report to team 31 March 00. - Responses to RI comments to team 18 August 00.	- Ecological risk assessment to team 13 November 00.

024751

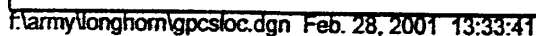
**LONGHORN ARMY AMMUNITION PLANT
IRP STATUS SUMMARY**

As Of 14 September, 2000

SCHEDULED MEETINGS AND VISITS TO LHAAP				
Date / Time	Purpose of Meeting / Visit	Location		
18 October /10:00	Monthly Managers' Meeting	LHAAP		
6-8 November	Installation Action Plan Meeting	Dallas, Texas		
01 Inert Burning Grounds	24	Washout & Unlined Evaporation Pond	60	Former Storage Bldg. 411 & 714
11 Suspected TNT Burial Grounds at Ave P&Q	27	South Test Area	XX(54)	Ground Signal Test Area
12 Landfill 12	29	Former TNT Production Area	52	Magazine Area
16 Landfill 16	32	Former TNT Disposal Area	63	Burial Pits
17 Burning Ground 2/Flashing Area	35	Process Wastewater Sumps		
18 Burning Ground 3	50	Former Waste Disposal Facility		



Locations sampled 10 August 2000. Remainder of locations not sampled due to dry conditions.



**Goose Prairie Creek Sampling Detection Results. Sampled 8 August 2000.
Analyzed for Explosives (Method 8330), Volatile Organics (Method 8260B), and
Perchlorate (Method 300.0- PQL 4 ug/L)**

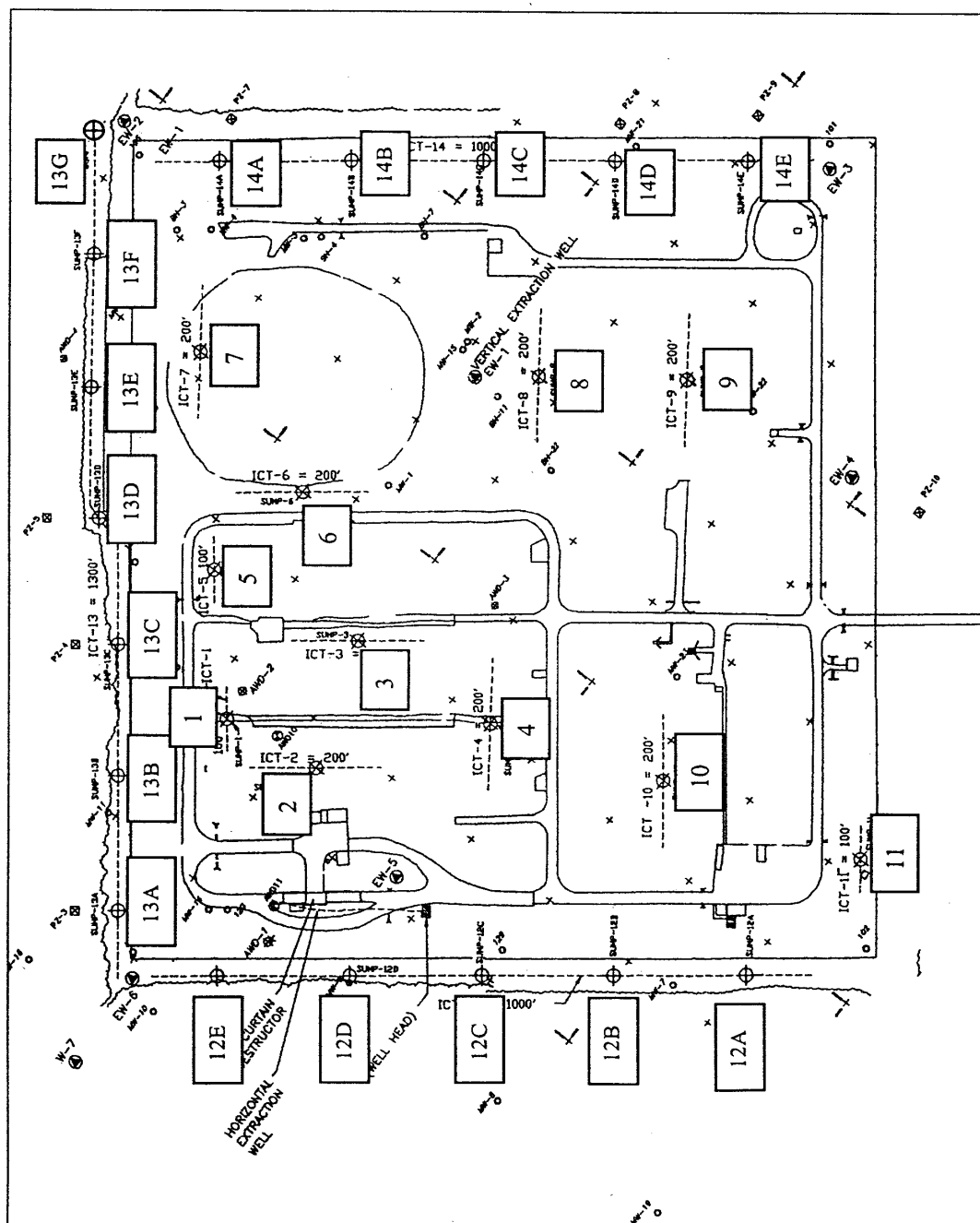


Figure 2. Burning Ground No. 3 ICT Sump Locations

024756

**Longhorn Army Ammunition Plant
Technical Review Committee Meeting**

14 September 2000

10:30 a.m.

Sign - In Sheet

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**Final
REMEDIAL INVESTIGATION REPORT
Volume 1: Report**

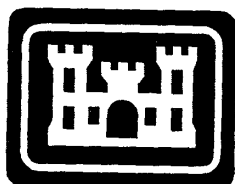
for the

**SITE 16 LANDFILL REMEDIAL
INVESTIGATION and FEASIBILITY
STUDY**



At the

**Longhorn Army Ammunition Plant
(LHAAP)
Karnack, Texas**



Submitted to

**U.S. Army Corps of Engineers
Tulsa District**

Contract No. DACA56-97-D-0001

October, 2000

Jacobs Engineering Group, Inc
St. Louis, Missouri

**FINAL
REMEDIAL INVESTIGATION REPORT
SITE 16 LANDFILL
LONGHORN ARMY AMMUNITION PLANT (LHAAP)
KARNACK, TEXAS**

Submitted to
**U.S. ARMY CORPS of ENGINEERS
TULSA DISTRICT**

Prepared by
JACOBS ENGINEERING GROUP, INC.
13723 Riverport Drive
Maryland Heights, MO 63043

OCTOBER 2000

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Appendix II

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Resistivity Interpretation

Appendix III

Well Location Summary

Soil Boring Logs

Well Construction Diagrams

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Geophysical Logs

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Table and Lists of Laboratory Analysis Performed

USAEHA 1980

EPS 1984

EPS 1987

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Table and Lists of Laboratory Analysis Performed

Phase I through Phase III Hits Only Tables

Sediment Samples

VOCs

SVOCs

Pesticides/PCBs

Explosives

Dioxins/Furans

Metals

Anions

Soil Samples

VOCs

SVOCs

Pesticides/PCBs

Explosives

Dioxins/Furans

Metals

Anions

Surface Water Samples

VOCs

SVOCs

Pesticides/PCBs

Explosives

Dioxins/Furans

Metals

Anions

Groundwater Samples

VOCs

SVOCs

Pesticides/PCBs

Explosives

Dioxins/Furans

Metals

LIST of ACRONYMS and ABBREVIATIONS

BGS – Below Ground Surface
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
CFR – Code of Federal Regulations
cis-1,2-DCE – cis-1,2-dichloroethene
COC – Contaminant of Concern
DERTA –
1,3-DNB – 1,3-dinitrobenzene
2,6-DNT – 2,6-dinitrotoluene
DSERTS – Defense Site Environmental Restoration Tracking System
EPA – Environmental Protection Agency
F – Fahrenheit
FDWQL – Federal Drinking Water Quality Limit
FID – Flame Ionization Detector
FFA – Federal Facility Agreement
GC/EC – Gas Chromatograph/Electron Capture
GC/MS – Gas Chromatograph/Mass Spectrometer
HE – High Explosives
HMX – High Melt Explosive
HPLC – High Pressure Liquid Chromatography
I.D. – Inside Diameter
IRM – Interim Remedial Measure
IRP – Installation Restoration Program
LHAAP – Longhorn Army Ammunition Plant
NGVD – National Geodetic Vertical Datum
NPL – National Priority List
O.D. – Outside Diameter
PCB – Polychlorinated Biphenols
PID – Photo Ionization Detector
PVC – Polyvinyl Chloride
QA – Quality Assurance
QC – Quality Control
RA – Risk Assessment
RCRA – Resource Conservation and Recovery Act
RDX – Rapidly Detonating Explosive (cyclotrimethylenetrinitramine)
RFA – RCRA Facility Assessment
RI – Remedial Investigation
SMCL – Suggested Maximum Contaminant Level
SvE – Sverdrup Environmental, Inc.
SVOCs – Semivolatile Organic Compounds
TAL – Target Analyte List
TCE – Trichloroethene
TDHDWL – Texas Department of Health Drinking Water Limit
1,3,5-TNB – 1,3,5-trinitrobenzene
TNRCC – Texas Natural Resource Conservation Commission

LIST of ACRONYMS and ABBREVIATIONS (Continued)

TNT – 2,4,6-trinitrotoluene
TOC – Total Organic Carbon
TOX – Total Organic Halides
TWC – Texas Water Commission
USACE – United States Army Corps of Engineers
USAEHA – U.S. Army Environmental Hygiene Agency
USAMCCOM – U.S. Army Armament, Munitions and Chemical Command
USATHAMA – U.S. Army Toxic and Hazardous Materials Agency
USCS – Unified Soil Classification System
USEPA – United States Environmental Protection Agency
UST – Underground Storage Tank
VOCs – Volatile Organic Compounds

1.0 INTRODUCTION

1.1 Purpose of Report

This Remedial Investigation (RI) Report presents the findings of investigations performed at the Old Landfill, also referred to as Site 16, located at Longhorn Army Ammunition Plant (LHAAP), Karnack, Texas. The RI activities were conducted under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the United States Department of the Army (Army). The RI work was performed by Jacobs Engineering Group, Inc. (Jacobs), formerly Sverdrup Environmental, Inc. (SvE), St. Louis, Missouri under contracts DACA56-93-D002 and DACA56-97-D-0001 with the Tulsa District of United States Army Corps of Engineers (USACE) - Tulsa, Oklahoma. Supplemental RI work at Site 16 was conducted in conjunction with representatives from USACE.

The objective of this RI was to identify the extent and presence of contaminants of concern (COC) in surface waters, sediments, surface and subsurface soils as well as groundwater at Site 16. Investigations included evaluations of conditions within the old landfill boundaries and adjacent areas. The data generated by the field activities performed at Site 16 have been compiled to provide a summary of site conditions as well as provide information required for the Risk Assessment that will be provided under a separate cover. This report is submitted under the 1993 Texas Risk Reduction Program.

Perchlorate was identified as a contaminant of concern after the completion of the Phase III field activities. Additional investigative studies will be performed to identify the nature and extent of potential perchlorate contamination at Site 16. The results of these studies will be presented in future documents.

1.2 Site Background

LHAAP is a former government owned, contractor operated/maintained industrial facility under the jurisdiction of the United States Army Industrial Operations Command (IOC). There is currently no manufacturing/operating contractor at the LHAAP installation. A site map is presented in Figure 1-1, Appendix I.

1.2.1 Site Description

LHAAP

LHAAP is located in central east Texas in the northeast corner of Harrison County. The installation occupies 8,493 acres between State Highway 43 at Karnack, Texas and the western shore of Caddo Lake shown in Figure 1-1, Appendix I. The nearest cities are Marshall, Texas approximately 14 miles to the southwest, and Shreveport, Louisiana approximately 40 miles to the east. State Highways 43 and 134 provide access to the installation. Caddo Lake, a large fresh water lake situated on the Texas-Louisiana state line, bounds LHAAP to the north and east. The eastern fence of LHAAP is 3.5 miles from the Texas-Louisiana state border. The incorporated community of Uncertain, Texas and the unincorporated community of Karnack, Texas are located immediately north and west of the installation boundary, respectively. The remaining surrounding area is referred to as the Pineywoods of East Texas and is sparsely populated.

LHAAP is characterized by mixed pine-hardwood forests that cover gently rolling to hilly terrain with an average slope of 3 percent towards the northeast. Most of the terrain at LHAAP has slopes of 3 percent or less, but slopes as steep as 12 percent are common in the western and northwestern portions of the installation and along the Harrison Bayou floodplain. Land surrounding the facility is a mixture of forest and agricultural land. Ground surface elevations at LHAAP vary from 170 ft to 335 ft National Geodetic Vertical Datum, 1929 (NGVD29). Surface water from LHAAP drains to the northeast into Caddo Lake through Saunders Branch, Harrison Bayou, Central Creek, and Goose Prairie Creek.

Site 16

Site 16 encompasses an area of approximately 20 acres and is located in the south-central portion of LHAAP, just north of Avenue Q shown in Figure 1-1, Appendix I. The site initially consisted of an open area of grass, at the commencement of RI field activities, that was bounded on the western and northern edges by a gravel road and along the eastern and southern edges by wooded areas. Most of the terrain at Site 16 slopes 3 percent or less, primarily to the east toward Harrison Bayou, but slopes as steep as 5 to 20 percent are common along sections of the Harrison Bayou floodplain. Harrison Bayou, the largest bayou with a general continuous flow through the LHAAP installation, runs along the northeastern edge of Site 16. Ground surface elevations at Site 16 vary from approximately 170 ft to 200 ft above mean sea level as referenced to NGVD29. A Site map of Site 16 is presented in Figure 1-2, Appendix I.

1.2.2 Site History

LHAAP

LHAAP was established in October 1942 with the primary mission to produce 2,4,6-trinitrotoluene (TNT) flake (Plant 1 area). Monsanto Chemical Company was the first manufacturing contractor-operator of the plant. TNT flake production continued through World War II until August 1945 when Monsanto Chemical Company's role ended and the plant went on standby status until February 1952. From 1952 until 1956, Universal Match Corporation was the contractor-operator, producing such pyrotechnic ammunition as photoflash bombs, simulators, hand signals, and 40-mm tracers. The Plant 2 area was reportedly the main site of the pyrotechnic operations at LHAAP. During November of 1955, Thiokol Corporation began operation of the rocket motor facility (Plant 3 area). Thiokol Corporation assumed responsibility for total operation of the plant with the departure of Universal Match Corporation in 1956. Production of rocket motors continued to be the primary operation at LHAAP until 1965, when the production of pyrotechnic and illuminating ammunition was re-established. Thiokol's status as contractor-operator was terminated in June 1996.

The installation, from September 1988 to May 1991, was also utilized for the static firing and elimination of Pershing I and II rocket motors in compliance with the Intermediate-Range Nuclear Force Treaty in effect between the United States and the former Union of Soviet Socialist Republics.

In October 1996, approximately 1,435 acres surrounding Harrison Bayou were leased to the Caddo Lake Institute for biological and ecological studies by local schools. The plant became inactive and excess to the Army's needs in July 1997. In July 1998, the Army contracted Earth Tech to liquidate salvageable property.

LHAAP was placed on the National Priority List (NPL) on August 30, 1990. After being listed on the NPL, LHAAP, U.S. Environmental Protection Agency (USEPA) and the Texas Water Commission (TWC), now called the Texas Natural Resource Conservation Commission (TNRCC), entered into a CERCLA Section 120 Agreement for remedial activities. The CERCLA Section 120 Agreement, referred to as the Federal Facility Agreement (FFA), became effective December 30, 1991. A Resource Conservation and Recovery Act (RCRA) Facility Assessment (RFA) identified 57 potential sites of concern. Since that time, scrubbing of the list has resulted in the current Defense Site Environmental Restoration Tracking System (DSERTS) list of 47 sites which includes Site 16.

Site 16

Site 16 was used from 1942 to 1944 for the disposal of TNT wastewater ash generated from the TNT Wastewater Treatment Plant (Site 32). In the mid- to late-1950s, three rocket motor casings were reportedly burned and possibly buried on the eastern side of the site. During this time, a large bermed depression, encompassing the central section of the site, was reportedly used for the disposal of a variety of materials such as substandard TNT, barrels of chemicals, oil, paint, scrap iron, and wood. This area was reportedly backfilled and covered, and operations continued moving eastward, raising the ground surface to its precapped elevation of approximately 15 ft above original grade. Burn pits and waste storage were common at the site during the history of its operation, but little is reported or known about the nature of the wastes dealt with by these

activities. The site continued to be used for a variety of waste disposal and treatment activities until the 1980s, when the disposal of inert solid wastes was moved to the Active Landfill (Site 12). Site 16 Interim Remedial Measures (IRM), including the construction of the landfill cap by OHM Corporation, commenced in 1996. Following the construction of the landfill cap, the site terminology was changed from the Site 16-Old Landfill to the Site 16-Landfill.

Jacobs completed a groundwater treatability study and design analysis for Site 16 in 1996 for USACE. The design analysis activities were conducted in response to data obtained during Phase II RI field activities that indicated contaminated groundwater was entering Harrison Bayou through a surface water seep. Two shallow depth extraction wells and 12 piezometers were installed as part of the groundwater treatability study in 1996. An additional 2 shallow depth and 4 intermediate depth extraction wells and 8 piezometers were installed in 1997.

The 4 shallow depth (approximately 35 ft bgs) extraction wells (16EW01, 16EW02, 16EW03, and 16EW04) were nested with 4 intermediate depth (approximately 55 ft bgs) extraction wells (16EW05, 16EW06, 16EW07 and 16EW08). The exact depth and location of the extraction wells were determined in the field based on lithology and field data.

1.2.3 Previous Investigation History

LHAAP

Site investigations to assess the environmental quality of LHAAP, concerning the past use, storage, treatment, and disposal of toxic and hazardous materials, began during the 1970's as part of the United States Army Installation Restoration Program (IRP). Early studies were conducted by the United States Army Environmental Hygiene Agency (USAEHA). The United States Army Toxic and Hazardous Materials Agency (USATHAMA) subsequently identified twenty-seven primary sites before 1980. USEPA Region 6 subsequently placed LHAAP on the NPL in August 1990. LHAAP representatives combined 22 of the 27 sites with ongoing restoration activities into five groups. Group 1 consists of four sites (XX, 01, 11, and 27), Group 2 consists of six sites (12, 17, 18, 24, 29, and 32), Group 3 consists of two sites (13 and 14), Group 4

consists of eight sites (35a, 35b, 35c, 46, 47, 48, 50, and 60), and Group 5 consists of two sites (52 and 63). Site 16 was originally part of the Group 2 sites but has been separated out to accelerate remedial activities. Primary site types identified included storage areas, landfills, open burning grounds, industrial areas, burial pits, underground storage tanks (UST), sumps, and wastewater treatment plants. Environmental investigations have been completed for the Group 1, 3, and 5 sites with the determination that no further action was required for the sites within these groups. Remedial Investigation/Feasibility Study (RI/FS) activities are ongoing for Site 16 and the Group 2 and Group 4 sites. The principle COCs initially identified at LHAAP by USAEHA were heavy metals, volatile organic compounds (VOCs), and high explosives (HE). Sample matrices included groundwater, surface water, sediments, and soils.

Site 16

The following section provides a brief summary of previous investigations before 1993 (Pre-Phase I) conducted at Site 16 from 1980 to 1987. Table 1-1 presents a chronological investigation summary of these field activities. A description of the investigative activities after 1993 (Phase I, II, and III) is provided in Section 2.0 of this report.

TABLE 1-1
SITE 16 PRE-PHASE I CHRONOLOGICAL INVESTIGATION SUMMARY

Pre-Phase I	
USAEHA, 1980	• 5 monitoring wells installed (BH-12, BH-13, BH-14, BH-15, and BH-16)
EPS, 1982	• Monitoring well 122 installed on eastern edge of former landfill • 5 groundwater samples (BH-12, BH-13, BH-14, BH-16, and 122) (BH-15 was not sampled) • Surface water (SW 017) and stream sediment sampling (SED 017) in Harrison Bayou • 10 soil samples at depths 0.0'-2.5' and 2.5'-5.0' (701-705)
EPS, 1987	• 4 groundwater samples (BH-12, BH-13, BH-16, and 122), (BH-14 and BH-15 were not sampled) • 10 soil samples at 0.0'-5' on downslope edge of landfill (SS1 - SS10)

- 20 deep soil samples in quadrants I, II, III and IV of the landfill
- 2 soil borings drilled and sampled on eastern toe of site (L1, M1)
- 1 soil sample at 0.0'-0.5' (BG)

The Pre-Phase I investigation sampling points and monitoring well locations are presented in Figure 1-3, Appendix I. Associated soil boring logs, well construction diagrams and well abandonment forms are presented in Appendix III. The analytical data summaries, which were presented in the associated report documents, have been provided to assist in the determination of site conditions that influenced subsequent investigations. Laboratory data for each of the Pre-Phase I investigations are presented in Appendix IV.

USAEHA, 1980 Investigation

Site 16 was originally investigated by USAEHA in 1980. Five monitoring wells (BH-12, BH-13, BH-14, BH-15, and BH-16) were installed during this investigation. Groundwater samples were collected from each of the five monitoring wells and submitted for laboratory analyses of anions, HE, metals, phenols, and physical/chemical characteristics. The USAEHA report did not contain the laboratory analytical methods used for analysis. Laboratory analysis detected elevated chlorides and total dissolved solids (TDS) values, which is indicative of leachate generation.

EPS, 1982 Investigation

In 1982, Environmental Protection Systems (EPS) investigated the site for USATAHMA and published a report documenting the investigation in June 1984. As part of this investigation, monitoring well 122 was placed at the eastern downgradient edge of Site 16.

Five groundwater samples were collected, one from monitoring well 122, and one each from the existing monitoring wells BH-12, BH-13, BH-14, and BH-16; monitoring well BH-15 was not sampled. Groundwater samples from monitoring wells 122, BH-13, BH-14, and BH-16 contained chloride concentrations more than 300,000 µg/l. Analysis of the groundwater sample collected from monitoring well BH-12 detected a concentration of chromium at 55.8 µg/l.

Groundwater samples from each of the five monitoring wells sampled at Site 16 contained manganese concentrations more than 50 µg/l. 1,3,5-Trinitrobenzene (TNB) was detected in the groundwater sample from monitoring well BH-12 at a concentration of 6.09 µg/l.

Ten shallow soil samples were collected at depth intervals of 0.0'-2.5' and 2.5'-5' from five shallow soil borings (701 through 705) within the landfill boundary. Analysis of soil samples from borings 701 and 703 (0.0'-2.5') detected barium concentrations of 557.3 mg/kg and 991.1 mg/kg, respectively. 2,4,6-TNT was detected in soil boring 704 (0.0'-2.5') at a concentration of 13.6 mg/kg.

EPS collected one surface water and one sediment sample (SW017 and SED 017) from Harrison Bayou, immediately east of Site 16. Analysis of sediment sample 017 detected 1,3-dinitrobenzene (DNB), 2,4,6-TNT, and 2,6-dinitrotoluene (DNT) at concentrations of 12.2 mg/kg, 3.9 mg/kg, and 15.0 mg/kg, respectively.

EPS, 1987 Investigation

In 1987, a site investigation was performed by EPS at Site 16 for the Thiokol Corporation. EPS's report was published in May 1988. Groundwater samples were collected from existing monitoring wells 122, BH-12, BH-13, and BH-16; monitoring wells BH-14 and BH-15 were not sampled. Analysis of the groundwater sample collected from monitoring well 122 detected 2,6-DNT at a concentration of 8.6 µg/l. 1,3,5-TNB was detected in monitoring well BH-12 at a concentration of 411 µg/l. Lead was detected in monitoring well BH-16 at a concentration of 66 µg/l. Manganese was detected in groundwater samples from monitoring wells BH-12, BH-13, and BH-16 at concentrations of 190 µg/l, 80 µg/l, and 110 µg/l, respectively. Chloride was detected in the groundwater sample from monitoring well BH-16 at a concentration of 1.18 µg/l.

A total of ten surface soil samples (SS1 - SS10) were collected at depth intervals of 0.0'-0.5' along the eastern toe of the landfill. Deeper soil samples were collected from a total of 20 soil borings within the limits of the landfill and were composited both vertically and horizontally in an effort to characterize potential contamination within the landfill shown in Figure 1-3,

Appendix I. The landfill was divided into quadrants and five soil borings were drilled in each quadrant to a depth approximating the bottom of the landfilled material. Soil borings in quadrants II and III on the western half of the landfill were drilled to a depth of 5.0 ft each, with samples composited vertically from 0.0'-0.5' and 0.5'-5' in each boring. Soil borings in quadrant I and IV on the eastern half of the landfill were drilled to a depth of 15 ft, with samples composited vertically from 0.0'-0.5', 0.5'-5', 5'-10', and 10'-15'. Vertically composited samples were then composited horizontally within a given quadrant to yield one sample for each depth interval sampled. Two additional 5-ft deep soil borings were drilled (L1 and M1) along the eastern toe of the landfill. Samples from these soil borings were vertically composited from 0.0'-0.5' and 0.5'-5'. One 15-ft deep soil sample was collected just north of monitoring well BH-16 to furnish background information. This soil sample was vertically composited from 0.0'-0.5', 0.5'-5', 5'-10', and 10'-15'.

Analysis detected 2,4-DNT in the soil samples collected from the 10'-15' interval of quadrants I and IV at concentrations of 73 µg/kg and 47 µg/kg, respectively. 2,6-DNT was detected in quadrant IV and in the 5'-10' interval at 173 µg/kg and in the 10'-15' interval at a concentration of 87 µg/kg. 2,6-DNT was detected in quadrant I in the 10'-15' interval at a concentration of 100 µg/kg. Analysis detected 1,3,5-TNB in soil samples SS4, SS5, SS9, SS10, and quadrant II (0.0'-0.5') at concentrations of 19 µg/kg, 153 µg/kg, 39 µg/kg, 13 µg/kg, and 67 µg/kg, respectively.

Analysis detected chromium in soil samples from quadrant IV (0.5'-5' and 5'-10') at a concentration of 104 mg/kg and 43.7 mg/kg, respectively. Lead was detected in soil samples from quadrant II (0.0'-0.5' and 0.5'-5'), quadrant III (0.5'-5'), and quadrant IV (0.5'-5', 5'-10', and 10'-15'), at concentrations of 110 mg/kg, 980 mg/kg, 200 mg/kg, 140 mg/kg, 2,000 mg/kg, 330 mg/kg, and 1,300 mg/kg, respectively.

1.3 Report Organization.

This RI report is divided into 7 Sections. Section 1.0 defines the purpose, background information, site history summary of previous investigation summary, and report organization.

Section 2.0 discusses the history of Site 16 field activities. Section 3.0 discusses the results of the field activities performed during the phased investigation activities. Section 4.0 discusses the nature and extent of contamination. Section 5.0 discusses contaminant fate and transport. Section 6.0 references a baseline risk assessment that will be presented under a separate cover. Section 7.0 presents the summary and conclusions for the RI.

2.0 FIELD ACTIVITIES

2.1 Investigation Summary

Field activities associated with the Remedial Investigation (RI) conducted at Site 16 since 1993 include contaminant source, geological, soil, vadose zone, groundwater, surface water, and sediment investigations. Table 2-1 presents a chronological summary of field activities that have been conducted at Site 16 since 1993. Field activities before 1993 are discussed in Section 1.

TABLE 2-1
SITE 16 CHRONOLOGICAL INVESTIGATION SUMMARY

Phase I	
Jacobs, 1993	• 11 monitoring wells installed along perimeter of landfill (16WW01 - 16WW11) • 12 groundwater samples (16WW01 - 16WW11 and 122) • 7 soil borings: 4 shallow, 3 deep (16SB01 - 16SB07) • 5 surface water (16SW01 - 16SW05) • 5 sediment samples (16SD01 - 16SD05) • Wells BH14-16 are abandoned as part of the landfill cap construction
USACE, 1995	• Surface water and sediment samples from Harrison Bayou
Phase II	
Jacobs, 1995	• 20 surface water samples (16SW01 - 16SW04 and 16SW06 - 16SW21) • 20 sediment samples (16SD01 - 16SD04 and 16SD06 - 16SD21) • 7 monitoring wells installed (16WW12 - 16WW18) • 3 deep soil borings (16SB08 - 16SB10) • Natural gamma ray and single point resistivity survey (16SB08 - 16SB10) • 7 monitoring wells installed (4 shallow, 3 deep) • 19 groundwater samples (16WW01 - 16WW11 and 122 (resampled), 16WW12 - 16WW18) • 7 slug tests at monitoring wells • 21 Geoprobe groundwater samples (16PB02, 16PB04 - 16PB11, 16PB13, 16PB14, 16PB16 - 16PB21, and 16PB25 - 16PB28)
Groundwater Treatability Study	
Jacobs, 1996	• 2 extraction wells (16EW01 and 16EW02) installed • 12 piezometers (16PZ01 - 16PZ12) installed • Aquifer performance tests • Groundwater collection/treatment system installation and start-up
ETTL Engineers & Consultants, Inc., 1996	• Abandoned wells 122, 16WW01 - 16WW04, and 16WW07 - 16WW11

TABLE 2-1 (Cont.)
SITE 16 CHRONOLOGICAL INVESTIGATION SUMMARY

Phase III	
Jacobs, 1997	• Surface resistivity survey along 11 survey lines (Pre-Phase 3 in SOW) • 8 additional piezometers (16PZ13 - 16PZ20) installed • 16 soil samples from 16WW27, 16WW31, 16WW35, and 16WW37 • 20 additional monitoring wells (16WW19 - 16WW38) installed • 6 additional extraction wells (16EW03 - 16EW08) installed • 37 groundwater samples; 20 newly installed, 17 existing wells • Additional sampling from 16WW16, 16EW01, and 16WW36 • 5 sediment and surface water samples (16SW31 - 16SW35 and 16SD31 - 16SD35)
Jacobs, 1998	• 2½ -Month Sampling Event for the treatability study at Site 16. Collected 20 groundwater samples from 12 monitoring wells and 8 extraction wells 16WW(12, 14, 16, 22, 25, 26, 29, 30, and 35-38) and 16EW01 - 16EW08 analyzed for VOCs and Explosives • 5-Month Sampling Event for the treatability study at Site 16. 20 groundwater samples same as above • Collected groundwater elevation data from monitoring wells, extraction wells, and piezometers for modeling efforts and RI/FS • Collect 60 geoprobe soil gas samples • Replaced floats/cam links and cleaned all 8 extraction well pneumatic pumps
Interim Remedial Action	
OHM, 1998	• Construction of landfill cap on Old Landfill

Phase I RI field activities were performed by Jacobs Engineering Group, Inc. (Jacobs), formerly Sverdrup Environmental, Inc. (SvE), from April 4, 1993 through June 15, 1993. Activities included drilling and sampling of soil borings; drilling and installation of monitoring wells; well abandonment; and collection of groundwater, surface water, and sediment samples.

Phase II RI field activities were performed by Jacobs from January 30, 1995 through June 25, 1995. Activities included drilling and sampling of soil borings; drilling and installation of monitoring wells; in-situ permeability testing; down-hole geophysical surveys; and collection of groundwater, surface water, and sediment samples. In 1995, the Tulsa District of the United States Army Corps of Engineers (USACE) collected surface water and sediment samples from Harrison Bayou.

On January 29, 1996 through March 19, 1996, Jacobs performed field activities as part of the treatability study. Activities included the drilling and installation of extraction wells; drilling and

installation of piezometers; in-situ permeability and pumping tests; collection of groundwater samples; and installation and startup of a groundwater extraction/containment system.

On July 19, 1996, E TTL Engineers and Consultants, Inc. abandoned monitoring wells 122, 16WW01 - 16WW04, and 16WW07 - 16WW11. These monitoring wells were abandoned to accommodate the construction of the landfill cap at Site 16.

Phase III RI field activities were performed by Jacobs from May 17, 1997 through October 29, 1997. Activities included the drilling and installation of monitoring well pilot borings; drilling and installation of monitoring and extraction wells; drilling and installation of piezometers; a surface resistivity geophysical survey; and collection of groundwater, surface water, and sediment samples.

On January 20, 1998 through June 15, 1998, Jacobs performed field activities as part of a treatability study (2½ and 5-month sampling event). Activities included the collection of groundwater and soil gas samples, and maintenance of the groundwater recovery system's pneumatic pumps. OHM Corporation completed construction of the landfill cap in 1998.

2.1.1 Contaminant Source Investigations

Contaminant source investigation activities were undertaken at Site 16 to obtain information to identify possible source locations, potential releases, and engineering characteristics to assist in the evaluation of remedial actions. In addition, waste characteristics such as the type and quantity of contaminants that may be contained in or released to the environment and the physical or chemical characteristics of hazardous wastes present were investigated.

During Phase I field activities four soil borings were completed specifically as part of a contaminant source investigation. Three soil borings (16SB04, 16SB05, and 16SB06) were drilled within the suspected limits of the landfill in an effort to profile the depth of landfilled materials. A fourth soil boring (16SB02) was located within the suspected limits of one of the

former burn pit locations. In addition, seven pilot soil borings for monitoring wells (16WW03, 16WW04, and 16WW07 - 16WW11) were drilled within the suspected limits of the landfill. Soil boring locations are presented in Figure 2-1, Appendix I.

The soil borings were completed with a Diedrich 50 track-mounted, remote control drill rig using 4¼-inch inside diameter (I.D.) hollow-stem augers. Samples were collected with a 3-inch outside diameter (O.D.) stainless steel continuous core-sampling device to a depth approximately 2 ft below where groundwater was initially encountered. Geotechnical samples were collected from several borings at 2.5-ft intervals. Geotechnical samples were submitted for physical testing of moisture content, Atterberg limits, and grain size analysis. Soil samples were collected for chemical analysis at 5-ft intervals and were submitted for laboratory analysis of volatile organic compounds (VOC), semi-volatile organic compounds (SVOC), high explosives (HE), metals, anions, and pH. A complete list of the analytical methods employed and the specific chemical constituents analyzed for is presented in the tables in Appendix V.

Additional fieldwork conducted in conjunction with the Phase III field activities included sampling 60 soil gas survey points located within the suspected limits of the landfill. The landfill was sectioned off using 50-ft grid spacing. A Geoprobe unit was used to penetrate the landfill cap, which was under construction during this investigation. A vacuum pump was used to extract soil gas into a sample bag for on-site chemical analysis for VOCs using a gas chromatograph (GC). A total of 34 samples (16SG01 - 16SG12, 16SG14 - 16SG17, 16SG19, 16SG21, 16SG22, 16SG24 - 16SG26, 16SG28 - 16SG30, 16SG32, 16SG33, 16SG35 - 16SG39, and 16SG42 - 16SG45) were collected, one from each grid square. Due to saturated soil conditions at the original proposed sample locations, five soil gas samples were unable to be collected. The sample locations for these five samples were moved to other points on the grid. An additional 26 samples (16SGA - 16SGR, 16SGT - 16SGZ, and 16SGAA) were collected from select locations along the grid lines to further define elevated concentrations of VOCs identified by the first 34 samples. The soil gas sample locations are presented in Figure 2-3, Appendix I.

2.1.2 Geological Investigations

Field activities conducted during the Phase I, II, and III RI included geologic data collection. Soil samples were collected and visually classified in the field by a geologist using the Unified Soil Classification System (USCS) for the description of soils for engineering purposes. The geologist's observations were recorded on the boring logs. Downhole geophysical logging was performed on deep stratigraphic soil borings. A surface resistivity survey was also conducted at Site 16.

Soil Borings

During Phase I field activities, three deep soil borings (16SB01, 16SB03 and 16SB07) were drilled to further define the geologic stratigraphy at Site 16. These borings were drilled outside of the landfill boundary to reduce the potential for cross contamination of water-bearing zones. Soil samples for visual classification and geologic logging were collected from each of these borings at 5-ft intervals using a split spoon sampler. A representative soil sample from each split spoon was then collected for geotechnical analyses. No soil samples were collected for chemical analysis from these deep soil borings. A summary of geotechnical laboratory results is presented in Appendix III. Soil boring locations are presented in Figure 2-1, Appendix I.

The borings were drilled using a CME 75 truck mounted drill rig using 4¼-inch I.D. hollow-stem augers and samples were collected with 2-inch O.D. standard steel split-spoon samplers. Boring 16SB01 was continuously sampled to a depth of 150 ft to provide visual classification of the materials encountered. At the completion of each boring, a natural gamma ray and neutron density log was obtained. The borings were backfilled with grout after geophysical logging was complete.

During Phase II field activities three deep soil borings (16SB08, 16SB09, and 16SB10) were advanced to depths of 330 ft below ground surface (BGS), 255 ft (BGS), and 310 ft (BGS), respectively. The deep borings were drilled to provide stratigraphic information of the deep subsurface geology at Site 16. As with the Phase I deep soil borings, soil samples for visual

classification and geologic logging were collected from each of these borings at 5-ft intervals using a split spoon sampler. A representative soil sample from each split spoon was then collected for geotechnical analyses. A total of 140 samples were submitted for geotechnical analyses that included visual classification, moisture content, Atterberg limits, and grain size analysis. No soil samples were collected for chemical analysis from these deep soil borings. Soil boring locations are presented in Figure 2-1, Appendix I. A summary of geotechnical analysis results is presented in Appendix III.

During Phase III field activities soil samples were collected from pilot borings drilled for the installation of monitoring wells (16WW19 - 16WW38 and 16EW03 - 16EW08). Soil samples for visual classification and geologic logging were collected from each of these borings at 5-ft intervals using a split spoon sampler. No soil samples were collected for geotechnical analysis from these pilot borings. Soil boring locations are presented in Figure 2-1, Appendix I. In addition, a surface geophysical electric resistivity imaging survey was conducted at Site 16. This survey was performed to obtain additional subsurface geologic information northeast of the old landfill. A total of 11 survey lines, oriented in a southeast/northwest direction, consisted of 56 nodes placed at intervals of 4-meters. The surface resistivity survey line locations are presented in Figure 2-2, Appendix I. The resistivity profiles are presented in Appendix II.

Geological Logs

The lithology encountered during drilling activities was recorded in detail, using the USACE drilling log form (USACE Eng. Form 1836). These logs provide a record of lithologic descriptions, samples collected, depth of borings, and drilling procedures used. When discreet samples were not taken, descriptions were determined from adjacent geological logs or from the characterization of drill cuttings. Boring logs from the Site 16 investigations are included in Appendix III.

Electronic Boring Logs

Downhole geophysical logging was performed during Phase II field activities to obtain additional information on lithology of the deep soil boring (16SB08, 16SB09, and 16SB10), and

to allow for further correlation of the subsurface stratigraphy. Geophysical logging runs (natural gamma ray, single point resistivity, and induced conductivity) were performed during the downward and upward advance of the logging tool in the borehole. The geophysical logging plots are presented in Appendix III.

Well Abandonment

In 1993, monitoring wells BH-12 through BH-16 were abandoned at Site 16. The existing reports do not specify what contractor or agency performed these well abandonment activities. In 1996, ETTL Engineers & Consultants, Inc. abandoned monitoring wells 122, 16WW01 - 16WW04, and 16WW07 - 16WW11. The monitoring wells abandoned in 1996 were performed as part of the construction of the landfill cap at Site 16. Monitoring well abandonment forms are presented in Appendix III.

2.1.3 Soil and Vadose Zone Investigations

The soil investigations conducted as part of the Phase I, II, and III RI were intended to locate and identify potential source areas of VOC contamination within the landfill. Soil samples from discrete depth intervals were collected for laboratory chemical analysis and/or field screened with a photo ionization detector (PID) or flame ionization detector (FID) to detect the presence of VOC vapors.

During Phase I field activities seven pilot borings were drilled for the installation of monitoring wells and four soil borings were drilled within or adjacent to the suspected limits of the landfill. Geotechnical samples were collected from several borings at 2.5-ft intervals. Geotechnical samples were submitted for physical testing of moisture content, Atterberg limits, and grain size analysis. Soil samples were collected for chemical analysis at 5-ft intervals and were submitted for laboratory analysis of VOCs, SVOCs, HE, metals, anions, and pH. A complete list of the analytical methods employed and the specific chemical constituents analyzed for is presented in the tables in Appendix V. Boring locations are presented in Figure 2-1, Appendix I.

During Phase II field activities seven pilot borings for the installation of monitoring wells (16WW12 - 16WW18) were drilled at Site 16. Soil samples were collected from each of the borings at 5-ft intervals and field screened using a PID or FID to quantify the presence of VOC vapors. Soil samples were submitted for geotechnical analysis that included visual classification, moisture content, Atterberg limits, and grain size analysis. No soil samples from these boring were submitted for laboratory chemical analysis. Boring locations are presented in Figure 2-1, Appendix I.

During Phase III field activities soil samples were collected from pilot borings drilled for the installation of monitoring wells 16WW19 - 16WW38 and extraction wells 16EW03 - 16EW08. Soil samples were collected from each of the borings at 5-ft or 2-ft intervals and field screened using a PID or FID to quantify the presence of VOC vapors. Four of the pilot borings drilled for the installation of monitoring wells (16WW19, 16WW31, 16WW35, and 16WW37) were selected to provide soil samples for chemical analysis. These pilot borings were selected to include one location in the center portion of the previously identified contaminated groundwater plume and the remainder to be representative of the surrounding area. A total of four depth discrete soil samples were collected from each of pilot boring locations at depth intervals of 0.0'-0.5', 1'-3', 5'-7', and 14'-15' if saturated soils were not encountered. A total of 13 soil samples were submitted for chemical analysis for VOCs, HE, metals, dioxins/furans, pesticides/polychlorinated biphenyls (PCB), and anions. A complete list of the analytical methods employed and the specific chemical constituents analyzed for is presented in the tables in Appendix V. No soil samples were collected for geotechnical analysis from these pilot borings. Boring locations are presented in Figure 2-1, Appendix I.

2.1.4 Groundwater Investigation

Groundwater investigation activities conducted before 1993 indicated that contamination was leaching from the landfill. Subsequent investigations conducted as part of the Phase I, II, and III RI have defined the horizontal and vertical extent of groundwater contamination. Groundwater

extraction wells installed during the treatability study are currently being used to intercept the contaminant plume upgradient of Harrison Bayou.

During Phase I field activities 11 monitoring wells (16WW01 - 16WW11) were installed at Site 16. Five monitoring wells (16WW01, 16WW03, 16WW05, 16WW07, and 16WW09) were completed in the shallow water-bearing zone at Site 16. The remaining six monitoring wells (16WW02, 16WW04, 16WW06, 16WW08, 16WW10, and 16WW11) were completed in the intermediate water-bearing zone. The locations of the monitoring wells are presented in Figure 2-1, Appendix I. A groundwater sample was collected from each of the newly installed monitoring wells and existing monitoring well 122. These samples were analyzed for VOCs, SVOCs, HE, metals, and anions. In addition, fifteen groundwater grab samples were collected from within the hollow stem augers during the drilling of soil borings 16SB01 - 16SB07. The groundwater grab samples were analyzed for total organic halides (TOX), total organic carbon (TOC), HE, nitrates, sulfates, chlorides, and total phenols. A complete list of the analytical methods employed and the specific chemical constituents analyzed for is presented in the tables in Appendix V.

During Phase II field activities, 21 groundwater samples (16PB02, 16PB04 - 16PB11, 16PB13, 16PB14, 16PB16 - 16PB21, and 16PB25 - 16PB28) were collected from direct push borings drilled with a Geoprobe unit at the locations shown in Figure 2-3, Appendix I. The groundwater samples were analyzed onsite by a mobile field laboratory using a GC for VOCs and high performance liquid chromatograph (HPLC) for HE. Each groundwater sample was also submitted to an offsite laboratory for metals analysis. Select groundwater samples were also submitted for laboratory analysis of VOCs, HE, and metals as part of the quality control (QC) protocol. The collection of groundwater samples continued laterally to evaluate the horizontal extent of contamination until low or non-detectable concentrations of VOCs and HE were identified. Data obtained from the groundwater sampling was used to evaluate the necessity, number, and location of future monitoring wells.

During Phase II field activities seven monitoring wells (16WW12 - 16WW18) were installed at Site 16. Four monitoring wells (16WW12 - 16WW14, and 16WW16) were completed in the shallow water-bearing zone at Site 16. The remaining three monitoring wells (16WW15, 16WW17, and 16WW18) were completed in the lower deep water-bearing zone. The locations of the monitoring wells are presented in Figure 2-1, Appendix I. A groundwater sample was collected from each of the newly installed monitoring wells and 12 existing monitoring wells. These samples were analyzed for VOCs, HE, and metals. A complete list of the analytical methods employed and the specific chemical constituents analyzed for is presented in the tables in Appendix V.

Data obtained during Phase I and Phase II indicated that groundwater contamination from Site 16 might potentially be affecting Harrison Bayou. To evaluate potential remedial measures for the control of contaminated groundwater, a treatability study was initiated in January 1996. The initial part of the treatability study consisted of the installation of two groundwater extraction wells (16EW01 and 16EW02) completed in the shallow water-bearing zone, and 12 piezometers (16PZ01 - 16PZ12) positioned in six nested pairs between and upgradient of the two extraction wells. These piezometers, completed in both the shallow and intermediate water-bearing zones, were used to measure changes in groundwater elevation and evaluate the extent of hydraulic control exerted over the groundwater system by the extraction wells. The locations of the extraction wells and piezometers are shown in Figure 2-1, Appendix I. Boring logs and well/piezometer construction diagrams are presented in Appendix III.

A series of step-drawdown, continuous-rate, and constant-drawdown pumping tests were conducted using the extraction wells and piezometers. These tests were conducted to determine representative values for the hydraulic characteristics of the shallow and intermediate depth water-bearing zones. During the course of the pumping tests, 18 groundwater samples were collected and analyzed for VOCs, SVOCs, HE, and metals. Following the completion of the pumping tests, the extraction wells continued operating so that the long-term effects and degree of hydraulic control exerted on the groundwater system could be evaluated. Data from the

pumping tests and analytical results were then presented in the Design Analysis Report, June 1996.

During treatability study field activities, it was noted that some of the groundwater samples exhibited a yellowish tint. USACE contracted with a research laboratory to determine the cause of the coloration. It was determined that the compound responsible for the coloration was tetrahydroxycyclopentadienone tricarbonyl iron oxide. USACE then conducted toxicity tests (bioassays) on groundwater containing this compound and determined it to be non-toxic to aquatic life. The exact concentrations of this particular compound present in the groundwater can not be quantified at this time because no standards exist.

During Phase III field activities, 20 additional monitoring wells (16WW19 - 16WW38) were installed at the locations shown in Figure 2-1, Appendix I. Nine of the monitoring wells were completed in the shallow water-bearing zone. Eight of the monitoring wells were completed in the intermediate water-bearing zone. Three of the monitoring wells were completed in the upper portion of the deep water-bearing zone. Sixteen of the monitoring wells were installed as nested well pairs consisting of a shallow and intermediate monitoring well. Boring logs and well construction diagrams are presented in Appendix III.

In addition, during the Phase III field investigation, six groundwater extraction wells (16EW03 - 16EW08) and eight piezometers (16PZ13 - 16PZ20) were installed at locations shown in Figure 2-1, Appendix I. Extraction wells 16EW03 and 16EW04 were completed in the shallow water-bearing zone. Extraction wells 16EW05 - 16EW08 were completed in the intermediate water bearing zone. The extraction wells were installed as nested well pairs consisting of a shallow and intermediate extraction well. Piezometers 16PZ13 - 16PZ20 were completed in both the shallow and intermediate water-bearing zones as four nested pairs positioned between and adjacent to the extraction wells. Boring logs and piezometer construction diagrams are presented in Appendix III.

Groundwater samples were collected from the 20 newly installed and 10 existing monitoring wells and from the six newly installed and two existing extraction wells. Monitoring well and extraction well locations are shown in Figure 2-1, Appendix I. Groundwater samples were analyzed for VOCs, HE, metals, and anions. Additionally, groundwater samples from monitoring wells 16WW16, 16EW01, and 16WW36 were analyzed for pesticides/PCBs, and dioxins/furans. A complete list of the analytical methods employed and the specific chemical constituents analyzed for is presented in the tables in Appendix V.

As part of the treatability study, groundwater samples were collected from select wells after 2½ and 5-month of continuous operation of the extraction system. Groundwater samples were collected from monitoring wells 16WW12, 16WW14, 16WW16, 16WW22, 16WW25, 16WW26, 16WW29, 16WW30, and 16WW35 - 16WW38; and extraction wells 16EW01 - 16EW08 and analyzed for VOCs and HE. A complete list of the analytical methods employed and the specific chemical constituents analyzed for is presented in the tables in Appendix V.

Monitoring Well Construction

Monitoring wells were installed as part of the Phase I, II, and III RI to evaluate groundwater conditions at Site 16. The Phase I monitoring wells were installed according to the Final Field Work Plan, March 1993. The Phase II monitoring wells were installed according to the Final Phase II Work Plan, Group 2 Sites, January 1995. The Phase III monitoring wells were installed according to the Final Work Plan, March 1998. Monitoring well locations are presented in Figure 2-1, Appendix I. Boring logs and monitoring well construction diagrams are presented in Appendix III.

Monitoring well development was performed as detailed in the work plans. All development work was conducted under the direction of a geologist or engineer, any field measured parameters and observations were recorded. Groundwater was disposed of in accordance with the Comprehensive Investigation Derived Waste Management Plan, June 1996.

Slug Tests

Rising head hydraulic conductivity tests (slug test) were performed on each of the monitoring wells installed during Phase I, II, and III RI field activities to better define the movement of groundwater within the screened interval of the monitoring wells. Time versus drawdown plots of the test data were used to determine the hydraulic conductivity of the screened water bearing zone of each well. Slug testing and hydraulic conductivity values are discussed in Section 3.0.

2.1.5 Surface Water and Sediment Investigations

The surface water and sediment investigations conducted as part of the Phase I, II, and III RI were performed to determine if contaminants of concern had migrated from drainage pathways at Site 16 towards Harrison Bayou. Additional surface water and sediment samples were also collected from Harrison Bayou, upgradient of Site 16, along the southern edge of the facility.

During Phase I field activities, five surface water samples (16SW01 - 16SW05) and five sediment samples (16SD01 - 16SD05) were collected at the locations shown in Figure 2-4, Appendix I. Four of the surface water and sediment samples targeted the drainage paths leading from the site to determine if contaminants of concern were migrating toward Harrison Bayou. A fifth location was chosen upgradient to define background concentrations of constituents of concern. Surface water and sediment samples were analyzed for VOCs, SVOCs, HE, metals, and anions. A complete listing of the analytical methods employed and the specific chemical constituents analyzed for is presented in the tables in Appendix V.

During Phase II field activities, twenty surface water samples (16SW01 - 16SW04 and 16SW06 - 16SW21) and 20 sediment samples (16SD01 - 16SD04 and 16SD06 - 16SD21) were collected at the locations shown in Figure 2-4, Appendix I. Fifteen of the samples were collected from drainage paths leading from the site to determine if contaminants of concern were migrating offsite in surface water runoff. The remaining five samples were collected from Harrison Bayou upgradient of the site. The surface water and sediment samples were analyzed for VOCs, HE,

and metals. A complete listing of the analytical methods employed and the specific chemical constituents analyzed for is presented in the tables in Appendix V.

During Phase III field activities, five surface water samples (16SW31 - 16SW35) and five sediment samples (16SD31 - 16SD35) were collected at the locations shown in Figure 2-3, Appendix I. These samples were collected to determine if contaminants of concern were moving offsite due to surface water runoff. The surface water and sediment samples were analyzed for VOCs, HE, metals, pesticides/PCBs, and dioxins/furans. A complete listing of the analytical methods employed and the specific chemical constituents analyzed for is presented in the tables in Appendix V.

2.1.6 Interim Remedial Action

After the Phase III investigation was completed at Site 16, OHM Corporation constructed a landfill cap on the landfill as part of an Interim Remedial Action (IRA). The new surface topography of the landfill is presented in Figure 2-5, Appendix I. The landfill cap is constructed of compacted clay and a flexible membrane covered by a vegetative layer.

3.0 SITE 16 - LANDFILL PHYSICAL CHARACTERISTICS

3.1 Surface Features

Site 16 is located in the south-central portion of the Longhorn Army Ammunition Plant (LHAAP), just north of Avenue Q. Harrison Bayou runs along the eastern edge of the site. The site encompasses approximately 20 acres and is presently comprised of the recently capped landfill and mixed pine-hardwood forests, which cover gently rolling to hilly terrain. Most of the terrain at Site 16 slopes 3 percent or less primarily to the east toward Harrison Bayou, but slopes as steep as 5 to 20 percent are common along sections of the floodplain. Ground surface elevations at Site 16 vary from approximately 170 ft to 200 ft above mean sea level (MSL) as referenced to the National Geodetic Vertical Datum, 1929 (NGVD29).

3.2 Meteorology

LHAAP is situated near the unincorporated community of Karnack, Texas that is located in the northeastern region of the state and is approximately 32 degrees north of the equator. This geographical location allows for mild winters and hot summers, with an average relative humidity of 55 percent. In winter, the average temperature is 46 degrees F and the average daily minimum temperature is 35 degrees. In summer, the average temperature is 81 degree and the average daily maximum temperature is 92 degrees. Precipitation is uniformly distributed throughout the year, reaching a slight peak in spring. The total average annual precipitation is 46.9 inches. Snowfalls are infrequent with an average seasonal snowfall of 1.5 inches, (Soil Survey of Harrison County, Texas, 1989).

3.3 Surface Water Hydrology

Surface drainage from Site 16 is predominantly through numerous small intermittent flowing streams and gullies located throughout the site. The primary surface drainage feature present at Site 16 is Harrison Bayou that forms the eastern boundary of the site and flows in a northeasterly direction eventually discharging into Caddo Lake. Harrison Bayou is a perennial stream with a

base flow that varies with the seasons. Harrison Bayou is prone to flooding during periods of significant rainfall. Other surface drainage pathways are man made features associated with the newly capped landfill. These drainage pathways direct surface water away from the landfill cap through a series of drainage swales. Surface drainage features are presented in Figure 2-5, Appendix I.

3.4 Geology

The subsurface geology at Site 16 consists primarily of a thin veneer of Quaternary alluvium mantling Tertiary age formations of the Wilcox and Midway groups. Underlying these are Cretaceous age formations of the Navarro and Taylor groups respectively. A generalized stratigraphic column of the formations present at Site 16 is presented in Figure 3-1.

The Wilcox formation, which constitutes the majority of the unconsolidated sediments underlying Site 16, consists of interbedded sands, silts, and clays. This Eocene series, an undifferentiated formation, was deposited in a regressive fluvial-deltaic and transgressive marine environments (Fisher, 1964) that leads to considerable heterogeneity across the site. From boring logs generated during monitoring well construction, the unconsolidated sediments of the Wilcox formation are interpreted as consisting of a series of three sandy water bearing zones separated by silty clayey semiconfining layers.

The uppermost portion of the Wilcox consists of medium plastic sandy silts and clays ranging in thickness from 5 ft to 15 ft. The first water-bearing zone, or shallow saturated sand zone, that ranges in thickness from 9 ft to 18 ft and underlies these surficial sediments. This shallow saturated sand zone consists of silty fine sand containing some silt and clay lenses, and is at first dry to moist then generally becomes saturated at depths of 15 ft to 20 ft below ground surface (BGS). A medium to highly plastic silty clay layer, 3 ft to 22 ft thick, underlies the shallow saturated sand zone. An intermediate saturated sand zone, consisting of a fine to medium silty sand, is then encountered below the semiconfining layer at depths of 30 ft to 50 ft BGS. The intermediate saturated sand zone generally contains fewer fines than the shallow saturated sand zone and exhibits a higher hydraulic conductivity.

Figure 1-X**Generalized Stratigraphic Column**

STRATIGRAPHIC UNITS			
SYSTEM	SERIES	GROUP	FORMATION
QUATERNARY	RECENT	ALLOVIUM	Topstratum
			Substratum
	PLEISTOCENE	TERRACE DEPOSITS	undifferentiated
TERTIARY	EOCENE	WILCOX	undifferentiated
	PALEOCENE	MIDWAY	undifferentiated
CRETACEOUS	GULFIAN	NAVARRO	Upper Navarro Clay
			Upper Navarro Maral
			Nacatoch Sand
			Lower Navarro Fm.
		TAYLOR	Upper Taylor Fm.
			Pecan Gap Chalk
			Wolfe City Sand
			Lower Taylor Fm.

Source: Regional Structural Cross Sections and General
Stratigraphy, East Texas Basin. Bureau of Economic Geology, 1981

Beneath the intermediate saturated sand zone is a silt to silty clay layer ranging in thickness from 5 ft to 30 ft. Underlying this silt to silty clay layer is a massive homogeneous silty, clayey, fine sand that extends from a depth of approximately 75 ft BGS to the top of the Midway formation.

The Midway formation that underlies the Wilcox formation is generally encountered at depths of 225 ft to 307 ft BGS at Site 16, and is a Tertiary, thick, calcareous to noncalcareous, clay containing some sand. The exact thickness of the Midway formation is difficult to determine because it can not be readily differentiated from the upper portion of the underlying Navarro Group (Upper Cretaceous). These formations tend to form the base of the overlying Eocene aquifer system effectively isolating it from the deeper flow systems (Fogg and Kretler, 1982).

3.5 Soils

Three types of surface soils have been identified at Site 16 as presented in the Soil Survey of Harrison County, Texas. The Scottsville Association present on the uplands, the Eastwood Association present along slopes between the uplands and floodplains, and the Socagee Association present in floodplains associated with large streams.

Soils corresponding to the Scottsville Association consist of a very fine sandy loam and form on the upland portions of Site 16. Scottsville soils are moderately well drained with a very low permeability. Scottsville soils have a very high available water capacity and a high shrink-swell potential in the subsurface.

Soils corresponding to the Eastwood Association consist of a very fine sandy loam and are formed predominantly on the slopes along the floodplain of Harrison Bayou. Eastwood soils are moderately well drained with a very low permeability and a moderate available water capacity. Eastwood soils exhibit a high shrink-swell potential in the subsurface.

Soils corresponding to the Socagee Association consist of a silty clay loam and are formed in the floodplain of Harrison Bayou that is prone to frequent flooding, occurring mostly from December through May. Socagee soils are poorly drained with a moderately low permeability and have a high available water capacity.

3.6 Hydrogeology

Groundwater and geologic data obtained during the remedial investigation (RI) field activities at Site 16 indicates varying degrees of heterogeneity within the subsurface hydrogeology. This is indicative of the fluvial-deltaic type depositional environment typical of Quaternary and Wilcox Group sediments that comprises the unconsolidated deposits underlying the site. The unconsolidated sediments of the Wilcox Group are comprised primarily of elongated, interconnected, channel-fill sand deposits within alluvial belts interbedded with less permeable interchannel sediments. These interbedded, less permeable deposits tend to form aquitards that limit the flow between the saturated zones. Based upon boring logs, Site Characterization and Analysis Penetrometer System (SCAPS) data, and surface resistivity geophysical surveys, the subsurface hydrogeology at Site 16 can generally be characterized as consisting of three water-bearing zones, a shallow saturated sand zone, an intermediate saturated sand zone, and deep saturated sand zone, separated by semiconfining clay layers. These water-bearing zones and semiconfining clay zones are depicted in the geologic cross sections presented in Figure 3-2, Appendix I.

The heterogeneity of the site and the degree of interconnection between the shallow and intermediate saturated sand zones were evident during the groundwater extraction treatability study that was conducted at Site 16. As part of this treatability study, a series of groundwater pumping tests were conducted using two of the extraction wells completed in the shallow saturated sand zone. Results of these tests produced diverse well yields, transmissivity values, and storativity values from each of the extraction wells although these wells were only separated by 100 ft. In addition, piezometers completed in the intermediate saturated sand zone showed signs of drawdown when the shallow saturated sand zone was pumped indicating that these two saturated sand zones are hydraulically interconnected. Complete results of the treatability study are presented in the Design Analysis Report, June 1996.

Rising head slug tests were conducted on all of the monitoring wells installed at Site 16 since 1993 as part of the RI. Hydraulic conductivity values were calculated using the Bouwer-Rice method. For the shallow saturated sand zone, hydraulic conductivity values ranged from a minimum value of $4.94\text{E-}05$ cm/sec at well 122, located at the southeast corner of the landfill, to

a maximum value of $1.15\text{E-}03$ cm/sec at monitoring well 16WW38 located just north of the landfill. The hydraulic conductivity geometric mean value for the shallow saturated sand zone is $8.7\text{E-}04$ cm/sec. For the intermediate saturated sand zone, hydraulic conductivity values ranged from a minimum value of $5.93\text{E-}04$ cm/sec at well 16WW33, located in the northern portion of the site, to a maximum value of $3.97\text{E-}02$ cm/sec at monitoring well 16WW29, located adjacent to Harrison Bayou. The hydraulic conductivity geometric mean value for the intermediate saturated sand zone is $1.5\text{E-}03$ cm/sec. For the upper portion of the deep saturated sand zone, hydraulic conductivity values ranged from a minimum value of $1.91\text{E-}05$ cm/sec at well 16WW19, located east of the landfill, to a maximum value of $1.47\text{E-}05$ cm/sec at well 16WW21, located in the northeast portion of the site. The hydraulic conductivity geometric mean value for the upper portion of the deep saturated sand zone is $1.7\text{E-}05$ cm/sec. For the lower portion of the deep saturated sand zone, hydraulic conductivity values ranged from a minimum value of $5.021\text{E-}04$ cm/sec at well 16WW15, located to the north of the landfill, to a maximum value of $3.39\text{E-}04$ cm/sec at well 16WW18, located to the east of the landfill. The hydraulic conductivity geometric mean value for the lower portion of the deep saturated sand zone is $4.2\text{E-}04$ cm/sec. A complete listing of all hydraulic conductivity values for each of the monitoring wells at Site 16 is presented in Table 3-1 along with the calculated geometric mean for each of the identified water-bearing zones. These hydraulic conductivity values are within the expected range of values for silts, sandy silts, and silty sands (Freeze and Cherry, 1979).

A series of static water level measurements were collected over time from the shallow, intermediate, and deep monitoring wells at Site 16 and are presented in Table 3-2. These values were used to construct piezometric surface maps for the shallow sand zone, intermediate sand zone, and upper and lower portions of the deep sand zone shown in Figures 3-3 through 3-10, Appendix I. A review of these piezometric surface maps indicates that the hydraulic gradients within the shallow, intermediate, and deep saturated sand zones vary in magnitude and direction laterally across the site due to changes in topography and the heterogeneity of the site geology. A comparison of the 1997 to 1998 figures illustrates how local hydraulic gradient variations are induced by the continued operation of the extraction wells installed as part of a treatability study.

TABLE 3-1
Hydraulic Conductivity Values for Monitoring Wells at Site 16

Well Identification No.	Total Depth of Well (ft)	Ground Surface Elevation (ft) MSL	TOT Elevation (ft) MSL	Hydraulic Conductivity (cm/sec)	Well Identification No.	Total Depth of Well (ft)	Ground Surface Elevation (ft) MSL	TOT Elevation (ft) MSL	Hydraulic Conductivity (cm/sec)
Shallow Zone					Intermediate Zone				
16-122	25.23	184.26	186.19	4.94E-05	16WW02	50.10	181.37	184.09	2.05E-04
16WW01	19.31	181.49	184.02	1.02E-03	16WW04	52.51	191.68	194.19	4.94E-04
16WW03	26.58	191.65	193.94	1.02E-05	16WW06	62.10	202.56	204.87	4.94E-04
16WW05	33.26	202.61	207.39	4.94E-04	16WW08	44.39	187.76	189.72	4.94E-03
16WW07	10.40	187.79	189.71	1.52E-03	16WW10	48.25	180.88	183.24	4.94E-04
16WW09	22.25	200.17	203.94	1.52E-03	16WW11	60.85	184.59	186.71	4.94E-04
16WW12	26.76	185.98	188.62	6.19E-03	16WW23	34.00	177.77	177.77	4.65E-03
16WW13	22.63	175.59	178.32	4.94E-03	16WW25	49.00	188.49	188.49	4.94E-04
16WW14	29.98	195.02	198.65	4.08E-03	16WW27	36.00	177.09	177.09	2.82E-03
16WW16	31.31	193.04	195.66	3.73E-03	16WW29	42.00	179.94	179.94	4.94E-04
16WW22	31.00	199.81	199.81	1.34E-03	16WW31	49.00	202.44	202.44	4.58E-03
16WW24	16.00	177.72	177.72	3.76E-03	16WW33	49.00	202.64	202.64	3.93E-04
16WW26	17.50	188.48	188.48	2.12E-04	16WW35	43.50	190.53	190.53	1.47E-03
16WW28	21.00	176.67	176.67	2.40E-04	16WW37	45.50	201.72	201.72	3.55E-04
16WW30	30.00	178.12	178.12	1.20E-02	Geometric Mean				1.5E-03
16WW32	32.00	202.53	202.53	7.85E-04	Lower Deep Zone				
16WW34	32.00	202.60	202.60	1.00E-04	16WW15	307.00	19.00	198.71	5.02E-04
16WW36	21.50	190.35	190.35	2.30E-02	16WW17	225.00	195.04	197.81	1.24E-03
16WW38	29.00	201.69	201.69	1.15E-03	16WW18	283.00	180.73	185.23	3.39E-04
Geometric Mean				8.7E-04	Geometric Mean				4.2E-04
Upper Deep Zone									
16WW19	95.00	181.87	181.87	1.91E-05					
16WW20	110.00	198.93	198.93	1.58E-05					
16WW21	100.00	194.52	197.74	1.47E-05					
Geometric Mean				1.7E-05					

Table 3-2
Site 16 Static Groundwater Levels

Well Identification No.	Groundwater Elevation 10/20/97 (ft) MSL	Groundwater Elevation 10/28/98 (ft) MSL	Groundwater Elevation 12/06/98 (ft) MSL	Well Identification No.	Groundwater Elevation 10/20/97 (ft) MSL	Groundwater Elevation 10/28/98 (ft) MSL	Groundwater Elevation 12/06/98 (ft) MSL
Shallow Zone				Intermediate Zone			
16-122	---	---	---	16EW05	---	173.70	---
16EW01	---	172.07	---	16EW06	---	174.06	---
16EW02	---	171.91	---	16EW07	---	173.56	---
16EW03	---	173.54	---	16EW08	---	172.64	---
16EW04	---	172.62	---	16PZ01	174.19	174.12	174.36
16PZ02	174.04	174.08	174.35	16PZ03	174.15	174.02	174.18
16PZ04	174.11	174.08	174.25	16PZ05	173.98	174.11	174.40
16PZ06	174.09	174.02	174.30	16PZ07	174.21	174.12	174.48
16PZ08	175.60	174.04	174.32	16PZ09	173.35	173.71	174.29
16PZ10	173.89	173.82	174.19	16PZ11	174.34	174.20	174.49
16PZ12	174.34	174.22	174.48	16PZ13	174.12	173.97	174.38
16PZ14	173.94	173.93	174.12	16PZ15	174.15	174.01	174.31
16PZ16	173.91	173.74	174.22	16PZ17	172.51	172.97	174.37
16PZ18	173.91	173.04	174.06	16PZ19	174.60	173.35	174.12
16PZ20	173.65	172.74	174.16	16WW02 ¹	---	---	---
16WW01 ¹	---	---	---	16WW04 ¹	---	---	---
16WW03 ¹	---	---	---	16WW06	179.28	178.85	179.27
16WW05	180.10	179.33	179.74	16WW08	---	---	---
16WW07 ¹	---	---	---	16WW10 ¹	---	---	---
16WW09 ¹	---	---	---	16WW11 ¹	---	---	---
16WW12	173.20	173.47	174.07	16WW23	171.76	173.80	174.51
16WW13	171.61	173.63	174.82	16WW25	172.24	173.87	174.63
16WW14	176.31	175.88	176.23	16WW27	170.80	172.95	173.69
16WW16	176.81	176.35	176.71	16WW29	174.52	173.42	174.12
16WW22	173.94	173.89	174.31	16WW31	174.60	174.31	174.74
16WW24	169.22	173.76	174.27	16WW33	175.06	174.96	175.33
16WW26	173.44	173.55	174.26	16WW35	174.93	174.81	175.03
16WW28	168.32	172.24	176.35	16WW37	177.15	176.58	176.74
16WW30	171.57	173.22	174.02	Upper Deep Zone			
16WW32	174.53	174.35	174.78	16WW19	174.48	175.12	175.72
16WW34	175.05	174.67	175.05	16WW20	177.27	176.07	176.55
16WW36	176.08	175.85	175.00	16WW21	175.16	174.93	175.54
16WW38	177.16	176.66	177.00	Lower Deep Zone			
				16WW15	176.89	176.46	177.51
				16WW17	175.98	175.50	175.86
				16WW18	176.79	---	177.28

The piezometric surfaces depicted from data obtained on October 28, 1998 show an average hydraulic gradient in the shallow saturated sand zone of approximately 0.0104 ft/ft in a northeasterly direction. The intermediate saturated sand zone has an average hydraulic gradient of approximately 0.0059 ft/ft in a northeasterly direction. The upper portion of the deep saturated sand zone has an average hydraulic gradient of approximately 0.0044 ft/ft in an easterly direction. The lower portion of the deep saturated sand zone has an average hydraulic gradient of approximately 0.0027 ft/ft in an easterly direction.

Based upon the average hydraulic conductivity values obtained from the slug test data and the hydraulic gradients derived from the piezometric surface maps, average groundwater velocities can be calculated using the relationship $v = Ki/n$. Where n is the effective porosity of the saturated materials and is estimated at a value of 25%, K is the hydraulic conductivity of the material and i is the hydraulic gradient. The average groundwater flow velocity calculated for the shallow saturated sand zone is approximately 36.7 ft/yr and the average groundwater flow velocity calculated for the intermediate saturated sand zone is approximately 36.5 ft/yr. In the upper portion of the deep saturated sand zone the average groundwater flow velocity calculated is approximately 0.31 ft/yr and the average groundwater flow velocity calculated for the lower portion of the deep saturated sand zone is approximately 4.8 ft/yr.

3.7 Demography and Land Use

LHAAP, which encompasses Site 16, is located near the unincorporated community of Karnack, Texas. LHAAP has a land use classification of industrial. Karnack is a rural community with a population of 775 people with the main occupation of the populace being farming. The incorporated community of Uncertain, Texas, population 205 people, is located to the northeast of LHAAP on the edge of Caddo Lake. Uncertain serves as a resort area and an access point to Caddo Lake. The industries in the surrounding area consist of agriculture, timber, oil and natural gas production, and recreation.

There are four public water supply wells located near LHAAP. Only two of the four public water supply wells are in use. One well is located in and owned by Caddo Lake State Park. It is completed to a depth of 315 ft and has been in use since 1935. The other active public supply

well is owned by the Karnack Water Supply Corporation and services the town of Karnack. It is located approximately 1/2 mile southeast of the town. The well is completed to a depth of 430 ft and the pump is set at a depth of 200 ft. It has been in use since 1942. The two other public supply wells, are used by the Karnack School and the George Washington Carver School as standby wells only. The Karnack School well is completed to a depth of 265 ft and the George Washington Carver School well is completed to a depth of 105 ft. All other wells in the area surrounding LHAAP are used for livestock and domestic purposes. These wells are typically completed to a depth of 250 ft. There is one water supply well currently in use at LHAAP. This well is located at the Fire Station/Security Office and supplies water to this building. At one time, two additional water supply wells were located within the Administration Area of the installation. Both were probably constructed in 1942. One supplied potable water to the Administration Area and the other was used as a standby well. Both were abandoned and probably plugged in the 1950s. Construction and plugging data are not available and an exact location of the wells is unknown.

3.8 Ecology

LHAAP and Site 16 are part of the Cypress Bayou Basin occurring in the Pineywoods ecological region of Texas (CLI, 1995). The Pineywoods is a deep inland extension of the Gulf Coastal Plain that extends into Texas, Louisiana, Arkansas, and Oklahoma. The area is characterized by mixed pine-hardwood forests that cover gently rolling to hilly terrain (USDA, 1994). This topography and mild climate support an abundant and diverse plant community, and provides a great diversity of habitats at LHAAP, including mesic slopes, mesic creek bottoms, bottomland flats, wetlands, forests, and grasslands. This diversity of vegetation and habitats suggests that there is the potential for a large variety of animal species to inhabit LHAAP (CLI, 1995, USACE, 1992).

LHAAP is forested predominate with loblolly and short-leaf pines, as well as sweet gum, black tupelo, ash, bald cypress, a variety of oaks, and a few scattered willows. Most of the forested land at LHAAP is managed to improve the timber harvest of pine. In many areas of the installation oaks and other trees were removed to encourage further pine growth (USACE, 1992) Harrison Bayou enters LHAAP on the southern edge of the installation and crosses the eastern

boundary of Site 16. Harrison Bayou carries 30% of the surface drainage of LHAAP and transverses LHAAP in a northeasterly direction. Harrison Bayou is an important part of the Caddo Lake watershed, supporting one of the last remaining old-growth bottomland hardwood forests in the southeastern United States. Harrison Bayou, as well as the lower reach of the Saunders Branch drainage, contain stands of hardwoods dating back to the 1830's (CLI, 1995).

Caddo Lake is a eutrophic, natural water body located to the northeast of Site 16. The surface area of the lake covers approximately 51 square miles and has a mean depth of 6 ft. The lake's watershed encompasses approximately 2,700 square miles. The lake is divided by the Texas-Louisiana state line, and lies within the boundaries of Marion and Harrison Counties, Texas, and Caddo Parish, Louisiana. Caddo Lake is a center for recreational activities and serves as a public water supply source for Blanchard, Louisiana and a secondary water supply source for Shreveport, Louisiana. Over-water oil production also occurs in the lake.

Common mammals found at LHAAP and Site 16 include white-tailed deer, red and gray foxes, eastern cottontail and swamp rabbits, fox and gray squirrels, opossum, skunk, armadillo, raccoon, and beaver (USACE, 1992). These species and others that potentially inhabit the area are based on mammal distribution records for Texas (Davis, 1974), and mammals known to inhabit the Cypress Bayou Basin (Campo, 1986). Based on these sources, as many as 51 mammalian species could inhabit LHAAP. In addition to mammals, a total of 334 bird species have been documented as inhabiting Caddo Lake's drainage system and potentially inhabiting LHAAP at sometime throughout the year. A reported 53 different reptile species inhabit the Cypress Bayou Basin (CLI, 1995). A complete listing of the mammal, bird, and reptile species potentially inhabiting LHAAP and Site 16 is presented in Appendix C of the Group 2 Baseline Risk Assessment Work Plan (Weston, 1998).

Twenty-two federal and/or state endangered or threatened species potentially inhabit LHAAP and Site 16. Table 3-3 presents a listing of these species. Five of these species are listed on both the federal and state lists. Nine of these species have been observed at LHAAP (CLI, 1995).

TABLE 3-3
FEDERAL AND STATE LISTING OF
ENDANGERED AND THREATENED SPECIES AT LHAAP

	POTENTIAL PRESENCE AT LHAAP
FEDERAL ENDANGERED SPECIES	
Red-cooked Wood Pecker (<i>Picoides borealis</i>)	Confirmed
Wood Stork (<i>Myrceria americana</i>)	Confirmed
FEDERAL THREATENED SPECIES	
American Alligator (<i>Alligator mississippiensis</i>)	Confirmed
Piping Plover (<i>Charadrius melodus</i>)	Possible
Artic Peregrine Falcon (<i>Falco pergrinus tundrius</i>)	Possible
Bald Eagle (<i>Haliaeetus leucocephalus</i>)	Confirmed
STATE ENDANGERED SPECIES	
Paddlefish (<i>Polydon spathula</i>)	Possible
Louisiana Pine Snake (<i>Pituophis melanoeucus ruthveni</i>)	Confirmed
Bald Eagle (<i>Haliaeetus leucocephalus</i>)	Confirmed
Red-cooked Wood Pecker (<i>Picoides borealis</i>)	Confirmed
Louisiana Black Bear (<i>Ursus americanus luteolus</i>)	Possible
STATE THREATENED SPECIES	
Blackside Darter (<i>Percina maculata</i>)	Possible
Bluehead Shiner (<i>Notropis hubbsi</i>)	Possible
Creek Chubsucker (<i>Erimyzon oblongus</i>)	Possible
Blue Sucker (<i>Cycleptus elongatus</i>)	Possible
Texas Horned Lizard (<i>Phrynosoma cornutum</i>)	Possible
Alligator Snapping Turtle (<i>Macrolemys temminckii</i>)	Confirmed
Canebrake Rattlesnake (<i>Crotalus horridus atricaudatus</i>)	Confirmed
Nothern Scarlet Snake (<i>Cemnomphora coccinea copei</i>)	Possible
White-faced Ibis (<i>Plegadis chihi</i>)	Possible
Wood Stork (<i>Myrceria americana</i>)	Confirmed
Piping Plover (<i>Charadrius melodus</i>)	Possible
Artic Peregrine Falcon (<i>Falco pergrinus tundrius</i>)	Possible
Bachman's Sparrow (<i>Aimophila aestivalis</i>)	Confirmed
Eastern Big-eared Bat (<i>Plecotus rafinesquei</i>)	Possible
River Otter (<i>Lutra canadensis</i>)	Confirmed

4.0 NATURE AND EXTENT OF CONTAMINATION

4.1 Introduction

Analytical results from historic investigations performed at Site 16 identified the following contaminants: volatile organic compounds (VOC), semi-volatile organic compounds (SVOC), pesticides/polychlorinated biphenyls (PCB), high explosives (HE), anions, and metals. Site investigations to delineate the extent of these compounds included the Phase I, II, and III Remedial Investigation (RI) and the Groundwater Treatability Study. A complete summary of the detected compounds and associated concentrations for soil, sediment, surface water, and groundwater samples is provided in the following section. The media tested and analyses performed during each investigation are summarized in Table 4-1. A complete list of analytical methods employed and specific chemical constituents analyzed for is presented in Appendix V along with tables of detected compounds by media.

Table 4-1
Analytical Test Summary

Investigation/ Medium	Analytical Tests						
	VOCs	SVOCs	Pesticides/ PCBs	Explosives	Dioxins/ Furans	Metals	Anions
Phase I							
Surface water	X	X		X		X	X
Sediments	X	X		X		X	X
Soils	X	X		X		X	X
Groundwater	X	X		X		X	X
Phase II							
Surface water	X			X		X	
Sediments	X			X		X	
Groundwater	X			X		X	
Treatability Study							
Groundwater	X	X		X		X	
Phase III							
Surface water	X		X	X	X	X	X
Sediments	X		X	X	X	X	
Soils	X		X	X	X	X	
Groundwater	X		X	X	X*	X	X

*-Only groundwater samples 16WW16, 16WW36, and Extraction Well 16EW01 were submitted for Dioxin/Furans analysis.

Criteria used to evaluate the analytical data obtained from groundwater, sediments, and soil samples collected during the site investigations are based on the Texas Natural Resource Conservation Commission (TNRCC) Risk Reduction Standard No. 2 and are referred to as Medium Specific Concentrations (MSC). MSCs address individual contaminants in a specific medium and consider one or more exposure pathway, such as, water ingestion (water MSC) and soil ingestion by inhalation of vapors and particulates (soil MSC). The analytical data from surface water samples obtained during the RI field activities were evaluated against the Texas Water Quality Standards (TWQS) Aquatic Life Criteria. MSC and TWQS comparison values are presented in Table 4-2.

MSC and TWQS values are not available for all the chemical constituents detected in media sampled at Site 16. Comparing the detected concentration to the soil MSC for industrial use, based on groundwater protection (SAI-Ind.), was the primary evaluation method for soils. When MSC values were not available for soils, the United States Environmental Protection Agency (USEPA) Region 6 Human Health Medium-Specific Screening Levels for industrial soil were used. The evaluation method for groundwater was performed by first comparing detected concentrations to the groundwater MSC values for industrial use (GW-Ind.). When MSC values were not available for groundwater, USEPA Region 6 Human Health Medium-Specific Screening Levels for tap water were used.

Background values used for comparison of metals data were obtained from the "Soils Background Concentration Report" prepared by the Tulsa District of United States Army Corps of Engineers (USACE) in May 1995 for the Longhorn Army Ammunition Plant (LHAAP). When background values were not available for soils, inorganic background values from the USEPA Region 6 Human Health Medium-Specific Screening Levels (September 2000) were used.

During Phase III field activities surface water, sediment, soil, and select groundwater samples were collected and analyzed for dioxin/furan compounds. Dioxin/furan compounds were detected in each medium at varying concentrations.

Table 4-2
TNRCC Soil and Groundwater MSCs

Compound	TNRCC MEDIUM-SPECIFIC CONCENTRATIONS (MSCs)		TNRCC MEDIUM-SPECIFIC CONCENTRATIONS (MSCs)			LHAAP SOIL BACKGROUND LEVELS		LHAAP GROUND-WATER LEVELS
	GW-Ind	SAI-Ind	Compound	GW-Ind	SAI-Ind	SURFACE SOILS (mg/kg)	SUBSURFACE SOILS (mg/kg)	
DIOXINS	(pg/l)	(pg/g)	ANIONS	(mg/l)	(mg/kg)			(mg/l)
55722-27-5	---	---	Chloride	---	---	N.A.	N.A.	1416
1,2,3,4,6,7,8-HpCDF	45 ^{1,2}	3000 ^{2,3}	Nitrate	10	3000000	N.A.	N.A.	6.18 ⁵
1,2,3,4,6,7,8-HpCDD	---	---	Nitrite	1	190000	N.A.	N.A.	6.18 ⁵
1,2,3,4,7,8-HxCDF	45 ^{1,2}	3000 ^{2,3}	Sulfate	---	---	N.A.	N.A.	3475
1,2,3,4,7,8-HxCDD	4.5 ^{1,2}	300 ^{2,3}						
1,2,3,6,7,8-HxCDF	4.5 ^{1,2}	300 ^{2,3}	METALS	(mg/l)	(mg/kg)			
1,2,3,6,7,8-HxCDD	4.5 ^{1,2}	300 ^{2,3}	Aluminum	100	1000000	20700	23900	13.4
1,2,3,7,8-HxCDF	4.5 ^{1,2}	300 ^{2,3}	Antimony	0.006	490	I.D.	I.D.	N.D.
1,2,3,7,8-HxCDD	4.5 ^{1,2}	300 ^{2,3}	Arsenic	0.05	20	29.7	36.8	0.022
1,2,3,7,8-PeCDF	9.0 ^{1,2}	600 ^{2,3}	Barium	2	59000	287	138	1.99
1,2,3,7,8-PeCDD	0.9 ^{1,2}	60 ^{2,3}	Beryllium	0.004	270	2.0 ⁶	2.0 ⁶	N.A.
2,3,4,6,7,8-HxCDF	4.5 ^{1,2}	300 ^{2,3}	Cadmium	0.005	410	1.0 ⁶	1.0 ⁶	0.055
2,3,4,7,8-Pentachlorodibenzofuran	0.9 ^{1,2}	60 ^{2,3}	Calcium	---	---	1090	2740	320
2,3,7,8-Tetrachlorodibenzofuran	4.5 ^{1,2}	300 ^{2,3}	Chromium	0.1	1600	22.8	26.2	0.11
Dioxin	0.5	30.000	Cobalt	6.1	110000	19.1	12.5	0.053
HPCDF	---	---	Copper	1.3	74000	6.7	10.7	0.043
Heptachlorodibenzo-p-dioxins	11 ^{1,2}	480 ^{2,3}	Iron	11 ¹	100000 ³	31000	42300	68
HxCDF	---	---	Lead	0.015	1000	17.4	13	0.3
Hexachlorodibenzo-p-dioxin	11 ^{1,2}	480 ^{2,3}	Magnesium	---	---	474	2240	277
OCDF	450 ^{1,2}	30000 ^{2,3}	Manganese	14	81000	2330	376	11.8
OCDD	450 ^{1,2}	30000 ^{2,3}	Mercury	0.002	9.6	0.1 ⁶	0.1 ⁶	0.001
PECDF	---	---	Nickel	0.1	12000	6.3	19.1	0.06
PECDD	---	---	Potassium	---	---	481	887	5.5
Tetrachlorodibenzo-p-dioxin	0.45	30	Selenium	0.05	9300	0.2 ⁶	0.2 ⁶	0.14
			Silver	0.51	2900	2.3	1.6	0.03
			Sodium	---	---	N.A.	N.A.	1470
SVOCs	(ug/l)	(ug/kg)	Strontium	22 ¹	100000 ³	13.3	39.1	6.15
Bis(2-ethylhexyl)phthalate	6	65000	Thallium	0.002	150	14.1	10.6	N.D.
Butyl benzyl phthalate	20000	200000000	Vanadium	0.72	3000	66 ⁶	2.0 ⁶	N.A.
Di-n-butylphthalate	10000	100000000	Zinc	31	410000	8.4	84.5	0.23
Flouranthene	4100	36000000						
			EXPLOSIVES	(ug/l)	(mg/kg)			
VOCs	(ug/l)	(ug/kg)	2,4-Dinitrotoluene	0.42	4.2			
1,1,2-Trichloroethane	5	17000	2,6-Dinitrotoluene	0.42	4.2			
1,1-Dichloroethane	10000	200000000	4-Amino-2,6-dinitrotoluene	---	---			
1,1-Dichloroethene	70	20000000	HMX	1800 ¹	53000 ³			
1,2-Dichloroethane	5	470	1,3-Dinitrobenzene	10	100			
1,2-Dichloroethene (total)	70 ⁴	20000000 ⁴	3-Nitrotoluene	1000	10000			
Acetone	10000	79000000	Nitrobenzene	51	510			
Benzene	5	1500	RDX	6.1 ¹	270 ³			
1,2,4-Trimethylbenzene	---	---	1,3,5-Trinitrobenzene	3100	31000			
1,3,5-Trimethylbenzene	---	---	Tetryl	---	---			
Bromodichloromethane	100	92000	2,4,6-Trinitrotoluene	51	510			
Chloroform	100	510						
cis-1,2-Dichloroethylene	70	20000000	PCBs and CHLORINATED					
trans-1,2-Dichloroethene	100	40000000	PESTICIDES	(ug/l)	(ug/kg)			
Ethylbenzene	700	6900000	Aldrin	0.017	140			
2-Butanone (Methyl Ethyl Ketone)	8200	160000000	Aroclor 1260	---	---			
Methylene chloride	5	16000						
Naphthalene	4100	920000						
Styrene	100	23000000						
Tetrachloroethene	5	17000						
Toluene	1000	2400000						
Trichloroethene	5	6600						
Trichlorofluoromethane	31000	61000000						
Vinyl chloride	2	7						
Xylene (total)	10000	3600000						

- Values represented are EPA Region 6 Human Health Medium-Specific Screening Levels for Tap Water, no MSC's for this constituent were available from TNRCC.
- Dioxin/Furan MSC's for Industrial soil and groundwater were calculated using the US EPA Toxicity Equivalency Factors.
- Values represented are EPA Region 6 Human Health Medium-Specific Screening Levels for Industrial Soil, no MSC's for this constituent were available from TNRCC.
- No values for total 1,2 Dichloroethene were available, isomers with the lowest value, cis-1,2 Dichloroethene, values are presented here.
- Nitrate background values as reported by USACE include Nitrite.
- Values represented are EPA Region 6 Background Concentration.
- Indicates no MSC's from TNRCC and no EPA Region 6 Human Health Medium-Specific Screening Levels were available for this constituent.
- I.D. Indicates USACE reported insufficient data to perform background concentration calculations.
- N.A. Indicates USACE reported constituent was not analyzed.

Dioxin/furan compounds do not have associated MSC values for soil or groundwater. Consequently, concentrations used to evaluate dioxin/furan compounds were calculated using USEPA Toxicity Equivalency Factors.

The following subsections present a summary of the compounds identified and range of detected concentrations for each medium sampled at Site 16. Included are comparisons of the analytical results and the identification of compounds that exceeded MSC values. Summaries are presented for the source area, vadose zone, soil, sediment, surface water, and groundwater media.

4.2 Source Area Sample Results

Investigation derived data from the source area, the landfill, were collected during Phase I and III field activities. During Phase I field activities, soil samples were collected from four soil borings (16SB02, 16SB04, 16SB05, and 16SB06), located within the limits of the landfill, at depth intervals ranging from the surface to approximately 20 ft below ground surface (bgs). Additionally, a soil gas survey was conducted during Phase III field activities by collecting subsurface vapors at various depth intervals (maximum depth of 15 ft) beneath the landfill. The following subsections present a summary of the investigative results for the source area.

4.2.1 Vadose Zone Sample Results

Investigation of the vadose zone consisted of a soil gas survey conducted to provide information on materials beneath the surface of the landfill in an attempt to identify "hot spots". Sixty soil gas samples were collected using a Geoprobe unit and analyzed for VOCs using an onsite laboratory. A grid was established on the eastern half of the landfill (Figure 2-3, Appendix I) using existing survey stakes. Some of the sample locations were moved due to saturated soil conditions. The soil gas samples depth intervals and analytical results are presented in Table 4-3. An isoconcentration map of total VOCs concentrations detected in the soil gas samples is presented in Figure 4-1, (Appendix I).

Table 4-3 Site 16 - Soil Gas Survey Summary

Compound ug/L	Location 16SG																
	1 10-15 ft	2 10-15 ft	3 10-15 ft	4 10-15 ft	7 10-15 ft	8 10-15 ft	9 8-15 ft	10 10-15 ft	11 8-15 ft	12 10-12 ft	14 10-15 ft	15 6-12 ft	16 10-15 ft	17 10-15 ft	19 10-15 ft	21 10-15 ft	22 10-15 ft
Benzene																	
Bromomethane																	
Chloroform										7.81	1.16 J		3.48 J				5.46
1,1-Dichloroethene		5.7															71.1
c-1,2-Dichloroethene		5.91	4.88 J					1.12 J									
t-1,2-Dichloroethene																	
Methylene Chloride																	
Naphthalene																	
Tetrachloroethene																	
Trichloroethene	6.34	376 E	52.1	3.81 J	1.17 J	4 J	1.64 J	1.26 J	4 J	37.4	17.9	6.17	26.4 B	11.8 B	1.9 JB	66	
Trichlorofluoromethane																	
Toluene																	1.85 J
1,2,3-Trichlorobenzene																	
1,2,4-Trichlorobenzene																	
1,1,1-Trichloroethane																	
Vinyl Chloride																	800 E
Total VOC's	6	388	57	4	2	4	3	1	4	45	19	6	9.94 40	13	0	2	944

Compound ug/L	Location 16SG																
	24 10-15 ft	25 8-15 ft	26 10-15 ft	28 8-15 ft	29 6-12 ft	30 3.5-4 ft	32 5-15 ft	33 8-12 ft	35 5-10 ft	36 3-10 ft	37 3-10 ft	38 6-10 ft	39 3-10 ft	42 3-8 ft	43 3-8 ft	44 3-8 ft	45 3-8 ft
Benzene						2.39 J											
Bromomethane																	
Chloroform			6.98					6.54						6.12	6.96	6.32	5.81
1,1-Dichloroethene		16.2					1.47 J					2.54 J					
c-1,2-Dichloroethene																	
t-1,2-Dichloroethene																	
Methylene Chloride																	
Naphthalene												1.19 JB					
Tetrachloroethene					2.29 J												
Trichloroethene	1.19 JB	12.1 B 14.7					4.41 J		3.16 JB	3.82 JB		1.87 JB		7.72	1.75 J	8.87	8.87
Trichlorofluoromethane																	
Toluene																	
1,2,3-Trichlorobenzene												2.05 JB					
1,2,4-Trichlorobenzene												1.73 J					
1,1,1-Trichloroethane											14.2 B						
Vinyl Chloride		22.7			12.9	242 E				242 E		121	15.2		1.18 J		
Total VOC's	1	66	7	0	15	244	6	7	3	246	14	130	15	14	10	15	15

J- The data indicates the presence of the analyte below the quantitation limit.

E- Concentrations exceed the calibration range of the instrument; analyte values should be considered estimated.

B- The analyte was detected in the associated blank as well as in the sample.

Total VOC values are rounded to the nearest whole number.

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[illegible]

Compound ug/L	Location 16SG										Summary						
	R	T	U	V	W	X	Y	Z	AA	Minimum Depth(ft)	Maximum Sample	Depth(ft)	Conc.	Number of Detections			
	10-15 ft	5-15 ft	8-12 ft	5-10 ft	5-10 ft	5-10 ft	10-15 ft	10-15 ft	5-10 ft								
Benzene				6.96							16SG30	3.5-4	2.39J	16SGV	5-10	6.96	2
Bromomethane											16SG17	10-15	1.04J	16SG7	10-15	1.15	2
Chloroform	5.73	5.09	5.31	5.36	7.02		5.3	5.79			16SGL	10-15	1.35J	16SG12	10-12	7.81	18
1,1-Dichloroethene											16SGW	5-10	1.02J	16SGV	5-10	1.140E	8
c-1,2-Dichloroethene	10.8	10.1		16000	E 55.9			294	E		16SGH	10-15	1.01J	16SGV	5-10	16000E	19
t-1,2-Dichloroethene				820	E						16SGV	5-10	820E	16SGV	5-10	820E	1
Methylene Chloride				475	E			171			16SGL	10-15	25.8	16SGV	5-10	475E	4
Naphthalene											16SG38	6-10	1.19JB	16SG38	6-10	1.19JB	1
Tetrachloroethene				7.24							16SGV	5-10	7.24	16SGV	5-10	7.24	1
Trichloroethene	26.6	5.84	18.2	34000	E 191	13.3	4.6	J 1770	E 6.5		16SG7	10-15	1.17J	16SGV	5-10	34000E	50
Trichlorofluoromethane											16SG25	8-15	15	16SG25	8-15	15	1
Toluene				9.86							16SG22	10-15	1.9J	16SGV	5-10	9.86	2
1,2,3-Trichlorobenzene											16SG38	6-10	2.05JB	16SG38	6-10	2.05JB	1
1,2,4-Trichlorobenzene											16SG38	6-10	1.73J	16SG38	6-10	1.73J	1
1,1,1-Trichloroethane				4.11	J						16SGV	5-10	4.11J	16SG37	3-10	14.2B	3
Vinyl Chloride	29.8		50.5	17700	E 93			104			16SG43	3-8	1.18J	16SGV	5-10	17700E	17
Total VOC's	73	21	74	70169	348	13	10	2442	7		16SG19,28,A,D,J	0		16SGV	5-10	70169	55/60

J- The data indicates the presence of the analyte below the quantitation limit.

E- Concentrations exceed the calibration range of the instrument: analyte values should be considered estimated.

Total VOC values are rounded to the nearest whole number.

LHAAP Site 16 Landfill

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Sixteen different VOCs were detected in the soil gas samples as indicated in Table 4-3. The highest total VOCs concentration of 70,169 $\mu\text{g/l}$ was detected in soil gas sample 16SGV that is situated in the central portion of the landfill. Due to the high concentrations detected, 6 of the compounds were reported with estimated values since the concentration exceeded the calibration range of the gas chromatograph. The next 2 highest total VOCs concentrations were detected in soil gas samples 16SGN and 16SGZ at 3,266 $\mu\text{g/l}$ and 2,442 $\mu\text{g/l}$, respectively. The location soil gas sample 16SGZ was collected from is approximately 150 ft northeast of location 16SGV. The location soil gas sample 16SGN was collected from is in the northeast portion of the landfill approximately 50 ft south from the edge of the landfill limits.

Nine additional soil gas samples had total VOC concentrations greater than 100 $\mu\text{g/l}$, ranging from 130 $\mu\text{g/l}$ and 944 $\mu\text{g/l}$. Forty-three soil gas samples had total VOC concentrations less than 100 $\mu\text{g/l}$. Five soil gas samples had no detectable VOCs. The 4 most frequently detected VOCs were trichloroethene, cis-1,2-dichloroethene, chloroform, and vinyl chloride. A summary of the minimum and maximum concentration detected for each VOC along with the detection frequency is provided in Table 4-3.

4.2.2 Soil Sample Results

Soil samples for chemical analysis were collected within the suspected source area during Phase I field activities. Four soil borings (16SB02, 16SB04, 16SB05, and 16SB06) were located within the limits of the landfill in an attempt to profile the depth of buried materials and to collect soil samples from the suspected source area. Table 4-1 lists the analyses performed on soil samples and the soil borings locations are presented in Figure 2-1. A summary of the minimum and maximum concentrations of compounds detected in the soil samples is presented in Table 4-4. A summary of detected compounds is presented in Appendix V.

Five VOCs were detected in soil samples collected during Phase I field activities with two compounds trichloroethene, and vinyl chloride detected at concentrations in excess of MSC values. A listing of each soil sample that exceeded the MSC values are presented in Table 4-5.

Table 4-4
Source Area Soil Sample Summary Phase I and Phase III

Volatile Compounds Detected at Site 16 (ug/kg)	MSC	Minimum Detected Concentration			Maximum Detected Concentration			Frequency of detections
		Minimum conc.	Date Sampled	Location (depth)	Max. Conc.	Date Sampled	Location (depth)	
Acetone	79000000	19	4/16/93	16SB04(15-17)	90	4/16/93	16SB04(0-4)	5
Methylene Chloride	16000	8	4/17/93	16SB(20-22)QC	1400	4/17/93	16SB02(15-16)	2
Trichloroethene	6600	7	4/17/93	16SB02(0-2)	10000	4/17/93	16SB02(16-17)	10
cis-1,2-Dichloroethene	20000000	6.5	4/17/93	16SB02(5-7)	16000	4/16/93	16SB04(0-4)	8
Vinyl Chloride	7	15	4/16/93	16SB04(15-17)	70	4/16/93	16SB04(0-4)	2

Semivolatile Compounds Detected at Site 16 (ug/kg)	MSC	Minimum conc.	Date Sampled	Location (depth)	Max. Conc.	Date Sampled	Location (depth)	Frequency of detections
Bis(2-ethylhexyl)phthalate	65000	930	4/16/93	16SB05(0-2)QC	930	4/16/93	16SB05(0-2)QC	1
Di-n-butylphthalate	100000000	790	4/16/93	16SB05(0-2)QC	3100	4/16/93	16SB04(20-22)	6
Fluoranthene	36000000	460	4/16/93	16SB04(15-16)	460	4/16/93	16SB04(15-16)	1

Metals Detected at Site 16 (mg/kg)	MSC	Minimum conc.	Date Sampled	Location (depth)	Max. Conc.	Date Sampled	Location (depth)	Frequency of detections
Arsenic	20	1.31J	4/16/93	16SB05(8.5-10)	6.74	4/15/93	16SB06(5-7)	11
Barium	59000	49.5	4/16/93	16SB05(8.5-10)	935	4/16/93	16SB04(0-4)	19
Chromium	1600	6.6	4/17/93	16SB02(20-22)	27.4	4/15/93	16SB06(10-11)	19
Lead	1000	4.26	4/16/93	16SB05(8.5-10)	36.4J	4/15/93	16SB06(0-2)	19
Nickel	12000	3.86	4/16/93	16SB05(0-2)	17.2	4/15/93	16SB06(14-15)	19
Silver	2900	1.36	4/16/93	16SB04(10-12)	2.36	4/16/93	16SB04(0-4)	2

Anions Detected at Site 16 (mg/kg)	MSC	Minimum conc.	Date Sampled	Location (depth)	Max. Conc.	Date Sampled	Location (depth)	Frequency of detections
Chloride		2.8	4/15/93	16SB06(5-7)	156	4/17/93	16SB02(20-22)QC	18
Nitrate	3000000	0.14	4/16/93	16SB05(15-16)	4.4	4/16/93	16SB05(0-2)QC	4
Sulfate		1.3	4/17/93	16SB02(10-12)	4460	4/16/93	16SB04(15-17)	18

MSC- Medium Specific Concentrations (Bold Values exceed the MSC for that compound).

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

Table 4-5
Breakdown of Soil Samples in Source Area which Exceed MSCs

VOC compound	MSC (ug/kg)	Sampling Location	Concentration (ug/kg)
Trichloroethene	6600	16SB02 (16-17)	10,000
Vinyl Chloride	7	16SB04(0-4)	70
		16SB02(20-22)QC	32
		16SB04 (15-17)	15

Three SVOCs were detected in soil samples collected from within the limits of the landfill: bis(2-ethylhexyl)phthalate, di-n-butylphthalate, and flouranthene. None of the detected SVOCs concentrations exceeded MSC values.

Soil samples collected within the landfill limits were analyzed for anions, chloride, nitrate and sulfate and were detected in the concentration ranges presented in Table 4-4.

Six metals, arsenic, barium, chromium, lead, nickel and silver, were detected in soil samples collected from within the limits of the landfill at concentrations below MSC values. Three surface soil samples and 1 subsurface soil sample had detected metal concentrations above the LHAAP soil background concentration levels as presented in Table 4-6

Table 4-6

Source Area Soil Samples which Exceed LHAAP Soil Background Metals Concentrations

Barium			
Surface 287 mg/kg		Subsurface 138 mg/kg	
Location (Depth)	Concentration	Location (Depth)	Concentration
16SB04 (0-0.5)	935	No Samples Exceed	
Chromium			
Surface 22.8 mg/kg		Subsurface 26.2 mg/kg	
Location (Depth)	Concentration	Location (Depth)	Concentration
16SB04 (0-0.5)	24.3	16SB06(10-15)	27.4
Lead			
Surface 17.4 mg/kg		Subsurface 13 mg/kg	
Location (Depth)	Concentration	Location (Depth)	Concentration
16SB04 (0-0.5)	23	No Samples Exceed	
16SB05 (0-0.5)	31.8		
16SB06 (0-0.5)	36.4		
Nickel			
Surface 6.3 mg/kg		Subsurface 19.1 mg/kg	
Location (Depth)	Concentration	Location (Depth)	Concentration
16SB06 (0-0.5)	7.57	No Samples Exceed	

4.3 Soil Sample Results (Outside Landfill)

During the Phase I and III field activities soil samples were collected outside the suspected limits of the landfill. These soil samples were collected primarily during the installation of monitoring wells 16WW01 - 16WW11, 16WW27, 16WW31, 16WW35, and 16WW37.

A summary of the minimum and maximum concentration of compounds detected is presented in Table 4-7, and a complete listing of compounds detected is presented in Appendix V.

Five VOCs, acetone, methylene chloride, styrene, toluene and trichloroethene were detected in the soil samples at concentrations below MSC values. Two SVOCs were detected in the soil samples, butyl benzyl phthalate and di-n-butylphthalate at concentrations below MSC values. Soil samples were also analyzed for chloride, nitrate, and sulfate anions. Nitrate was detected in the soil samples at concentrations below the MSC value. No MSC values are available for chloride and sulfate. Metal concentrations detected in the soil samples were at concentrations below applicable MSC values.

The 12 metals detected in soil samples collected outside the landfill limits exceed the LHAAP soil background concentration levels for surface and subsurface soils are presented in Table 4-8. The 12 metals are barium, calcium, chromium, cobalt, lead, magnesium, manganese, nickel, potassium, silver, strontium, and zinc. In the subsurface soil samples barium and nickel background concentrations were exceeded the most (15 and 16 times respectively) and in the surface soil samples magnesium, nickel, and zinc background concentrations were exceeded the most (3, 3, and 4 times respectively). The mercury concentration detected in one of the subsurface soil samples exceeds the EPA Region 6 background concentration of 0.1 mg/kg.

Seventeen dioxin/furan compounds were detected in one or more of the soils samples. There are no available TWQS values for dioxin/furan compounds. The US EPA Toxicity Equivalency Factor values for dioxin/furan compounds were not exceeded in the soil samples submitted for analysis.

Table 4-7
Non-Source Area Soil Sample Summary Phase I and Phase III

Volatile Compounds Detected at Site 16 (ug/kg)	MSC	Minimum Detected Concentration			Maximum Detected Concentration			Frequency of detections
		Minimum conc.	Date Sampled	Location (depth)	Max. Conc.	Date Sampled	Location (depth)	
Acetone	79000000	13	6/25/97	16WW35(1-3)	67	5/14/93	16WW10(4.5-6.5)	9
Methylene Chloride	16000	5	5/29/97	16WW31(0-0.5)	15	5/29/97	16WW31(5-7)	5
Styrene	23000000	2	6/25/97	16WW35(1-3)	2	6/25/97	16WW35(1-3)	1
Toluene	2400000	2	5/29/97	16WW31(14-15)	6	5/5/93	16WW09A(5-7)	2
Trichloroethene	6600	9.8	5/4/93	16WW01(10-12)	1500J	5/12/93	16WW04(10-12)	7

Semivolatile Compounds Detected at Site 16 (ug/kg)	MSC	Minimum conc.	Date Sampled	Location (depth)	Max. Conc.	Date Sampled	Location (depth)	Frequency of detections
Butyl benzyl phthalate	200000000	960	5/12/93	16WW04(0-2)	960	5/12/93	16WW04(0-2)	1
Di-n-butylphthalate	100000000	520	5/5/93	16WW09A(5-7)	3200B	5/13/93	16WW11(4.5-6)	5

Anions Detected at Site 16 (mg/kg)	MSC	Minimum conc.	Date Sampled	Location (depth)	Max. Conc.	Date Sampled	Location (depth)	Frequency of detections
Chloride		2.82	5/5/93	16WW09A(5-7)QC	442	5/12/93	16WW04(10-12)QC	22
Nitrate	3000000	0.16	5/4/93 5/14/93	16WW01(0-2)QC 16WW10(0-2)QC	4.57	5/17/97	16WW27(0-0.5)	9
Sulfate		3.35	5/4/93	16WW05(10-12)	138	5/11/93	16WW07(0-2)	37

Metals Detected at Site 16 (mg/kg)	MSC	Minimum conc.	Date Sampled	Location (depth)	Max. Conc.	Date Sampled	Location (depth)	Frequency of detections
Aluminum	1000000	4330	5/29/97	16WW31(14-15)	21500	5/31/97	16WW37(1-3)	14
Antimony	490	0.48	5/29/97	16WW31(1-3)	0.48	5/29/97	16WW31(1-3)	1
Arsenic	20	1.4	5/29/97	16WW31(14-15)	14.4J	5/4/93	16WW05(0-2)	47
Barium	59000	28.8	5/4/93	16WW03(5-7)	463	5/5/93	16WW06(5-7)	46
Beryllium	270	0.31	5/31/97	16WW37(5-7)	1.4	5/29/97	16WW31(0-0.5)	14
Cadmium	410	0.51	5/17/97	16WW27(0-0.5)	0.86	5/31/97	16WW37(1-3)	4
Calcium	-----	118	5/17/97	16WW27(1-3)	15100	5/31/97	16WW37(0-0.5)	14
Chromium	1600	5.9	5/31/97	16WW37(5-7)	36.7	5/4/93	16WW05(0-2)	47
Cobalt	110000	2	5/29/97	16WW31(14-15)	19.8	5/31/97	16WW37(0-0.5)	14
Copper	74000	1.4	5/29/97	16WW31(0-0.5)	8.8	6/25/97	16WW35(5-7)	14
Iron	100000 ³	6430	5/29/97	16WW31(14-15)	29900	6/25/97	16WW35(5-7)	14
Lead	1000	3.02J	5/12/93	16WW02(0-2)	213J	5/11/93	16WW07(5-7)	47
Magnesium	-----	179	5/29/97	16WW31(0-0.5)	2280	6/25/97	16WW35(5-7)	14
Manganese	81000	19	5/29/97	16WW31(5-7)	1270	5/17/97	16WW27(0-0.5)	14
Mercury	9.6	0.02	6/25/97	16WW35(0-0.5)	0.56	5/14/93	16WW08(3-5)	7
Nickel	12000	3.94	5/5/93	16WW09A(5-7)QC	47.2	5/4/93	16WW05(5-7)	46
Potassium	-----	481	5/17/97	16WW27(1-3)	1560	5/31/97	16WW37(1-3)	12
Selenium	9300	0.61	5/29/97	16WW31(1-3)	1.4	6/25/97	16WW35(0-0.5)QC	5
Silver	2900	0.55	5/31/97	16WW37(0-0.5)	4.88	5/11/93	16WW07(5-7)	3
Sodium	-----	21.1	5/29/97	16WW31(0-0.5)	458	6/25/97	16WW35(5-7)	14
Strontium	100000 ³	2.4	5/29/97	16WW31(0-0.5)	62.7	5/31/97	16WW37(0-0.5)	14
Thallium	150	0.18	5/31/97	16WW37(1-3)	5.96	5/12/93	16WW02(0-2)	13
Vanadium	3000	8.5	5/29/97	16WW31(5-7)	43.3	5/31/97	16WW37(1-3)	14
Zinc	410000	11.9	5/29/97	16WW31(1-3)	45.3	6/25/97	16WW35(5-7)	14

3. Values represented are EPA Region 6 Human Health Medium-Specific Screening Levels for Industrial Soil, no MSC's for this constituent were available from TNRCC.

J- The analyte was not positively identified; the associated value is the approximate concentration of the analyte in the sample

B- The analyte was detected in an associated blank (Organics only).

Table 4-7 (Continued)
Non-Source Area Soil Sample Summary Phase I and Phase III

Dioxins/Furans Detected at Site 16 (mg/kg)	TRRP Tier I Soil PCLs	Minimum Detected Concentration			Maximum Detected Concentration			Frequency of detections
		Minimum conc.	Date Sampled	Location (depth)	Max. Conc.	Date Sampled	Location (depth)	
Total TCDF	300	.91J	5/17/97	16WW27(0-0.5)	.91J	5/17/97	16WW27(0-0.5)	1
1,2,3,4,6,7,8-HpCDF	3,000	3.4J	5/31/97	16WW37(0-0.5)	9	5/17/97	16WW27(0-0.5)	2
1,2,3,4,6,7,8-HpCDD	—	4.8J	5/29/97	16WW31(0-0.5)	110	5/17/97	16WW27(1-3)	13
1,2,3,4,7,8,9-HpCDF	3,000	1.3J	5/17/97	16WW27(0-0.5)	1.3J	5/17/97	16WW27(0-0.5)	1
1,2,3,4,7,8-HxCDF	300	2.5J	5/17/97	16WW27(0-0.5)	2.5J	5/17/97	16WW27(0-0.5)	1
1,2,3,4,7,8-HxCDD	300	0.43J	6/1/97	16WW37(14-15)	1J	5/17/97	16WW27(0-0.5)	3
1,2,3,6,7,8-HxCDF	300	.39J	5/31/97	16WW37(0-0.5)	0.73J	5/17/97	16WW27(0-0.5)	2
1,2,3,6,7,8-HxCDD	300	.46J	5/29/97	16WW31(5-7)	2.3J	5/17/97	16WW27(0-0.5)	6
1,2,3,7,8,9-HxCDD	300	.54J	5/29/97	16WW31(1-3)	2.5J	5/29/97	16WW31(0-0.5)	8
2,3,4,6,7,8-HxCDF	300	.21J	5/31/97	16WW37(1-3)	.59J	5/17/97	16WW27(0-0.5)	3
HPCDF	—	1.6J	5/17/97	16WW27(1-3)	29	5/17/97	16WW27(0-0.5)	3
Heptachlorodibenzo-p-dioxin	480	12	5/29/97	16WW31(0-0.5)	210	5/17/97	16WW27(1-3)	13
HXCDF	—	.21J	5/31/97	16WW37(1-3)	21J	5/17/97	16WW27(0-0.5)	3
Hexachlorodibenzo-p-dioxin	480	3J	6/25/97	16WW35(1-3)	26J	5/17/97	16WW27(0-0.5)	10
OCDF	30,000	.6J	5/29/97	16WW31(14-15)	7.8J	5/17/97	16WW27(0-0.5)	6
OCDD	30,000	200	5/29/97	16WW31(0-0.5)	15000J	5/17/97	16WW27(1-3)	13
PECDF	—	0.81	5/31/97	16WW37(0-0.5)	2.2J	5/17/97	16WW27(0-0.5)	2

J- The analyte was not positively identified; the associated value is the approximate concentration of the analyte in the sample

Table 4-8
Soil Samples Collected Outside of the Landfill Limits which
Exceed Soil Background Metals Concentrations

Barium			
Surface 287 mg/kg		Subsurface 138 mg/kg	
Location (Depth)	Concentration	Location (Depth)	Concentration
No Samples Exceed		16WW06(5-7)	463
		16WW03(15-17)	438
		16WW06(20-22)	353
		16WW05(5-7)	301
		16WW05(20-22)	268
		16WW37(1-3)	208
		16WW06(10-12)	205
		16WW05(15-17)	172
		16WW05(10-12)	166
		16WW31(5-7)	165
		16WW37(1-3)	147
		16WW09A(5-7)	147
		16WW09A(0-2)	147
		16WW05(0-2)	146
		16WW05(25-27)	139
Calcium			
Surface 1090 mg/kg		Subsurface 2740 mg/kg	
Location (Depth)	Concentration	Location (Depth)	Concentration
16WW37(0-0.5)	15100	16WW37(1-3)	3090
16WW27(0-0.5)	1540		
Chromium			
Surface 22.8 mg/kg		Subsurface 26.2 mg/kg	
Location (Depth)	Concentration	Location (Depth)	Concentration
16WW31(0-0.5)	31.5J	16WW05(0-2)	36.7
		16WW03(0-2)	32.9
		16WW06(0-2)	23.7
Cobalt			
Surface 19.1 mg/kg		Subsurface 12.5 mg/kg	
Location (Depth)	Concentration	Location (Depth)	Concentration
16WW37(0-0.5)	19.8	16WW37(1-3)	12.6
16WW31(0-0.5)	13.3		
Lead			
Surface 17.4 mg/kg		Subsurface 13 mg/kg	
Location (Depth)	Concentration	Location (Depth)	Concentration
16WW37(0-0.5)	21.8	16WW07(5-7)	213J
		16WW06(5-7)	22.3
		16WW09A(5-7)	18.9
		16WW06(15-17)	15.4
		16WW05(20-22)	13.7
		16WW37(1-3)	13.1
Magnesium			
Surface 474 mg/kg		Subsurface 2240 mg/kg	
Location (Depth)	Concentration	Location (Depth)	Concentration
16WW27(0-0.5)	1030	16WW35(5-7)	2280
16WW35(0-0.5)	1020		
16WW37(0-0.5)	688		

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

Table 4-8 (continued)
Soil Samples Collected Outside of the Landfill Limits which
Exceed Soil Background Metals Concentrations

Manganese			
Surface 2330 mg/kg		Subsurface 376 mg/kg	
Location (Depth)	Concentration	Location (Depth)	Concentration
No Samples Exceed		16WW37(1-3)	472
Mercury			
Surface 0.1* mg/kg		Subsurface 0.1* mg/kg	
Location (Depth)	Concentration	Location (Depth)	Concentration
No Samples Exceed		16WW08(3-5)	0.56
Nickel			
Surface 6.3 mg/kg		Subsurface 19.1 mg/kg	
Location (Depth)	Concentration	Location (Depth)	Concentration
16WW35(0-0.5)	10.4	16WW05(5-7)	47.2
16WW27(0-0.5)	9	16WW06(5-7)	44.6
16WW37(0-0.5)	8.2	16WW06(20-22)	26.4
		16WW06(10-12)	25.4
		16WW05(20-22)	23.7
		16WW05(15-17)	23.5
		16WW03(10-12)	20.5
		16WW05(0-2)	16.5
		16WW03(0-2)	13.7
		16WW08(0-1)	12.4
		16WW06(0-2)	11.1
		16WW04(0-2)	9.96
		16WW09A(0-2)	8.88
		16WW07(0-2)	8.53
		16WW11(0-2)	6.8
Potassium			
Surface 481 mg/kg		Subsurface 887 mg/kg	
Location (Depth)	Concentration	Location (Depth)	Concentration
16WW35(0-0.5)	1070	16WW37(1-3)	1560
16WW37(0-0.5)	846	16WW35(5-7)	1100
16WW27(0-0.5)	570		
Silver			
Surface 2.3 mg/kg		Subsurface 1.6 mg/kg	
Location (Depth)	Concentration	Location (Depth)	Concentration
No Samples		16WW07(5-7)	4.88
		16WW09A(5-7)	4.38
Strontium			
Surface 13.3 mg/kg		Subsurface 39.1 mg/kg	
Location (Depth)	Concentration	Location (Depth)	Concentration
16WW37(0-0.5)	62.7	No Samples	
16WW27(0-0.5)	34.1		
Zinc			
Surface 8.4 mg/kg		Subsurface 84.5 mg/kg	
Location (Depth)	Concentration	Location (Depth)	Concentration
16WW37(0-0.5)	38.9	No Samples	
16WW27(0-0.5)	27.3		
16WW35(0-0.5)	22.2		
16WW31(0-0.5)	13.3		

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

* Values represented are EPA Region 6 Background Concentration

4.4 Sediment Sample Results

Sediment samples were collected during Phase I, II, and III field activities at Site 16. A summary of the minimum and maximum concentrations of compounds detected in the sediment samples is presented in Table 4-9 and Table 4-10 provides the maximum concentration detected for each sediment sample.

During Phase I and III field activities, 3 VOCs, acetone, styrene and trichloroethene, were detected in the sediment samples at concentrations below MSC values. One PCB isomer, Aroclor 1260, was detected in sample 16SD32 at a concentration of 81 µg/kg. No MSC value is available for Aroclor 1260.

Twenty metals were detected in the sediment samples with concentrations below respective MSC levels. Sediment sample results for metals were also compared to values from five southern boundary sediment samples (16SD17 – 16SD21) which were collected during Phase II along the southern boundary of LHAAP near Plant Road (see Figure 2-4, Appendix I. A summary of the sediment samples and the 8 metals that exceed the sediment background concentration levels are presented in Table 4-11. The eight metals that exceeded background concentrations are arsenic, arium, chromium, copper, lead, nickel, selenium, and zinc.

Twenty-five dioxin/furan compounds were detected in five sediment samples submitted for analysis. There are no available TWQS values for dioxin/furan compounds. The US EPA Toxicity Equivalency Factor values for eight of the dioxin/furan compounds were exceeded in one or more of the sediment samples. Table 4-11 provides a summary of the samples and concentrations which exceed the objectives.

Table 4-9
Sediment Sample Summary Phase I, Phase II and Phase III

Volatile Compounds Detected at Site 16 (ug/kg)	MSC	Minimum Detected Concentration			Maximum Detected Concentration			Frequency of detections
		Minimum conc.	Date Sampled	Location	Max. Conc.	Date Sampled	Location	
Acetone	79000000	12J	3/16/95	16SD15	170	5/2/93	16SD05QC	6/26
Styrene	23000000	93	2/21/95	16SD08	93	2/21/95	16SD08	1/26
Trichloroethene	6600	24	10/29/97	16SD35	24	10/29/97	16SD35	1/26

PCB Compounds Detected at Site 16 (ug/kg)	MSC	Minimum conc.	Date Sampled	Location	Max. Conc.	Date Sampled	Location	Frequency of detections
Aroclor 1260	None Available	81	4/16/93	16SD32	81	4/16/93	16SD32	1/5

Anions Detected at Site 16 (mg/kg)	MSC	Minimum conc.	Date Sampled	Location	Max. Conc.	Date Sampled	Location	Frequency of detections
Chloride		5.1	4/14/93	16SD02	54.7	5/2/93	16SD05	4/5
Nitrate	3000000	0.18	4/14/93	16SD02	0.37	4/14/93	16SD04	2/5
Sulfate		3.9	4/14/93	16SD02	234	5/4/93	16SD01	5/5

Metals Detected at Site 16 (mg/kg)	MSC	Minimum conc.	Date Sampled	Location	Max. Conc.	Date Sampled	Location	Frequency of detections
Aluminum	1000000	5000	10/29/97	16SD34	15000	10/29/97	16SD35	5/5
Arsenic	20	1.57J	3/6/95	16SD17	9.49	10/29/97	16SD35	25/26
Barium	59000	53.8	2/28/95	16SD02	383.5	2/21/95	16SD08	26/26
Beryllium	270	0.392	10/29/97	16SD34	1.179	10/29/97	16SD35	5/5
Cadmium	410	0.169	10/29/97	16SD32	0.189	10/29/97	16SD33	3/26
Calcium	---	1000	10/29/97	16SD32	1700	10/29/97	16SD31	4/5
Chromium	1600	6.33	2/21/95	16SD12	40.9	4/14/93	16SD03	26/26
Cobalt	110000	6.39	10/29/97	16SD34	6.39	10/29/97	16SD34	1/5
Copper	74000	3.2	3/6/95	16SD18	14	10/29/97	16SD35	24/25
Iron	100000	1300	10/29/97	16SD31	31000	10/29/97	16SD35	5/5
Lead	1000	4.58	2/21/95	16SD08	49.3	2/21/95	16SD09	26/26
Magnesium	---	700	10/29/97	16SD34	2800	10/29/97	16SD35	4/5
Manganese	81000	161	10/29/97	16SD31	512	10/29/97	16SD33	5/5
Nickel	12000	4.1	2/21/95	16SD12	24	5/13/97	16SD05	26/26
Potassium	---	1300	10/29/97	16SD32&34	3500	10/29/97	16SD35	5/5
Selenium	9300	0.668	10/29/97	16SD34	3.41	10/29/97	16SD35	13/26
Strontium	100000 ¹	9.14	10/29/97	16SD34	21.7	10/29/97	16SD35	5/5
Thallium	150	1.83	5/2/93	16SD05	1.83	5/2/93	16SD05	1/26
Vanadium	3000	17.1	10/29/97	16SD34	45.1	10/29/97	16SD35	5/5
Zinc	410000	13	2/21/95	16SD10	179	10/29/97	16SD33	25/25

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

Table 4-9 (continued)
Sediment Sample Summary Phase I, Phase II and Phase III

Dioxins/ Furans Detected at Site 16 (ng/kg)		Minimum conc.	Date Sampled	Location	Max. Conc.	Date Sampled	Location	Frequency of detections
2,3,7,8-TCDD	300	.2J	10/29/97	16SD35	.33J	10/29/97	16SD33	2/5
2,3,7,8-TCDF	300	.79J	10/29/97	16SD34	3.6J	10/29/97	16SD33	5/5
Total TCDF	—	.79J	10/29/97	16SD34	19.1J	10/29/97	16SD33	5/5
1,2,3,4,6,7,8-HpCDF	3000	.2J	10/29/97	16SD31	27.2J	10/29/97	16SD33	5/5
1,2,3,4,6,7,8-HpCDD	—	.66J	10/29/97	16SD34	958J	10/29/97	16SD33	5/5
1,2,3,4,7,8,9-HpCDF	45	1.2J	10/29/97	16SD35	2.6J	10/29/97	16SD33	4/5
1,2,3,4,7,8-HxCDF	300	.5J	10/29/97	16SD34	3.7J	10/29/97	16SD32 16SD33	5/5
1,2,3,4,7,8-HxCDD	4.5	1.2J	10/29/97	16SD31 16SD32	2.3J	10/29/97	16SD33	4/5
1,2,3,6,7,8-HxCDF	300	.54J	10/29/97	16SD35	1J	10/29/97	16SD33	4/5
1,2,3,6,7,8-HxCDD	4.5	1.2J	10/29/97	16SD34	11.5J	10/29/97	16SD33	5/5
1,2,3,7,8,9-HxCDD	4.5	.83J	10/29/97	16SD34	8.5J	10/29/97	16SD35	5/5
1,2,3,7,8,9-HxCDF	4.5	.44J	10/29/97	16SD35	.44J	10/29/97	16SD35	1/5
HPCDF	—	6.2J	10/29/97	16SD34	122J	10/29/97	16SD33	5/5
Heptachlorodibenzo-p-dioxins	11	134J	10/29/97	16SD34	2070J	10/29/97	16SD33	5/5
HXCDF	—	3.1J	10/29/97	16SD34	32.5J	10/29/97	16SD33	5/5
Hexachlorodibenzo-p-dioxin	11	8.5J	10/29/97	16SD34	107J	10/29/97	16SD33	5/5
OCDF	450	4.2J	10/29/97	16SD34	91.9J	10/29/97	16SD35	5/5
OCDD	450	1760J	10/29/97	16SD34	6000J	10/29/97	16SD31	5/5
PECDF	—	1.4J	10/29/97	16SD34	11.8J	10/29/97	16SD33	5/5
2,3,4,7,8-PeCDF	0.9	.42J	10/29/97	16SD35	1.2J	10/29/97	16SD33	3/5
PECDD	—	.81J	10/29/97	16SD32	5.9J	10/29/97	16SD33	4/5
1,2,3,7,8-PeCDD	0.9	.87J	10/29/97	16SD35	1.1J	10/29/97	16SD33	2/5
Tetrachlorodibenzo-p-dioxin	0.45	.82J	10/29/97	16SD32	5.6J	10/29/97	16SD35	4/5
1,2,3,7,8- PeCDF	9	.32J	10/29/97	16SD35	.69J	10/29/97	16SD32	3/5
2,3,4,6,7,8-HxCDF	4.5	.84J	10/29/97	16SD34	2.2J	10/29/97	16SD32 16SD33	5/5

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

Table 4-10
Site 16 - Sediment Sample Summary

Metals Detected at Site 16 (mg/kg)	16SD01 2/21/95	16SD02 2/28/95	16SD03 2/20/95	16SD04 2/21/95	16SD05 5/13/93	16SD06 2/20/95	16SD07 2/21/95	16SD08 2/21/95	16SD09 2/21/95	16SD10 2/21/95	16SD11 2/28/95	16SD12 2/21/95	16SD13 2/21/95	16SD14 2/21/95	16SD15 3/16/95	16SD16 3/16/95	16SD17 3/6/95	16SD18 3/6/95	16SD19 3/6/95	16SD20 3/6/95	16SD21 5/10/95	16SD31 10/29/97	16SD32 10/29/97	16SD33 10/29/97	16SD34 10/29/97	16SD35 10/29/97	MSC (mg/kg)
Aluminum	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7600	5600	15000	5000	15000	1000000
Antimony																											490
Arsenic	2.21	7.17**	3.85**	8.53		2.63	4.13	3.01	4.8	5.59	3.63	2.23	3.26	2.84*	3.75J	1.91J	1.57J	2.28J	2.3J	3.24J	6.9	3.83	9.25J	5.15	2.71	9.49	20
Barium	295**	53.8	58.8	224**	220	64.5	94.9	383.5	209.3	72.3	86.1	58.8	182.1	139	236.7	150.3	117.6	145.3	266.1	278	194	92	78*	170	97	150	59000
Beryllium	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.51	0.599	0.614	0.392	1.179	270
Cadmium																							0.169	0.189		0.183	410
Calcium	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1700	1000	1400		1100	-----
Chromium	28.8**	12.7**	40.9**	21.8	28.3	13.5	10.2	11.1	15.7	18.9	22.6	6.33	8.42	8.76	20.8	13.2	6.88	9.13	17.8	12.5	12	9.98	19.9	11.6	9.35	25.7	1600
Cobalt	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		6.39		110000
Copper	10.5	6.1	4	5.8	N/A	8.5	6.8	6	10.3	3.4	6.1	4.7	5.8	4.8	8.1	11.9	4.4*	3.2	8.2	8.6	5.3	5.43	9.85	9.25		14	74000
Iron	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1300	23000	12000	7800	31000	100000
Lead	29**	17.3**	14.5**	17.7**	31.2	10.5	7.62	4.58	49.3	23.4	9.99	6.3	10.9	11.6	26.7J	14.3J	7.83J	8.98	14.8	13.3	19.3	8.18	20	11.9	7.22	15.2	1000
Magnesium	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	880		1000	700	2800	-----
Manganese	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	161	460	512	444	213	81000
Mercury																											9.6
Nickel	16.8**	10.3**	6.08**	14.4**	24	8.26	6.05	14.4	17.3	5.85	8.2	4.7	10.1	10.1	17.3	11.5	6.95	4.97	12.7	11.1	9.8	8.14	8.9	9.03	5.82	17.3	12000
Potassium	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1700	1300	1600	1300	3500	-----
Selenium				1.95J**					0.8						0.87	0.82	0.7**	0.8J	1.15J	1.33J		1.81	1.87	1.27	0.668	3.41	9300</

Dioxins/ Furans Detected at Site 16 (ng/kg)	16SD01 2/21/95	16SD02 2/28/95	16SD03 2/20/95	16SD04 2/21/95	16SD05 5/13/93	16SD06 2/20/95	16SD07 2/21/95	16SD08 2/21/95	16SD09 2/21/95	16SD10 2/21/95	16SD11 2/28/95	16SD12 2/21/95	16SD13 2/21/95	16SD14 2/21/95	16SD15 3/16/95	16SD16 3/16/95	16SD17 3/6/95	16SD18 3/6/95	16SD19 3/6/95	16SD20 3/6/95	16SD21 5/10/95	16SD31 10/29/97	16SD32 10/29/97	16SD33 10/29/97	16SD34 10/29/97	16SD35 10/29/97	MSC (ng/kg)
2,3,7,8-TCDD	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		.33J		.2J	300
2,3,7,8-TCDF	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.8J	2.3J	3.6J	.79J	1.1J	300
Total TCDF	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8.3J	9.9J	19.1J	.79J	4.9J	—
1,2,3,4,6,7,8-HpCDF	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2J	15.8J	27.2J	2.5J	10J	3000
1,2,3,4,6,7,8-HpCDD	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	140J	92.1J	958J	66J	864J	—
1,2,3,4,7,8,9-HpCDF	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.4J	1.9J	2.6J		1.2J	45
1,2,3,4,7,8-HxCDF	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.1J	3.7J	3.7J	.5J	1.4J	300
1,2,3,4,7,8-HxCDD	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.2J	1.2J	2.3J		1.6J	4.5
1,2,3,6,7,8-HxCDF	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	.77J	.98J	1J		.54J	300
1,2,3,6,7,8-HxCDD	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4.3J	2.8J	11.5J	1.2J	11.1J	4.5
1,2,3,7,8,9-HxCDD	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.4J	2.4J	7.8J	.83J	8.5J	4.5
1,2,3,7,8,9-HxCDF	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A					.44J	4.5
HPCDF	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	44.2J	48.7J	122J	6.2J	42.3J	—
Heptachlorodibenzo-p-dioxins	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	294J	193J	2070J	134J	1620J	11
HXCDF	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	20.9J	26.9J	32.5J	3.1J	13J	—
Hexachlorodibenzo-p-dioxin	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	43.4J	19.4J	107J	8.5J	97.9J	11
OCDF	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	49.7J	22.2J	91.9J	4.2J	29.8J	450
OCDD	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6000J	3610J	1999J	1760J	1989J	450

VOCs Detected at Site 16 (ug/kg)	16SD01 2/21/95	16SD02 2/28/95	16SD03 2/20/95	16SD04 2/21/95	16SD05 5/13/93	16SD06 2/20/95	16SD07 2/21/95	16SD08 2/21/95	16SD09 2/21/95	16SD10 2/21/95	16SD11 2/28/95	16SD12 2/21/95	16SD13 2/21/95	16SD14 2/21/95	16SD15 3/16/95	16SD16 3/16/95	16SD17 3/6/95	16SD18 3/6/95	16SD19 3/6/95	16SD20 3/6/95	16SD21 5/10/95	16SD31 10/29/97	16SD32 10/29/97	16SD33 10/29/97	16SD34 10/29/97	16SD35 10/29/97	MSC (mg/kg)
Acetone	103				170*	26					22				12 J 39			35	79	82	13						
Methylene Chloride								93																			
Styrene																											
Trichlorethene																									24		

[illegible]

** Indicates maximum concentration for the compound for 16SD01-16SD04 was from 1993 sampling event

* Indicates the maximum concentration identified for this compound was from a duplicate sample collected during the sampling event

N/A - Compound was not analyzed for at this location during the sampling event

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

B- The analyte was detected in an associated blank (Organics only).

MSC- Medium-Specific Concentrations (**Bold** values exceed the MSC for that compound)

1. Values represented are EPA Region 6 Human Health Medium-Specific Screening Levels for Tap Water, no MSC's for this constituent were available from TNRCC.

3. Values represented are EPA Region 6 Human Health Medium-Specific Screening Levels for Industrial Soil, no MSC's for this constituent were available from

Table 4-11
Sediment Samples Exceeding Background Sediment Concentrations

Compound (mg/kg)	Metals and Background Concentrations							
	Arsenic 3.26	Barium 200	Chromium 11.7	Copper 5.82	Lead 12.8	Nickel 9.1	Selenium 1.09	Zinc 28
I6SD01		295	28.8	10.5	29	16.8	N/A	55.6
I6SD02	7.17		12.7	6.1	17.3	10.3	N/A	28.9
I6SD03	3.85		40.9		14.5		N/A	
I6SD04	8.53	224	21.8		17.7	14.4	1.95	39
I6SD05		220	28.3		31.2	24	N/A	N/A
I6SD06			13.5	8.5			N/A	40.4
I6SD07	4.13			6.8			N/A	168
I6SD08		383.5		6		14.4	N/A	
I6SD09	4.8	209.3	15.7	10.3	49.3	17.3	N/A	57
I6SD10	5.59		18.9		23.4		N/A	
I6SD11	3.63		22.6	6.1			N/A	29.4
I6SD12							N/A	
I6SD13						10.1	N/A	
I6SD14						10.1	N/A	
I6SD15	3.75	236.7	20.8	8.1	26.7	17.3	N/A	51.1
I6SD16			13.2	11.9	14.3	11.5	N/A	33.9
I6SD19		266.1	17.8	8.2	14.8	12.7	1.15J	46
I6SD20		278	12.5	8.6	13.3	11.1	1.33J	32
I6SD21	6.9		12		19.3	9.8		
I6SD31	3.83						1.81	56.8
I6SD32	9.25			9.85	20		1.87	33.7
I6SD33	5.15		19.9	9.25			1.27	179
I6SD34								
I6SD35	9.49		25.7	14	15.2	17.3	3.41	54.2

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

4.5 Surface Water Sample Results

Surface water samples were collected during the Phase I, II, and III field activities at the locations shown on Figure 2-4 in Appendix I. A summary of the minimum and maximum concentrations of compounds detected in the surface water samples is presented in Table 4-12 and Table 4-13 provides the maximum concentrations detected for each surface water sample. Five VOCs, acetone, cis-1,2-dichloroethylene, p-isopropyltoluene, naphthalene and vinyl chloride, were detected in surface water samples. Surface water samples were also analyzed for anions, chloride, nitrate, nitrate plus nitrite and sulfate. Twenty three metals were detected in the surface water samples with copper, lead, and zinc detected at concentrations exceeding TWQS values. Table 4-14 summarizes the surface water samples which exceed the TWQS values.

Twenty-one dioxin/furan compounds were detected in one or more of the surface water samples. There are no available TWQS values for dioxin/furan compounds. The US EPA Toxicity Equivalency Factor values for nine of the dioxin/furan compounds were exceeded in one or more of the surface water samples.

Table 4-12
Surface Water Sample Summary Phase I, Phase II and Phase III

Volatile Compounds Detected at Site 16 (ug/l)	TWQS	Minimum Detected Concentration			Maximum Detected Concentration			Frequency of detections
		Minimum conc.	Date Sampled	Location	Max. Conc.	Date Sampled	Location	
Acetone	---	8J	2/21/95	16SW14	26	10/29/97	16SW32	5/26
Naphthalene		0.81	10/29/97	16SW34	11	10/29/97	16SW31	2/5
Vinyl Chloride		3.2	10/29/97	16SW34	3.2	10/29/97	16SW34	1/26

Anions Detected at Site 16 (ug/l)	TWQS	Minimum conc.	Date Sampled	Location	Max. Conc.	Date Sampled	Location	Frequency of detections
Chloride		30	10/29/97	16SW34	89	10/29/97	16SW31	8/10
Nitrate		4.74	5/4/93	16SW01	4.74	5/4/93	16SW01	1/5
Nitrate as Nitrite (asN)		0.058	10/29/97	16SW34	0.156	10/29/97	16SW33	3/10
Sulfate		21.1	5/13/93	16SW05	762	10/29/97	16SW32	8/10

Metals Detected at Site 16 (mg/l)	TWQS	Minimum conc.	Date Sampled	Location	Max. Conc.	Date Sampled	Location	Frequency of detections
Aluminum	991	1.2	10/29/97	16SW35	83	10/29/97	16SW31	5/5
Antimony		0.005	10/29/97	16SW31	0.005	10/29/97	16SW31	1/26
Arsenic	0.36	0.005	2/21/95	16SW07	0.031	10/29/97	16SW31	6/26
Barium		0.062	3/6/95	16SW20	1.7	10/29/97	16SW34	26/26
Beryllium		0.0007	10/29/97	16SW32	0.0038	10/29/97	16SW31	3/5
Cadmium	0.00642	0.0061	10/29/97	16SW31	0.0061	10/29/97	16SW31	1/26
Calcium		44	10/29/97	16SW35	97	10/29/97	16SW31	5/5
Chromium	0.521	0.012	2/28/95	16SW02	0.072	10/29/97	16SW31	5/26
Cobalt		0.053	10/29/97	16SW32	0.053	10/29/97	16SW32	1/5
Copper	0.00481	0.005	2/21/95	16SW08	0.089	10/29/97	16SW31	15/26
Iron		4.7	10/29/97	16SW35	120	10/29/97	16SW31	5/5
Lead	0.0125	0.005	10/29/97	16SW33	0.075	10/29/97	16SW31	7/26
Magnesium		36	10/29/97	16SW31&33	66	10/29/97	16SW34	5/5
Manganese		0.266	10/29/97	16SW33	15.1	10/29/97	16SW32	5/5
Mercury	0.0024	0.0005	10/29/97	16SW31	0.0005	10/29/97	16SW31	1/26
Nickel	0.409	0.066	10/29/97	16SW31	0.066	10/29/97	16SW31	1/26
Potassium		9.1	10/29/97	16SW35	21	10/29/97	16SW32	5/5
Selenium	0.02	0.008	10/29/97	16SW32	0.017	10/29/97	16SW31	2/26
Sodium		20	10/29/97	16SW34	230	10/29/97	16SW32	5/5
Strontium		0.656	10/29/97	16SW33	1.11	10/29/97	16SW31	5/5
Thallium		0.002	10/29/97	16SW32	0.002	10/29/97	16SW32	1/26
Vanadium		0.143	10/29/97	16SW31	0.143	10/29/97	16SW31	1/5
Zinc	0.0337	0.009	2/21/95 & 3/6/95	16SW13 & 16SW20	1	10/29/97	16SW31	25/26

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

Table 4-12 (continued)
Surface Water Sample Summary Phase I, Phase II and Phase III

Dioxins/Furans Detected at Site 16 (pg/l)	MSCs	Minimum conc.	Date Sampled	Location	Max. Conc.	Date Sampled	Location	Frequency of detections
2,3,7,8-TCDD	---	1.1J	10/29/97	16SW33	1.1J	10/29/97	16SW33	1/5
1,2,3,4,6,7,8-HpCDF	45	2.3J	10/29/97	16SW35	38.4J	10/29/97	16SW31	5/5
1,2,3,4,6,7,8-HpCDD	---	26.7	10/29/97	16SW35	422J	10/29/97	16SW33	5/5
1,2,3,4,7,8,9-HpCDF	45	3.7J	10/29/97	16SW33	3.7J	10/29/97	16SW33	1/5
1,2,3,4,7,8-HxCDF	4.5	1.8J	10/29/97	16SW34	11.8J	10/29/97	16SW1	5/5
1,2,3,4,7,8-HxCDD	4.5	3.2J	10/29/97	16SW33	3.2J	10/29/97	16SW33	1/5
1,2,3,6,7,8-HxCDF	4.5	1.7J	10/29/97	16SW32	3.7J	10/29/97	16SW31	3/5
1,2,3,6,7,8-HxCDD	4.5	4.7J	10/29/97	16SW34	7.7J	10/29/97	16SW31	4/5
1,2,3,7,8,9-HxCDD	4.5	1.4J	10/29/97	16SW35	7.3J	10/29/97	16SW31	5/5
1,2,3,7,8,9-HxCDF	4.5	1.8J	10/29/97	16SW33	1.8J	10/29/97	16SW33	1/5
HPCDF	---	6.2J	10/29/97	16SW35	93.4J	10/29/97	16SW33	5/5
Heptachlorodibenzo-p- dioxins	11	54J	10/29/97	16SW35	892J	10/29/97	16SW33	5/5
HXCDF	---	29.5	10/29/97	16SW33	29.5	10/29/97	16SW33	1/5
Hexachlorodibenzo-p- dioxin	11	5J	10/29/97	16SW35	70.6J	10/29/97	16SW31	5/5
OCDF	450	2.4J	10/29/97	16SW35	71.8J	10/29/97	16SW31	5/5
OCDD	450	672J	10/29/97	16SW35	6780J	10/29/97	16SW33	5/5
2,3,4,7,8-PeCDF	0.9	2.3J	10/29/97	16SW33	5.2J	10/29/97	16SW33	2/5
PECDD	---	2.4J	10/29/97	16SW33	2.4J	10/29/97	16SW33	1/5
1,2,3,7,8-PeCDD	0.9	2.4J	10/29/97	16SW33	2.4J	10/29/97	16SW33	1/5
Tetrachlorodibenzo-p- dioxin	0.45	1.1J	10/29/97	16SW33	1.1J	10/29/97	16SW33	1/5

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

Table 4-13
Site 16 - Surface Water Summary

Site 16 - Surface Water Summary																												
Metals Detected at Site 16 (mg/l)	16SW01 2/21/95	16SW02 2/28/95	16SW03 2/20/95	16SW04 2/21/95	16SW05 5/13/93	16SW06 2/20/95	16SW07 2/21/95	16SW08 2/21/95	16SW09 2/21/95	16SW10 2/21/95	16SW11 2/28/95	16SW12 2/21/95	16SW13 2/21/95	16SW14 2/21/95	16SW15 3/16/95	16SW16 3/16/95	16SW17 3/6/95	16SW18 3/6/95	16SW19 3/6/95	16SW20 3/6/95	16SW21 5/10/95	16SW31 10/29/97	16SW32 10/29/97	16SW33 10/29/97	16SW34 10/29/97	16SW35 10/29/97	TWQS (mg/l)	
Aluminum	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	83	0.005	16*	6.7	19	1.2	991
Antimony							0.005															0.031	.011*		0.014	0.013	0.36	
Arsenic	0.006																					1.1	.41*	0.5	1.7	0.51		
Barium	0.312	0.163	0.116	0.177	0.155	0.246	0.91	0.197	0.154	0.344	0.291	0.183	0.096	0.09	0.084	0.124	.089*	0.171	0.072	0.062	0.101	0.0038	.0007*		0.0013			
Beryllium	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0061					0.00642	
Cadmium																						97	72*	56	49	44		
Calcium	N/A																					0.072	.025*		0.025		0.521	
Chromium		0.012					0.014																					
Cobalt	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.089					0.00481	
Copper	0.008	0.014				0.01	0.017	0.005	0.006	0.007	0.012	0.005	0.005				0.009	0.006	0.007	0.009		120	29*	6.6	41	4.7		
Iron	N/A																					0.075	0.027*	0.005	0.026		0.0125	
Lead		0.01**				0.019										.009J						36	42*	36	66	59		
Magnesium	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.11	15.1*	0.266	4.3	1.77		
Manganese	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0005					0.0024	
Mercury																						0.066					0.409	
Nickel																						18	21*	12	14	9.1		
Potassium	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.017	.008*				0.02	
Selenium																											0.00092	
Silver																						77	230	41	20	36		
Sodium	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.11	.947*	0.656	1.06	0.883		
Strontium	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A							
Thallium																						0.143						
Vanadium	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	.101*	0.05	0.092	0.025	0.0337	
Zinc	0.064	0.06	0.017	0.019		0.056	0.791	0.024	0.044	0.046	0.055	0.013	0.009	0.054	0.014	0.02	0.01	0.032	0.014	0.009	0.017							

Dioxins/Furans Detected at Site 16 (pg/l)	16SW01 2/21/95	16SW02 2/28/95	16SW03 2/20/95	16SW04 2/21/95	16SW05 5/13/93	16SW06 2/20/95	16SW07 2/21/95	16SW08 2/21/95	16SW09 2/21/95	16SW10 2/21/95	16SW11 2/28/95	16SW12 2/21/95	16SW13 2/21/95	16SW14 2/21/95	16SW15 3/16/95	16SW16 3/16/95	16SW17 3/6/95	16SW18 3/6/95	16SW19 3/6/95	16SW20 3/6/95	16SW21 5/10/95	16SW31 10/29/97	16SW32 10/29/97	16SW33 10/29/97	16SW34 10/29/97	16SW35 10/29/97	MSC (pg/l)
2,3,7,8-TCDD	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	38.4J	13.8J	20.7J	12.0J	2.3J	45
1,2,3,4,6,7,8-HpCDF	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	228J	264J	422J	276J	26.7	—
1,2,3,4,6,7,8-HpCDD	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A			3.7J			45
1,2,3,4,7,8,9-HpCDF	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	11.8J	3.9J	6.6J	1.8J	2.0J	4.5
1,2,3,4,7,8-HxCDF	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A			3.2J			4.5
1,2,3,4,7,8-HxCDD	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.7J	1.7J	1.9J			4.5
1,2,3,6,7,8-HxCDF	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7.7J	4.9J	6.9J	4.7J		4.5
1,2,3,6,7,8-HxCDD	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7.3J	4.0J	5.9J	4.0J	1.4J	4.5
1,2,3,7,8,9-HxCDD	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A			1.8J			4.5
1,2,3,7,8,9-HxCDF	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	119J	48.8J	93.4J	43.8J	6.2J	—
HPCDF	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	554J	579J	892J	597J	54J	11
Heptachlorodibenzo-p-dioxins	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A			29.5J			—
HxCDF	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	70.6J	36.5J	44J	34.4J	5J	11
Hexachlorodibenzo-p-dioxin	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	71.8J	32.5J	61.5J	15.4	2.4J	450
OCDF	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5720J	5790J	6780J	6290J	672J	450
OCDD	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5.2J		2.3J			0.9
2,3,4,7,8-PeCDF	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A			2.4J			—
PECDD	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A			2.4J			0.9
1,2,3,7,8-PeCDD	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A			1.1J			0.45
Tetrachlorodibenzo-p-dioxin	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A						

VOCs Detected at Site 16 (ug/l)	16SW01 2/21/95	16SW02 2/28/95	16SW03 2/20/95	16SW04 2/21/95	16SW05 5/13/93	16SW06 2/20/95	16SW07 2/21/95	16SW08 2/21/95	16SW09 2/21/95	16SW10 2/21/95	16SW11 2/28/95	16SW12 2/21/95	16SW13 2/21/95	16SW14 2/21/95	16SW15 3/16/95	16SW16 3/16/95	16SW17 3/6/95	16SW18 3/6/95	16SW19 3/6/95	16SW20 3/6/95	16SW21 5/10/95	16SW31 10/29/97	16SW32 10/29/97	16SW33 10/29/97	16SW34 10/29/97	16SW35 10/29/97	TWQS (mg/l)
Acetone									19 J																		
cis-1,2-dichloroethylene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	11					
Naphthalene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA				0.81		
Vinyl chloride																									20		

Anions Detected at Site 16 (mg/l)	16SW01 5/4/93	16SW02 4/14/93	16SW03 4/14/93	16SW04 4/14/93	16SW05 5/13/93	16SW06 2/20/95	16SW07 2/21/95	16SW08 2/21/95	16SW09 2/21/95	16SW10 2/21/95	16SW11 2/28/95	16SW12 2/21/95	16SW13 2/21/95	16SW14 2/21/95	16SW15 3/16/95	16SW16 3/16/95	16SW17 3/6/95	16SW18 3/6/95	16SW19 3/6/95	16SW20 3/6/95	16SW21 5/10/95	16SW31 10/29/97	16SW32 10/29/97	16SW33 10/29/97	16SW34 10/29/97	16SW35 10/29/97	TWQS (mg/l)
Chloride	40.9			76	85.6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	89	79	44	30	31	
Nitrate	4.74					N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.078*	0.156	0.058	N/A	
Nitrate plus Nitrite (as N)						N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	363	762	372	271	286	
Sulfate	169			110	21.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A						

** Indicates maximum concentration for the compound for 16SW01-16SW04 was from 1993 sampling event

* Indicates the maximum concentration identified for this compound was from a duplicate sample collected during the sampling event

N/A - Compound was not analyzed for at this location during the sampling event

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

B- The analyte was detected in an associated blank (Organics only).

TWQS- Texas Water Quality Standards (**Bold** values exceed the TWQS for that compound)

LHAAP Site 16 Landfill

Remedial Investigation Report - Final

Table 4-14
Surface Water Analytical Summary
Metals and Samples which Exceed TWQS Values

Metals which Exceed TWQS	TWQS (ug/l)	Sampling Location	Concentration (ug/l)
Copper	0.00481	16SW01	0.008
		16SW02	0.014
		16SW06	0.01
		16SW07	0.017
		16SW08	0.005
		16SW09	0.006
		16SW10	0.007
		16SW11	0.012
		16SW12	0.005
		16SW13	0.005
		16SW17	0.009
		16SW18	0.006
		16SW19	0.007
		16SW20	0.009
Lead	0.0125	16SW06	0.019
		16SW31	0.075
		16SW32	0.027
		16SW34	0.026
Zinc	0.0337	16SW01	0.064
		16SW02	0.06
		16SW06	0.056
		16SW07	0.791
		16SW09	0.044
		16SW10	0.046
		16SW11	0.055
		16SW14	0.054
		16SW31	1
		16SW32	0.101
		16SW33	0.05
		16SW34	0.092

During Phase II field activities, 1 surface water sample was collected from a seep on an exposed bank in the northeast portion of Site 16 above Harrison Bayou. This sample was identified as "Seep" and analyzed for VOCs. Concentrations of trichloroethene at 1,020 µg/l, cis-1,2-dichloroethene at 609 µg/l, and vinyl chloride at 65 µg/l were detected in this sample. The remaining VOCs were not detected above the quantitation limits. There are no TWQS values for the VOCs detected in this surface water sample.

4.6 Groundwater Sample Results

Groundwater samples were collected during Phase I, II, and III field activities. Table 4-15 and 4-16 summarize the maximum concentrations for the compounds detected in groundwater samples collected from wells at Site 16. Monitoring well locations are presented in Figure 2-2. The groundwater samples were analyzed for VOCs, SVOCs, HE, metals, anions, dioxin/furan compounds, and pesticides/PCBs. Table 4-1 summarizes the analysis performed on the groundwater samples collected during the field activities.

Twenty-four VOCs were detected in the groundwater samples, with nine VOCs detected above MSC values. Eight of the 24 detected VOCs, were detected in only one groundwater sample. With the exception of 1,1,2-trichloroethane, these VOCs concentrations were below MSC values. Table 4-17 provides a summary of the detected VOCs associated with the groundwater sampling at Site 16. A listing of detected VOCs and respective concentrations are presented in Appendix V.

Monitoring and extraction wells at Site 16 have been characterized into four groundwater zones, shallow, intermediate, upper deep and lower deep. Table 4-18 provides a listing of wells installed in each water zone.

Iso-concentration maps of total VOCs values from the October 1997 sampling event for the shallow and intermediate water bearing zones are presented in Figures 4-2 and Figures 4-3, (Appendix I).

Table 4-15
Site 16 - Groundwater Summary

Volatile Compounds Detected at Site 16 (ug/l)	16VVV01		16VVV02		16VVV03		16VVV04		16VVV05		16VVV06		16VVV07		16VVV08		16VVV09		16VVV10		16VVV11		16VVV12		16VVV13		MSC ug/l
	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	
1,1,2-Trichloroethane																											5
1,1-Dichloroethane																											10000
1,1-Dichloroethene	6	6/14/95			27	6/14/95																	8.1*	10/27/97	1.7	10/27/97	70
1,2-Dichloroethane																							24	10/27/97			5
1,2-Dichloroethene	321	6/14/95			66	6/14/95	41	6/15/95									16	6/15/95	27	6/15/95	23	6/16/95					70*
Acetone									23*	6/11/93	17	6/11/93															10000
Benzene																							4.1	10/27/97			5
1,2,4-Trimethylbenzene																											
1,3,5-Trimethylbenzene																											
Bromodichloromethane																											100
Chloroform	1	6/25/97							0.64	10/22/97	0.96	10/22/97													1.9	10/27/97	100
cis-1,2-Dichloroethylene	35	6/10/93			52	6/8/93	21	6/8/93															100	6/11/98	160	10/27/97	70
trans-1,2-Dichloroethene																							0.56	10/27/97	2.1	10/27/97	100
Ethylbenzene																											700
Carbon Disulfide	2	6/25/97																									
Iodomethane	0.7	6/25/97																									
Isobutyl alcohol																											
2-Butanone																									6.5	10/27/97	8200
Methylene chloride	4J	6/14/95			520	6/8/93	16*	6/15/95	4J	6/14/95							4J	6/15/95	3J	6/15/95			.56*	10/27/97	3J	6/13/95	5
Toluene																											1000
Trichloroethene	3950	6/14/95	10	6/13/95	6400	6/8/93	247	6/15/95	4.1	10/22/97	1.6	10/22/97							6	6/15/95	238	6/16/95	7500	10/27/97	12000	10/27/97	5
Trichlorofluoromethane	0.8	6/25/97			892	6/14/95																					31000
Vinyl chloride	9J	6/14/95					8*	6/15/95													13	6/16/95	14*	10/27/97	8.8	10/27/97	2
Xylene (total)	0.8	6/25/97																									10000

Semivolatile Compounds Detected at Site 16 (ug/l)	16VVV01		16VVV02		16VVV03		16VVV04		16VVV05		16VVV06		16VVV07		16VVV08		16VVV09		16VVV10		16VVV11		16VVV12		16VVV13		MSC (ug/l)
	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	
Bis(2-ethylhexyl)phthalate																									N/A		6
Butyl benzyl phthalate																									N/A		20000

PCB and Pesticides Detected at Site 16 (ug/l)	16VVV01		16VVV02		16VVV03		16VVV04		16VVV05		16VVV06		16VVV07		16VVV08		16VVV09		16VVV10		16VVV11		16VVV12		16VVV13		MSC (ug/l)
	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	
Aldrin	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		0.017

Explosive Compounds Detected at Site 16 (ug/l)	16VVV01		16VVV02		16VVV03		16VVV04		16VVV05		16VVV06		16VVV07		16VVV08		16VVV09		16VVV10		16VVV11		16VVV12		16VVV13		MSC (ug/l)
	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	
2,4-Dinitrotoluene																											0.42
2,6-Dinitrotoluene																											0.42
4-Amino-2,6-dinitrotoluene					0.66B	6/8/93	1.0B	6/8/93																			1800 ¹
HMX																											10
1,3-Dinitrobenzene																											1000
3-Nitrotoluene																											51
Nitrobenzene									1.9*	6/11/93																	6.1 ¹
RDX					0.6	6/14/95																					3100
1,3,5-Trinitrobenzene																0.68	6/14/95			0.74	6/19/95						
Tetryl																											
2,4,6-Trinitrotoluene					0.9	6/14/95																					51

* Indicates the maximum concentration identified for this compound was from a duplicate sample collected during the sampling event
N/A - Compound was not analyzed for at this location during the sampling event
J- The analyte was not positively identified: the associated numerical value is the approximate concentration of the analyte in the sample.
B- The analyte was detected in an associated blank (Organics only).
MSC- Medium-Specific Concentrations (**Bold** values exceed the MSC for that compound)
1. Values represented are EPA Region 6 Human Health Medium-Specific Screening Levels for Tap Water, no MSC's for this constituent were available from TNRCC.
4. No values for total 1,2 Dichloroethene were available, the most conservative polymer's, cis-1,2 Dichloroethene, values are presented here.

Table 4-15
Site 16 - Groundwater Summary

Volatile Compounds Detected at Site 16 (ug/l)	16WW14		16WW15		16WW16		16WW17		16WW18		16WW19		16WW20		16WW21		16WW22		16WW23		16WW24		16WW25		16WW26		MSC ug/l
	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	
1,1,2-Trichloroethane					12	6/15/95											0.6	10/24/97									5
1,1-Dichloroethane					36	10/27/97																					10000
1,1-Dichloroethene	0.75*	1/20/98			740	10/27/97									0.99	10/28/97	3.8	10/24/97									70
1,2-Dichloroethane					103	6/15/95											22	10/24/97									5
1,2-Dichloroethene					275000	6/15/95																					70*
Acetone							10	6/16/95																			10000
Benzene					5	6/15/95											1.8	10/24/97									5
1,2,4-Trimethylbenzene					24	10/27/97																					
1,3,5-Trimethylbenzene					16	10/27/97																					
Bromodichloromethane																											
Chloroform					5.2	10/27/97					0.77	10/24/97	0.61	10/24/97	0.79	10/28/97	0.52	10/24/97			0.59	10/23/97	36	10/23/97	1.3	10/23/97	100
cis-1,2-Dichloroethylene	10*	1/20/98			270000	1/21/98	0.6	10/27/97							360	10/28/97	120	1/20/98					7.9	1/21/98	570	1/21/98	70
trans-1,2-Dichloroethene					130	10/27/97																					100
Ethylbenzene					5	6/15/95																					700
Carbon Disulfide																											
Iodomethane																											
Isobutyl Alcohol																											8200
2-Butanone																											5
Methylene chloride					5J	6/15/95	4J	6/16/95	3J	6/15/95																	1000
Toluene					29	6/15/95																					5
Trichloroethene	82	1/20/98			25000	10/27/97	1.3	10/27/97			5	10/24/97	7.9	10/24/97	140	10/28/97	4300	1/20/98	1	10/23/97	2.1	10/23/97	2.9	1/21/98	270	1/21/98	31000
Trichlorofluoromethane																									5.1	1/21/98	2
Vinyl chloride					11000	10/27/97									4.8	10/28/97	14	10/24/97									10000
Xylene (total)					12	6/15/95																					

Semivolatile Compounds Detected at Site 16 (ug/l)	16WW14		16WW15		16WW16		16WW17		16WW18		16WW19		16WW20		16WW21		16WW22		16WW23		16WW24		16WW25		16WW26		MSC (ug/l)
	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	
Bis(2-ethylhexyl)phthalate	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		6
Butyl benzyl phthalate	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		20000

PCB and Pesticides Detected at Site 16 (ug/l)	16WW14		16WW15		16WW16		16WW17		16WW18		16WW19		16WW20		16WW21		16WW22		16WW23		16WW24		16WW25		16WW26		MSC (ug/l)
	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	
Aldrin	N/A		N/A				N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		0.017

Explosive Compounds Detected at Site 16 (ug/l)	16WW14		16WW15		16WW16		16WW17		16WW18		16WW19		16WW20		16WW21		16WW22		16WW23		16WW24		16WW25		16WW26		MSC (ug/l)
	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	
2,4-Dinitrotoluene																											0.42
2,6-Dinitrotoluene																											0.42
4-Amino-2,6-dinitrotoluene																											1800 ¹
HMX																											10
1,3-Dinitrobenzene																											1000
3-Nitrotoluene																											51
Nitrobenzene																											6.1 ¹
RDX																											3100
1,3,5-Trinitrobenzene																											
Tetryl					4.4	1/21/98																					51
2,4,6-Trinitrotoluene																											

* Indicates the maximum concentration identified for this compound was from a duplicate sample collected during the sampling event
N/A - Compound was not analyzed for at this location during the sampling event
J- The analyte was not positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
B- The analyte was detected in an associated blank (Organics only).
MSC- Medium-Specific Concentrations (**Bold** values exceed the MSC for that compound)
1. Values represented are EPA Region 6 Human Health Medium-Specific Screening Levels for Tap Water, no MSC's for this constituent were available from TNRCC.
4. No values for total 1,2 Dichloroethene were available, the most conservative polymer's, cis-1,2 Dichloroethene, values are presented here.

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Table 4-15
Site 16 - Groundwater Summary

Volatile Compounds Detected at Site 16 (ug/l)	16WW27		16WW28		16WW29		16WW30		16WW31		16WW32		16WW33		16WW34		16WW35		16WW36		16WW37		16WW38		16EW01		MSC ug/l
	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	
1,1,2-Trichloroethane																	2.2	10/24/97							-		5
1,1-Dichloroethane																	24	10/24/97	16	10/27/97					45*	6/11/98	10000
1,1-Dichloroethene																									160*	6/11/98	70
1,2-Dichloroethane																									2578	2/21/96	5
1,2-Dichloroethene																									3920	2/21/96	70 *
Acetone																											10000
Benzene							0.83	10/21/97																			5
1,2,4-Trimethylbenzene					0.68	6/11/98																					
1,3,5-Trimethylbenzene																											
Bromodichloromethane							2.9	10/21/97							1.1	10/22/97											100
Chloroform							14	10/21/97	0.58	10/22/97	0.53	10/22/97	0.69	10/22/97	7.7	10/22/97	1.4	10/24/97							21*	6/11/98	100
cis-1,2-Dichloroethylene					11	1/22/98	33	6/15/98									52	10/24/97	120	1/20/98	220	1/21/98	520	1/21/98	9500*	6/11/98	70
trans-1,2-Dichloroethene																	0.79	10/24/97									100
Ethylbenzene																											700
Carbon Disulfide																											
Iodomethane																											
Isobutyl Alcohol																							1100	1/21/98			
2-Butanone																											8200
Methylene chloride																									3500	10/29/97	5
Toluene																											1000
Trichloroethene					66	1/22/98	36	10/21/97	0.74	10/22/97	1.1	10/22/97	3	10/22/97	7.7	10/22/97	1800	10/24/97	11000	10/27/97	1500	1/21/98	160	1/21/98	58000*	10/29/97	5
Trichlorofluoromethane																											31000
Vinyl chloride																	9.9	10/24/97					7.1	1/21/98	100*	6/11/98	2
Xylene (total)																											10000

Semivolatile Compounds Detected at Site 16 (ug/l)	16WW27		16WW28		16WW29		16WW30		16WW31		16WW32		16WW33		16WW34		16WW35		16WW36		16WW37		16WW38		16EW01		MSC (ug/l)
	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	
Bis(2-ethylhexyl)phthalate	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		6
Butyl benzyl phthalate	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		20000

PCB and Pesticides Detected at Site 16 (ug/l)	16WW27		16WW28		16WW29		16WW30		16WW31		16WW32		16WW33		16WW34		16WW35		16WW36		16WW37		16WW38		16EW01		MSC (ug/l)
	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	
Aldrin	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A				N/A		N/A		0.04J	10/29/97	0.017

Explosive Compounds Detected at Site 16 (ug/l)	16WW27		16WW28		16WW29		16WW30		16WW31		16WW32		16WW33		16WW34		16WW35		16WW36		16WW37		16WW38		16EW01		MSC (ug/l)
	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	
2,4-Dinitrotoluene																									0.048	2/21/96	0.42
2,6-Dinitrotoluene																									0.263J	2/24/96	0.42
4-Amino-2,6-dinitrotoluene																									0.597	2/21/96	
HMX																									0.12	2/25/96	1800
1,3-Dinitrobenzene																									1.56	2/24/96	10
3-Nitrotoluene													0.72	7/9/97	0.2	7/9/97	1	7/9/97									1000
Nitrobenzene																									0.223	2/21/96	51
RDX																									1.9J	2/21/96	6.1
1,3,5-Trinitrobenzene																											3100
Tetryl																											
2,4,6-Trinitrotoluene																									1.56	2/25/96	51

* Indicates the maximum concentration identified for this compound was from a duplicate sample collected during the sampling event

N/A - Compound was not analyzed for at this location during the sampling event

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

B- The analyte was detected in an associated blank (Organics only).

MSC- Medium-Specific Concentrations (**Bold** values exceed the MSC for that compound)

1. Values represented are EPA Region 6 Human Health Medium-Specific Screening Levels for Tap Water, no MSC's for this constituent were available from TNRCC.

4. No values for total 1,2 Dichloroethene were available, the most conservative polymer's, cis-1,2 Dichloroethene, values are presented here.

Table 4-15
Site 16 - Groundwater Summary

Volatile Compounds Detected at Site 16 (ug/l)	16EW02		16EW03		16EW04		16EW05		16EW06		16EW07		16EW08		122		MSC ug/l
	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	
1,1,2-Trichloroethane																	5
1,1-Dichloroethane																	10000
1,1-Dichloroethene									12	6/11/98							70
1,2-Dichloroethane																	5
1,2-Dichloroethene																	70 *
Acetone															10	6/14/95	10000
Benzene																	5
1,2,4-Trimethylbenzene																	
1,3,5-Trimethylbenzene																	100
Bromodichloromethane																	100
Chloroform																	70
cis-1,2-Dichloroethylene	130	1/22/98	42	6/11/98	13	6/11/98	2700	1/22/98	1500	10/29/97			2.5	10/29/97			100
trans-1,2-Dichloroethene																	700
Ethylbenzene																	
Carbon Disulfide																	
Iodomethane																	
Isobutyl Alcohol																	8200
2-Butanone																	5
Methylene chloride																	1000
Toluene	21000	10/29/97	2800	6/11/98	1900	10/29/97	46000	1/22/98	22000	10/29/97	2.6	1/22/98	37	10/29/97			5
Trichloroethene																	31000
Trichlorofluoromethane																	2
Vinyl chloride									44	6/11/98							10000
Xylene (total)																	

Semivolatile Compounds Detected at Site 16 (ug/l)	16EW02		16EW03		16EW04		16EW05		16EW06		16EW07		16EW08		122		MSC (ug/l)
	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	
Bis(2-ethylhexyl)phthalate	26*	3/14/96	N/A		N/A		N/A		N/A		N/A		N/A				6
Butyl benzyl phthalate	7	3/14/96	N/A		N/A		N/A		N/A		N/A		N/A				20000

PCB and Pesticides Detected at Site 16 (ug/l)	16EW02		16EW03		16EW04		16EW05		16EW06		16EW07		16EW08		122		MSC (ug/l)
	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	
Aldrin																	0.017

Explosive Compounds Detected at Site 16 (ug/l)	16EW02		16EW03		16EW04		16EW05		16EW06		16EW07		16EW08		122		MSC (ug/l)
	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	
2,4-Dinitrotoluene	0.083*	3/14/96															0.42
2,6-Dinitrotoluene	0.117	2/29/96															0.42
4-Amino-2,6-dinitrotoluene	0.875	2/23/96															
HMX																	
1,3-Dinitrobenzene	1.29	2/23/96															10
3-Nitrotoluene																	1000
Nitrobenzene	0.344	2/23/96															51
RDX	4.75J	2/23/96															6.1
1,3,5-Trinitrobenzene	0.302	3/14/96															3100
Tetryl	0.349J	2/29/96															
2,4,6-Trinitrotoluene																	51

* Indicates the maximum concentration identified for this compound was from a duplicate sample collected during the sampling event

N/A - Compound was not analyzed for at this location during the sampling event

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

B- The analyte was detected in an associated blank (Organics only).

MSC- Medium-Specific Concentrations (**Bold** values exceed the MSC for that compound)

1. Values represented are EPA Region 6 Human Health Medium-Specific Screening Levels for Tap Water, no MSC's for this constituent were available from TNRCC.

4. No values for total 1,2 Dichloroethene were available, the most conservative polymer's, cis-1,2 Dichloroethene, values are presented here.

Table 4-16
Site 16 - Groundwater Summary

Metals Detected at Site 16 (mg/l)	16WW01		16WW02		16WW03		16WW04		16WW05		16WW06		16WW07		16WW08		16WW09		16WW10		16WW11		16WW12		16WW13		MSC (mg/l)
	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	
Aluminum	N/A		N/A		N/A		N/A		0.94	10/22/97	0.23	10/22/97	N/A		N/A		N/A		N/A		N/A		12*	10/27/97	4.6	10/27/97	100
Antimony																										0.006	
Arsenic																	0.007	6/15/95			.034J	6/16/95				0.05	
Barium	0.0303	6/10/93	0.662	6/13/95	0.582	6/8/93	0.044	6/8/93	0.544	6/11/93	0.825	6/11/93	0.487	6/14/95	0.0608	6/11/93	9.9	6/15/95	0.421	6/9/93	0.0514*	6/9/93	0.048	6/13/95	0.066	6/13/95	2
Beryllium	N/A		N/A		N/A		N/A						N/A		N/A		N/A		N/A		N/A					0.004	
Cadmium																										0.005	
Calcium	N/A		N/A		N/A		N/A		110	10/22/97	66	10/22/97	N/A		N/A		N/A		N/A		N/A		270	10/27/97	470	10/27/97	
Chromium			0.011	6/13/95	0.0159	6/8/93																1.82*	10/27/97	0.032	6/13/95	0.1	
Cobalt	N/A		N/A		N/A		N/A						N/A		N/A		N/A		N/A		N/A				1.1	10/27/97	6.1
Copper	N/A		N/A		N/A		N/A						N/A		N/A		N/A		N/A		N/A						1.3
Iron	N/A		N/A		N/A		N/A		1.1	10/22/97	8	10/22/97	N/A		N/A		N/A		N/A		N/A		23*	10/27/97	29	10/27/97	11
Lead									0.00613*	6/11/93			0.0113	6/11/93			0.00324	6/10/93									0.015
Magnesium	N/A		N/A		N/A		N/A		92	10/22/97	48	10/22/97	N/A		N/A		N/A		N/A		N/A		210	10/27/97	460	10/27/97	
Manganese	N/A		N/A		N/A		N/A		1	10/22/97			N/A		N/A		N/A		N/A		N/A		0.791	10/27/97	29.8	10/27/97	14
Mercury					0.00086	6/14/95	0.0003	6/15/95																		0.002	
Nickel	0.05	6/14/95	0.07	6/13/95	0.142	6/8/93																			0.484	10/27/97	0.1
Potassium	N/A		N/A		N/A		N/A						N/A		N/A		N/A		N/A		N/A						
Selenium							0.0156	6/8/93	0.01	10/22/97																	0.05
Silver																										0.51	
Sodium	N/A		N/A		N/A		N/A		390	10/22/97	170	10/22/97	N/A		N/A		N/A		N/A		N/A		540	10/27/97	860	10/27/97	
Strontium	N/A		N/A		N/A		N/A		2.55	10/22/97	2.32	10/22/97	N/A		N/A		N/A		N/A		N/A		5.33	10/27/97	10.4	10/27/97	22
Thallium																											0.002
Vanadium	N/A		N/A		N/A		N/A						N/A		N/A		N/A		N/A		N/A						0.72
Zinc																									0.224	10/27/97	31

Dioxins Detected at Site 16 (pg/l)	16WW01		16WW02		16WW03		16WW04		16WW05		16WW06		16WW07		16WW08		16WW09		16WW10		16WW11		16WW12		16WW13		MSCs (pg/l)
	Date		Date		Date		Date		Date		Date		Date		Date		Date		Date		Date		Date		Date		
	Max. Conc.	Sampled	Max. Conc.	Sampled	Max. Conc.	Sampled	Max. Conc.	Sampled	Max. Conc.	Sampled	Max. Conc.	Sampled	Max. Conc.	Sampled	Max. Conc.	Sampled	Max. Conc.	Sampled	Max. Conc.	Sampled	Max. Conc.	Sampled	Max. Conc.	Sampled	Max. Conc.	Sampled	
2,3,7,8-TCDF	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		4.5
1,2,3,4,6,7,8-HpCDD	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		—
1,2,3,4,7,8,9-HpCDF	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		45
1,2,3,4,7,8-HxCDF	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		4.5
1,2,3,6,7,8-HxCDF	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		4.5
1,2,3,4,6,7,8-HpCDF	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		45
1,2,3,6,7,8-HxCDD	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		4.5
1,2,3,7,8,9-HxCDD	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		4.5
1,2,3,4,7,8-HxCDD	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		4.5
Heptachlorodibenzo-p-dioxins	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		11
1,2,3,7,8-PeCDD	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		0.9
Tetrachlorodibenzo-p-dioxin	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		0.45
PECDD	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		—
1,2,3,7,8,9-HxCDF	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		4.5
HPCDF	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		—
1,2,3,7,8-PeCDF	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		9
Hexachlorodibenzo-p-dioxin	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		11
OCDF	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		450
OCDD	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		450
2,3,7,8-TCDD	N/A																								4.6	—	
2,3,4,7,8-PeCDF	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		0.9

Anions Detected at Site 16 (mg/l)	16WW01		16WW02		16WW03		16WW04		16WW05		16WW06		16WW07		16WW08		16WW09		16WW10		16WW11		16WW12		16WW13		MSC (mg/l)
	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	
Chloride	27.8	6/10/93	256	6/10/93	508.9	6/8/93	594	6/8/93	1270	10/22/97	596	10/22/97	7.6	6/11/93	248.5	6/11/93	118.7	6/10/93	342.8	6/9/93	313.4*	6/9/93	648	10/27/97	335	10/27/97	300 ²
Nitrate			0.39	6/10/93					0.17	6/11/93			0.11	6/11/93			0.49	6/10/93					N/A		N/A		10
Nitrate plus Nitrite(as N)									0.229	10/22/97													2.37*	10/27/97			
Sulfate	368.5	6/10/93	1854.9	6/10/93	4926	6/8/93	7266	6/8/93	36.4	6/11/93	5.92	10/22/97	86.4	6/11/93	412.9	6/11/93	677.9	6/10/93	234.5	6/9/93	2776*	6/9/93	1200	10/27/97	3111	10/27/97	300 ³

* Indicates the maximum concentration identified for this compound was from a duplicate sample collected during the sampling event

N/A - Compound was not analyzed for at this location during the sampling event

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

B- The analyte was detected in an associated blank (Organics only).

MSC- Medium-Specific Concentrations (**Bold** values exceed the MSC for that compound)

1. Values represented are EPA Region 6 Human Health Medium-Specific Screening Levels for Tap Water, no MSC's for this constituent were available from TNRCC.

2. Values for Chloride and Sulfate presented are TNRCC Secondary Constituent Levels, no MSC's for this constituent were available from TNRCC.

3. Values represented are EPA Region 6 Human Health Medium-Specific Screening Levels for Industrial Soil, no MSC's for this constituent were available from TNRCC.

Table 4-16
Site 16 - Groundwater Summary

Metals Detected at Site 16 (mg/l)	16WW14		16WW15		16WW16		16WW17		16WW18		16WW19		16WW20		16WW21		16WW22		16WW23		16WW24		16WW25		16WW26		MSC (mg/l)
	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	
Aluminum	3.3	10/24/97	0.75	10/28/97	17	10/27/97	0.21	10/27/97	0.27	10/28/97	3.1	10/24/97	40	10/24/97	2.1	10/28/97	8.4	10/24/97	0.57	10/23/97	46	10/23/97			9.3	10/23/97	100
Antimony																											0.006
Arsenic			.02J	6/22/95			.017J	6/16/95					0.023	10/24/97											0.011	10/23/97	0.05
Barium	0.176	6/13/95	.032J	6/22/95	0.06	6/15/95	6.5J	6/16/95	0.06	6/15/95			0.47	10/24/97					1.4	10/23/97	2.3	10/23/97			0.22	10/23/97	2
Beryllium													0.0074	10/24/97							0.0023	10/23/97			0.0006	10/23/97	0.004
Cadmium													0.0023	10/24/97													0.005
Calcium	170	10/24/97			180	10/27/97					13	10/24/97	20	10/24/97	16	10/28/97	310	10/24/97	140	10/23/97	34	10/23/97	170	10/23/97	5.7	10/23/97	
Chromium	3.09	10/24/97	0.012	6/22/95	0.324	10/27/97	0.027	6/16/95	0.051	6/15/95	0.06	10/24/97	0.129	10/24/97	0.018	10/28/97	0.069	10/24/97	0.037	10/23/97	5.22	10/23/97	0.019	10/23/97	0.114	10/23/97	0.1
Cobalt													0.059	10/24/97							0.197	10/23/97					6.1
Copper													0.062	10/24/97							0.051	10/23/97					1.3
Iron	16	10/24/97	1.1	10/28/97	21	10/27/97	0.39	10/27/97	0.41	10/28/97	3.1	10/24/97	41	10/24/97	1.9	10/28/97	11	10/24/97	180	10/23/97	160	10/23/97	110	10/23/97	14	10/23/97	11 ¹
Lead			0.03	6/22/95			0.02	6/16/95			0.006	10/24/97	0.052	10/24/97							0.037	10/23/97			0.008	10/23/97	0.015
Magnesium	120	10/24/97			140	10/27/97							15	10/24/97	8.2	10/28/97	220	10/24/97	81	10/23/97	32	10/23/97	99	10/23/97	6.9	10/23/97	
Manganese	0.483	10/24/97	0.018	10/28/97	0.831	10/27/97			0.015	10/28/97	0.059	10/24/97	0.747	10/24/97	0.25	10/28/97	0.167	10/24/97	11.9	10/23/97	4.77	10/23/97	3.19	10/23/97	0.286	10/23/97	14
Mercury																											0.002
Nickel	1.63	10/24/97			0.042	6/15/95			0.058	6/15/95	0.057	10/24/97	0.155	10/24/97	0.056	10/28/97					0.751	10/23/97	0.178	10/23/97	0.17	10/23/97	0.1
Potassium													15	10/24/97							10	10/23/97	5.1	10/23/97			
Selenium													0.01	10/24/97					0.008	10/23/97	0.008	10/23/97					0.05
Silver	0.067	10/24/97																			0.114	10/23/97					0.51
Sodium	520	10/24/97	230	10/28/97	580	10/27/97	190	10/27/97	220	10/28/97	150	10/24/97	53	10/24/97	79	10/28/97	810	10/24/97	200	10/23/97	220	10/23/97	170	10/23/97	16	10/23/97	
Strontium	3.05	10/24/97	0.058	10/28/97	2.93	10/27/97					0.411	10/24/97	0.989	10/24/97	0.736	10/28/97	5.58	10/24/97	2.9	10/23/97	0.92	10/23/97	4.68	10/23/97	0.122	10/23/97	22 ¹
Thallium																											0.002
Vanadium													0.128	10/24/97							0.097	10/23/97					0.72
Zinc			0.058	10/28/97			0.025	10/27/97					0.2	10/24/97							0.12	10/23/97			0.064	10/23/97	31

Dioxins Detected at Site 16 (pg/l)	16WW14		16WW15		16WW16		16WW17		16WW18		16WW19		16WW20		16WW21		16WW22		16WW23		16WW24		16WW25		16WW26		MSCs (pg/l)
	Max. Conc.	Date	Max. Conc.	Date	Max. Conc.	Date	Max. Conc.	Date	Max. Conc.	Date	Max. Conc.	Date	Max. Conc.	Date	Max. Conc.	Date	Max. Conc.	Date	Max. Conc.	Date	Max. Conc.	Date	Max. Conc.	Date	Max. Conc.	Date	
		Sampled		Sampled		Sampled		Sampled		Sampled		Sampled		Sampled		Sampled		Sampled		Sampled		Sampled		Sampled		Sampled	
2,3,7,8-TCDF	N/A		N/A		9.5		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		4.5
1,2,3,4,6,7,8-HpCDD	N/A		N/A		52.1		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		—
1,2,3,4,7,8,9-HpCDF	N/A		N/A				N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		45
1,2,3,4,7,8-HxCDF	N/A		N/A		3.4J		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		4.5
1,2,3,6,7,8-HxCDF	N/A		N/A				N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		4.5
1,2,3,4,6,7,8-HpCDF	N/A		N/A				N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		45
1,2,3,6,7,8-HxCDD	N/A		N/A				N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		4.5
1,2,3,7,8,9-HxCDD	N/A		N/A		3.9J		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		4.5
1,2,3,4,7,8-HxCDD	N/A		N/A				N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		4.5
Heptachlorodibenzo-p-dioxins	N/A		N/A		108		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		11
1,2,3,7,8-PeCDD	N/A		N/A				N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		0.9
Tetrachlorodibenzo-p-dioxin	N/A		N/A				N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		0.45
PeCDD	N/A		N/A				N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		—
1,2,3,7,8,9-HxCDF	N/A		N/A				N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		4.5
HPCDF	N/A		N/A				N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		—
1,2,3,7,8-PeCDF	N/A		N/A				N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		9
Hexachlorodibenzo-p-dioxin	N/A		N/A		8.7		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		11
OCDF	N/A		N/A		5.6		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		450
OCDD	N/A		N/A		1360		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		450
2,3,7,8-TCDD																										4.6	
2,3,4,7,8-PeCDF	N/A		N/A		3.1J		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		0.9

Anions Detected at Site 16 (mg/l)	16WW14		16WW15		16WW16		16WW17		16WW18		16WW19		16WW20		16WW21		16WW22		16WW23		16WW24		16WW25		16WW26		MSC (mg/l)
	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	
Chloride	748	10/24/97	120	10/28/97	533	10/27/97	105	10/27/97	104	10/28/97	376	10/24/97	25	10/24/97	88	10/28/97	1515	10/24/97	520	10/23/97	512	10/23/97	929	10/23/97	378	10/23/97	300 ²
Nitrate	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		10
Nitrate plus Nitrite(as N)	0.052	10/24/97			0.084	10/27/97	0.05	10/27/97			0.093	10/24/97	0.057	10/24/97	0.108	10/28/97	0.872	10/24/97	.06J	10/23/97	.059J	10/23/97	.068J	10/23/97			
Sulfate	323	10/24/97	1265	10/28/97	725	10/27/97	3.49	10/27/97	435	10/28/97	2312	10/24/97	3.1	10/24/97	278	10/28/97	5981	10/24/97	592	10/23/97	17	10/23/97	6540	10/23/97	2631	10/23/97	300 ²

* Indicates the maximum concentration identified for this compound was from a duplicate sample collected during the sampling event

N/A - Compound was not analyzed for at this location during the sampling event

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

B- The analyte was detected in an associated blank (Organics only).

MSC- Medium-Specific Concentrations (**Bold** values exceed the MSC for that compound)

1. Values represented are EPA Region 6 Human Health Medium-Specific Screening Levels for Tap Water, no MSC's for this constituent were available from TNRCC.

2. Values for Chloride and Sulfate presented are TNRCC Secondary Constituent Levels, no MSC's for this constituent were available from TNRCC.

3. Values represented are EPA Region 6 Human Health Medium-Specific Screening Levels for Industrial Soil, no MSC's for this constituent were available from TNRCC.

Table 4-16
Site 16 - Groundwater Summary

Metals Detected at Site 16 (mg/l)	16WW27		16WW28		16WW29		16WW30		16WW31		16WW32		16WW33		16WW34		16WW35		16WW36		16WW37		16WW38		16EW01		MSC (mg/l)
	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	
Aluminum	10	10/21/97	1.9	10/21/97							3.6	10/22/97	2.7	10/22/97	67	10/22/97			7.9	10/27/97	7.7	10/21/97	11	10/22/97	0.82	3/16/96	100
Antimony															0.014	10/22/97											0.006
Arsenic															0.014	10/22/97											0.05
Barium	0.93	10/21/97	0.47	10/21/97	0.21	10/21/97	0.77	10/21/97			1.3	10/22/97			1.8	10/22/97									0.111	2/21/96	2
Beryllium	0.0009	10/21/97													0.0037	10/22/97											0.004
Cadmium															0.0011	10/22/97											0.005
Calcium	48	10/21/97	21	10/21/97	66	10/21/97	42	10/21/97	100*	10/22/97	240	10/22/97	130	10/22/97	92	10/22/97	420	10/24/97	230	10/27/97	440*	10/21/97	170	10/22/97	300*	10/29/97	
Chromium	0.066	10/21/97	0.037	10/21/97			0.06	10/21/97	0.041*	10/22/97	0.369	10/22/97	0.082	10/22/97	2.85	10/22/97					0.251*	10/21/97	0.242	10/22/97			0.1
Cobalt															0.053	10/22/97											6.1
Copper															0.082	10/22/97									0.045	3/16/96	1.3
Iron	80	10/21/97	37	10/21/97	32	10/21/97	28	10/21/97	0.7	10/22/97	7	10/22/97	4.3	10/22/97	120	10/22/97	15	10/24/97	11	10/27/97	10*	10/21/97	17	10/22/97	6.21	3/16/96	11 [†]
Lead	0.011	10/21/97	0.003	10/21/97											0.057	10/22/97											0.015
Magnesium	29	10/21/97	16	10/21/97	39	10/21/97	31	10/21/97	69	10/22/97	130	10/22/97	86	10/22/97	74	10/22/97	430	10/24/97	200	10/27/97	320*	10/21/97	130	10/22/97	349	3/16/96	
Manganese	2.62	10/21/97	1.16	10/21/97	1.49	10/21/97	1.47	10/21/97	0.527	10/22/97	0.196	10/22/97	5.08	10/22/97	1.03	10/22/97	7.35	10/24/97	2.9	10/27/97	5.7*	10/21/97	0.229	10/22/97	1.03	3/16/96	14
Mercury																									0.0003	3/17/96	0.002
Nickel	0.05	10/21/97					0.175	10/21/97	*	*					0.699	10/22/97									0.047	3/16/96	0.1
Potassium															15	10/22/97											
Selenium															0.007	10/22/97											0.05
Silver															0.052	10/22/97											0.51
Sodium	110	10/21/97	100	10/21/97	120	10/21/97	140	10/21/97	270*	10/22/97	430	10/22/97	360	10/22/97	250	10/22/97	4400	10/24/97	1200	10/27/97	1300	10/21/97	570	10/22/97	770*	10/29/97	
Strontium	1.14	10/21/97	0.492	10/21/97	2.05	10/21/97	1.12	10/21/97	2.09	10/22/97	4.32	10/22/97	2.97	10/22/97	1.96	10/22/97	8.66	10/24/97	3.85	10/27/97	8.65*	10/21/97	3	10/22/97	6.89	3/16/96	22 [†]
Thallium							0.012	10/21/97																			0.002
Vanadium															0.146	10/22/97											0.72
Zinc	0.053	10/21/97					0.032	10/21/97							0.341	10/22/97									12.7	3/16/96	31

Dioxins Detected at Site 16 (pg/l)	16WW27		16WW28		16WW29		16WW30		16WW31		16WW32		16WW33		16WW34		16WW35		16WW36		16WW37		16WW38		16EW01		MSCs (pg/l)
	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	
2,3,7,8-TCDF	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A				5.3J	10/27/97	N/A		N/A				4.5
1,2,3,4,6,7,8-HpCDD	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A				5.5	10/27/97	N/A		N/A				—
1,2,3,4,7,8,9-HpCDF	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A						N/A		N/A		3.8J		45
1,2,3,4,7,8-HxCDF	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A						N/A		N/A		4.5J		4.5
1,2,3,6,7,8-HxCDF	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A						N/A		N/A		3		4.5
1,2,3,6,7,8-HxCDD	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A						N/A		N/A		3.7		45
1,2,3,4,6,7,8-HpCDF	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A						N/A		N/A		3.9		4.5
1,2,3,6,7,8-HxCDD	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A						N/A		N/A		4.9		4.5
1,2,3,7,8,9-HxCDD	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A						N/A		N/A		3.9J		4.5
1,2,3,4,7,8-HxCDD	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A				15.6	10/27/97	N/A		N/A				11
Heptachlorodibenzo-p-dioxins	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A						N/A		N/A		5		0.9
1,2,3,7,8-PeCDD	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A						N/A		N/A		4.6		0.45
Tetrachlorodibenzo-p-dioxin	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A						N/A		N/A		5		—
PECDD	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A						N/A		N/A		4.9		4.5
1,2,3,7,8,9-HxCDF	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A						N/A		N/A		3.7		—
HPCDF	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A						N/A		N/A		5.6J		9
1,2,3,7,8-PeCDF	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A						N/A		N/A		8.8J		11
Hexachlorodibenzo-p-dioxin	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A						N/A		N/A		7.2		450
OCDF	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A						N/A		N/A				450
OCDD	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A				94	7/10/97	189	10/27/97	N/A				—
2,3,7,8-TCDD																					N/A		N/A		5.4J		0.9
2,3,4,7,8-PeCDF	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A						N/A		N/A				

Anions Detected at Site 16 (mg/l)	16WW27		16WW28		16WW29		16WW30		16WW31		16WW32		16WW33		16WW34		16WW35		16WW36		16WW37		16WW38		16EW01		MSC (mg/l)
	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	
Chloride	323	10/21/97	342	10/21/97	240	10/21/97	390	10/21/97	1016	10/22/97	1430	10/22/97	997	10/22/97	492	10/22/97	668	10/24/97	357	10/27/97	596	10/21/97	1242	10/22/97	692*	10/29/97	300 [†]
Nitrate	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		10
Nitrate plus Nitrite(as N)					0.135	10/21/97							0.05	10/22/97	0.124	10/22/97	0.115	10/24/97			0.155	10/21/97	0.087	10/22/97	2.01*	10/29/97	
Sulfate	188	10/21/97	48.34	10/21/97	347	10/21/97	25.92	10/21/97	43.3*	10/22/97	18.91	10/22/97	63.1	10/22/97	16.05	10/22/97	9417	10/24/97	2136	10/27/97	6672	10/21/97	290	10/1/97	2188*	10/29/97	300 [†]

* Indicates the maximum concentration identified for this compound was from a duplicate sample collected during the sampling event

N/A - Compound was not analyzed for at this location during the sampling event

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

B- The analyte was detected in an associated blank (Organics only).

MSC- Medium-Specific Concentrations (**Bold** values exceed the MSC for that compound)

1. Values represented are EPA Region 6 Human Health Medium-Specific Screening Levels for Tap Water, no MSC's for this constituent were available from TNRCC.

2. Values for Chloride and Sulfate presented are TNRCC Secondary Constituent Levels, no MSC's for this constituent were available from TNRCC.

3. Values represented are EPA Region 6 Human Health Medium-Specific Screening Levels for Industrial Soil, no MSC's for this constituent were available from TNRCC.

Table 4-16
Site 16 - Groundwater Summary

Metals Detected at Site 16 (mg/l)	16EW02		16EW03		16EW04		16EW05		16EW06		16EW07		16EW08		122		BH-12		BH-13		BH-14		BH-15		BH-16		MSC (mg/l)
	Date		Date		Date		Date		Date		Date		Date		Date		Date		Date		Date		Date		Date		
	Max. Conc.	Sampled	Max. Conc.	Sampled	Max. Conc.	Sampled	Max. Conc.	Sampled	Max. Conc.	Sampled	Max. Conc.	Sampled	Max. Conc.	Sampled	Max. Conc.	Sampled	Max. Conc.	Sampled	Max. Conc.	Sampled	Max. Conc.	Sampled	Max. Conc.	Sampled	Max. Conc.	Sampled	
Aluminum	26.8	2/23/96	1.4	10/29/97											0.362	11/16/82	24.1	1/1/87	1.6	1/1/87	0.227	11/16/82			11.9	1/1/87	100
Antimony															0.001	1/1/87											0.006
Arsenic	0.007	2/23/96													0.017	6/2/93											0.05
Barium	0.192	2/23/96											0.57	10/29/97	1.2	6/2/93	0.34	1/1/87	0.5	1/23/80	0.0955	11/16/82	0.6	1/23/80	0.6	1980&87	2
Beryllium															0.00001	1/1/87	0.01	1/1/87	0.02	1/1/87	0.00297	11/16/82	0.01	1/23/80	0.00001	1/1/87	0.004
Cadmium			0.0018	10/29/97											0.01	1/1/87	0.02	1/1/87	0.01	1/1/87	0.00297	11/16/82	0.01	1/23/80	0.01	1/1/87	0.005
Calcium	370	10/29/97	150	10/29/97	74	10/29/97	490	10/29/97	160	10/29/97	200	10/29/97	39	10/29/97	5.2	1/23/80	33.9	1/23/80	81.7	1/23/80	100	1/23/80	135.4	1/23/80			
Chromium	0.047	2/23/96	0.586	10/29/97									0.012	10/29/97	0.0087	11/16/82	0.0558	11/16/82	0.0133	11/16/82	0.0076	11/16/82			0.028	1/1/87	0.1
Cobalt																											6.1
Copper	0.484	3/16/96	0.042	10/29/97											0.00003	1/1/87	0.03	1/1/87	0.02	1/1/87					0.00004	1/1/87	1.3
Iron	28.1	2/23/96	3.9	10/29/97	0.27	10/29/97	24	10/29/97	40	10/29/97	110	10/29/97	37	10/29/97			1	1/23/80	0.22	1/23/80					0.066	1/1/87	11 ¹
Lead															0.00367	6/2/93	0.0496	11/16/82			0.0809	11/16/82					0.015
Magnesium	473	2/29/96	120	10/29/97	73	10/29/97	400	10/29/97	120	10/29/97	120	10/29/97	26	10/29/97	32.5	1/23/80	63	1/23/80	118.8	1/23/80	115.1	1/23/80	15.5	1/23/80			
Manganese	1.68	2/23/96	2.79	10/29/97	0.713	10/29/97	5.55	10/29/97	3.22	10/29/97	5.53	10/29/97	1.4	10/29/97	4.46	11/16/82	0.19	1/1/87	0.127	11/16/82	0.321	11/16/82	0.13	1/23/80	0.36	11/16/82	14
Mercury	0.003J	2/29/96															0.0005	1/23/80	0.0004	1/23/80	0.0003	1/23/80	0.0003	1/23/80	0.0002	1/23/80	0.002
Nickel	0.079	2/23/96	0.457	10/29/97													0.049	11/16/82	0.034	11/16/82	0.073	11/16/82			0.165	11/16/82	0.1
Potassium																	0.71	1/23/80	1.28	1/23/80	1.21	1/23/80	2.75	1/23/80	1.89	1/23/80	
Selenium										0.01	10/29/97	0.008	10/29/97														0.05
Silver			0.014	10/29/97															0.01	1/1/87							0.51
Sodium	720	10/29/97	200	10/29/97	240	10/29/97	2100	10/29/97	530	10/29/97	200	10/29/97	100	10/29/97													
Strontium	8.5	2/29/96	3.3	10/29/97	1.73	10/29/97	9.9	10/29/97	3.61	10/29/97	5.99	10/29/97	1.11	10/29/97	1.13	1/1/87	0.12	1/23/80	0.93	11/16/82	1.56	11/16/82	2.3	1/23/80	2.92	11/16/82	22 ¹
Thallium																					0.14	11/16/82			0.16	11/16/82	0.002
Vanadium																											0.72
Zinc	37	3/13/96	0.2	10/29/97	0.021	10/21/97			0.199	10/29/97					0.00001	1/1/87	1.3	1/1/87	0.07	1/1/87	0.04	1/23/80	0.049	1/23/80	0.068	1/23/80	31

Dioxins Detected at Site 16 (pg/l)	16EW02		16EW03		16EW04		16EW05		16EW06		16EW07		16EW08		122		BH-12		BH-13		BH-14		BH-15		BH-16		MSCs (pg/l)
	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	
2,3,7,8-TCDF	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		4.5
1,2,3,4,6,7,8-HpCDD	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		—
1,2,3,4,7,8,9-HpCDF	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		45
1,2,3,4,7,8-HxCDF	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		4.5
1,2,3,6,7,8-HxCDF	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		4.5
1,2,3,4,6,7,8-HpCDD	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		45
1,2,3,6,7,8-HxCDD	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		4.5
1,2,3,7,8,9-HxCDD	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		4.5
1,2,3,4,7,8-HxCDD	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		4.5
Heptachlorodibenzo-p-dioxins	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		11
1,2,3,7,8-PeCDD	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		0.9
Tetrachlorodibenzo-p-dioxin	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		0.45
PeCDD	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		—
1,2,3,7,8,9-HxCDF	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		4.5
HPCDF	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		—
1,2,3,7,8-PeCDF	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		9
Hexachlorodibenzo-p-dioxin	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		11
OCDF	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		450
OCDD	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		450
2,3,7,8-TCDD																										—	
2,3,4,7,8-PeCDF	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A		0.9

Anions Detected at Site 16 (mg/l)	16EW02		16EW03		16EW04		16EW05		16EW06		16EW07		16EW08		122		BH-12		BH-13		BH-14		BH-15		BH-16		MSC (mg/l)
	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	Max. Conc.	Date Sampled	
Chloride	682	10/29/97	240	10/29/97	341	10/29/97	630	10/29/97	277	10/29/97	254	10/29/97	249	10/29/97	328	11/16/82	22	1/23/80	1056	11/16/82	826	11/16/82	1182	1/23/80	1180	1/1/87	300 ²
Nitrate	N/A		N/A		N/A		N/A		N/A		N/A		N/A		2.76	1/1/87	1.23	11/16/82	0.78	1/1/87					2.19	1/1/87	10
Nitrate plus Nitrite(as N)	0.134	10/29/97	0.164	10/29/97			1.77	10/29/97	0.488	10/29/97							13	1/23/80	0.27	1/23/80	0.43	1/23/80	12	1/23/80	11	1/23/80	
Sulfate	2948	10/29/97	1214	10/29/97	653	10/29/97	4863	10/29/97	1192	10/29/97	1256	10/29/97	301	10/29/97	122	11/16/82	5	1/23/80	17	1/23/80	67	11/16/82	21	1/23/80	67	11/16/82	300 ²

* Indicates the maximum concentration identified for this compound was from a duplicate sample collected during the sampling event

N/A - Compound was not analyzed for at this location during the sampling event

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

B- The analyte was detected in an associated blank (Organics only).

MSC- Medium-Specific Concentrations (**Bold** values exceed the MSC for that compound)

1. Values represented are EPA Region 6 Human Health Medium-Specific Screening Levels for Tap Water, no MSC's for this constituent were available from TNRCC.

2. Values for Chloride and Sulfate presented are TNRCC Secondary Constituent Levels, no Msc's for this constituent were available from TNRCC.

3. Values represented are EPA Region 6 Human Health Medium-Specific Screening Levels for Industrial Soil, no MSC's for this constituent were available from TNRCC.

Table 4-17
Groundwater Analytical Summary - VOCs

Volatile Organic Compound	Number of Samples with Detectable Conc.	MSC Value (ug/l)	Number of Samples that Exceed MSC	Comments
Methylene Chloride	16	5	6	Exceeded MSCs at 16WW03,04 and 16EW01
Trichloroethene	104	5	88	Exceeded MSCs at 16WW01,02,03,04,10,11,12,13, 14,16, 20,21,22,26,29,30,34,35,36,37,38 and 16EW01,02,03,04,05,06,08
1,1-Dichloroethene	16	70	2	Exceeded MSC on two sampling dates at 16WW16
cis-1,2-Dichloroethene	53	70	22	Exceeded MSCs at 16WW12,13,16,21, 22,26,36,37,38 and 16EW01,02,05,06
trans-1,2-Dichloroethene	4	100	1	Exceeded MSCs at 16WW16
1,1,2-Trichloroethane	1	5	1	Exceeded MSCs at 16WW16 on 6/15/95
1,2-Dichloroethane	6	5	6	Exceeded MSCs at 16WW12,16,22 and 16EW01
1,2-Dichloroethene	11	70	6	Exceeded MSCs at 16WW01,16 and 16EW01
Vinyl Chloride	17	2	17	Exceeded MSCs at 16WW01,04,11,12,13,16,21,22, 26,35,38 and 16EW01,06
1,1-Dichloroethane	4	10000	0	Detected at monitoring wells 16WW16,22,35
1,2,4-Trimethylbenzene	2		0	Detected at monitoring wells 16WW16 and 16WW29
Bromodichloromethane	3	100	0	Detected at monitoring wells 16WW25,30,34
Trichlorofluoromethane	2	31000	0	Detected at monitoring wells 16WW01,03
Chloroform	21	100	0	Detected at monitoring wells 16WW01,05,06,13,16,19, 20,21,22, 24,25,26,30,31,32,33,34,35 and 16EW01
Acetone	4	10000	0	Detected at monitoring wells 16WW06,17 and 16EW01 and 122
Benzene	4	5	0	Detected at monitoring wells 16WW12,16,22,30
Xylene	2	10000	0	Detected in monitoring well 16WW16
Carbon Disulfide	1		0	Detected in monitoring well 16WW01
Isobutyl alcohol	1		0	Detected in monitoring well 16WW38
1,3,5-Trimethylbenzene	1		0	Detected in monitoring well 16WW16
2-Butanone	1	8200	0	Detected in monitoring well 16WW13
Ethylbenzene	1	700	0	Detected in monitoring well 16WW16
Iodomethane	1		0	Detected in monitoring well 16WW01
Toluene	1	1000	0	Detected in monitoring well 16WW16

Table 4-18
Groundwater Zones at Site 16

Water Bearing Zone	Wells Installed in Groundwater Zone
Shallow	122, 16WW01,03,05,07,09,12,13,14,16,22,24,26,28,30,32, 34,36,38, and 16EW01,02,03,04
Intermediate	16WW02,04,06,08,10,11,23,25,27,29,31,33,35,37 and 16EW05,06,07,08
Upper Deep	16WW19,20,21
Lower Deep	16WW15,17,18

One compound, trichloroethene at a concentration of 1.3 µg/l, was detected in one of the three lower deep monitoring wells (16WW17) during the October 1997 sampling event. Trichloroethene was detected in each of the upper deep monitoring wells 16WW19, 16WW20 and 16WW21 at concentrations of 5, 7.9, 140 µg/l. The groundwater sample collected from monitoring well 16WW21 also contained concentrations of cis-1,2-dichloroethene at 360 µg/l and vinyl chloride at 4.8 µg/l. A map providing total VOCs in the upper deep and deep water bearing zone is presented in Figure 4-4 (Appendix I).

Laboratory analysis for SVOCs was performed on monitoring wells 16WW 01 – 16WW11 and two extraction wells 16EW01 and 16EW02. Only 2 SVOCs, bis(2-ethylhexyl)phthalate and butylbenzylphthalate were detected in groundwater samples collected from extraction well 16EW02. The bis(2-ethylhexyl)phthalate concentrations exceeded the MSC value in all 5 samples from 16EW02 and none of the butylbenzylphthalate concentrations exceeded the MSC value. Only 1 pesticide, aldrin, was detected in a groundwater sample collected from monitoring well 16EW01 at a concentration of 0.04 µg/l and exceeds the MSC value. Eleven HE compounds were detected in the groundwater samples at concentrations below MSC values. Table 4-19 provides a summary of SVOC, pesticides, and explosive compound detected at Site 16.

Anions, chloride, nitrate, nitrate plus nitrite, and sulfate, were analyzed for in the groundwater samples collected at Site 16. The detected nitrate and nitrate plus nitrite concentrations were below MSC values. There are no MSC values for chloride and sulfate. Chloride and sulfate values were compared to TNRCC Secondary Constituent Levels (SCL). Chloride concentrations exceeded the SCL value (SCL = 300 mg/l) in 32 samples and sulfate concentration exceeded the SCL value (SCL = 300 mg/l) in 30 samples. Table 4-20 provides a summary of anions detected at site 16 and the maximum concentration detected at each well is presented in Table 4-16. *Note from TNRCC 30 TAC 290.113 regarding Secondary Constituent Levels: The following secondary constituent levels are limits, applicable to all public water systems. No drinking water supply that does not meet the Secondary Constituent Levels may be used without written approval from the commission.*

Fifteen groundwater samples collected from monitoring and extraction wells completed in the shallow water bearing zone had sulfate concentrations that exceeded the SCL value. An iso-concentration map of the sulfate concentrations in the shallow water bearing zone is presented in Figure 4-5 (Appendix I). Twelve groundwater samples collected from monitoring and extraction wells completed in the intermediate water bearing zone had sulfate concentrations that exceeded the SCL value. An iso-concentration map of the sulfate concentrations in the intermediate water bearing zone is presented in Figure 4-6 (Appendix I). Sulfate concentrations exceeded the SCL value in groundwater samples collected from monitoring wells 16WW15, 16WW18, and 16WW19, completed in the deep water bearing zone. An iso-concentration map of the sulfate concentrations in the deep water bearing zone is presented in Figure 4-7 (Appendix I). The spatial distribution of sulfate concentrations detected in the groundwater samples collected from the shallow and intermediate water bearing zones suggests that the likely source is leachate from the landfill.

Table 4-19
Groundwater Analytical Summary - SVOCs, Pesticides and Explosives

Compound	Number of Samples with Detectable Conc.	MSC Value (ug/l)	Detectable Concentration Range (ug/l)	Comments
Semi-Volatiles				
Bis(2-ethylhexyl)phthalate	5	6	11-26*	Exceeds MSC at extraction well 16EW02
Butylbenzylphthalate	3	20000	5-7	Detected in extraction well 16EW02
Pesticide				
Aldrin	1	0.017	0.04J	Exceeds MSC in extraction well 16EW01
Explosives				
2,4-Dinitrotoluene	8	0.42	0.034J-0.083*	Detected at extraction wells 16EW01,02
2,6-Dinitrotoluene	10	0.42	0.045J-0.263J	Detected at extraction wells 16EW01,02
4-Amino-2,6-dinitrotoluene	18		0.059-1.0	Detected at wells 16WW03,04 and 16EW01,02
HMX	2	1800	0.12-2.9	Detected at wells 122 and 16EW01
1,3-Dinitrobenzene	18	10	0.329-1.56	Detected at extraction wells 16EW01,02
3-Nitrotoluene	3	1000	0.2-1.0	Detected at monitoring wells 16WW32,33,34
Nitrobenzene	8	51	0.062*-1.5	Detected at wells 16WW05 and 16EW01,02
RDX	15	6.1	0.27-4.75J	Detected at wells 16WW03 and 16EW01,02
1,3,5-Trinitrobenzene	3	3100	0.302-0.74	Detected at wells 16WW08,10 and 16EW02
Tetryl	3		0.349-4.4	Detected at wells 16WW16 and 16EW02
2,4,6-Trinitrotoluene	3	51	0.9-1.56	Detected at wells 16WW03 and 16EW01

* Indicates the minimum and/or maximum concentration identified for this compound was from a duplicate sample collected during the sampling event

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

Table 4-20
Groundwater Analytical Summary -Anions

Compound	Number of Samples with Detectable Conc.	MSC/SCL Value (mg/l)	Detectable Concentration Range (mg/l)	Comments
Chloride	49	300**	7.6-1515	Detected in all wells; Exceeds SCLs in 16WW03,04,05,06,10, 12, 13,14,16,19,22,23,24,25,26,27,28,30,31,32,33,34,35,36,37,38 and 16EW01,02,04,05
Nitrate	4	10	0.11-0.49	Only analyzed for in monitoring wells 16WW01-11; Detected in monitoring wells 16WW02,05,07,09 below MSCs
Nitrate plus Nitrite(as N)	23		0.05-2.37	Detected in wells 16WW06,12,14,16,17,19,20,21, 22,23,24,25,29,33,34,35,37,38 and 16EW01,02,03,05,06
Sulfate	49	300**	3.1-9417	Detected in all wells; Exceeds SCLs in 16WW01,02,03,04,08,09, 11,12,13,14,15,16,18,19,22,23,25,26,29,35,36,37 and 16EW01,02,03,04,05,06,07,08

** Indicates the comparison value is from the TNRCC Secondary Constituent Levels (SCL) list

Twenty groundwater samples collected from monitoring and extraction wells completed in the shallow water bearing zone had chloride concentrations that exceeded the SCL value. Distribution of the chloride concentrations in the shallow water bearing zone are presented in Figure 4-8 (Appendix I). Eleven groundwater samples collected from monitoring and extraction wells completed in the intermediate water bearing zone had chloride concentrations that exceeded the SCL value. Distribution of the chloride concentrations in the intermediate water bearing zone are presented in Figure 4-9 (Appendix I). The groundwater sample collected from monitoring well 16WW19, completed in the upper portion of the deep water bearing zone, had a chloride concentration that exceeded the SCL value. Distribution of the chloride concentrations in the deep water bearing zone are presented in Figure 4-10 (Appendix I). The chloride data is presented without contours because no patterns are apparent. The elevated chloride concentrations are believed to be the result of leachate from the landfill, however, the data does not present a discernable pattern of migration.

Twenty-three metals were detected in the groundwater samples with 10 of the detected metals exceeding MSC values. MSC values for barium, beryllium, cadmium, chromium, iron, lead, manganese, nickel, thallium, and zinc were exceeded in the groundwater samples at Site 16. The metals data is summarized in Table 4-21 and the maximum concentration detected at each well site is provided in Table 4-16.

Barium, chromium, iron, lead, manganese, nickel, thallium, and zinc concentrations detected in groundwater samples collected from the monitoring and extraction wells completed in the shallow water bearing zone exceeded MSC values. Barium concentrations exceeded the MSC value in 2 samples, chromium concentrations exceeded the MSC value in 8 samples, iron concentrations exceeded the MSC value in 12 samples, lead concentrations exceeded the MSC value in 2 samples, the magnesium concentration in 1 sample exceeded the MSC value, nickel concentrations exceeded the MSC value in 9 samples, the thallium concentration in 1 sample exceeded the MSC value, and the zinc concentration in 1 sample exceeded the MSC value.

Table 4-21
Groundwater Analytical Summary - Metals

Metals	Detectable Concentration Range (mg/l)	MSC Value (mg/l)	Number of Samples that Exceed MSC	Comments
Aluminum	0.11-67	100	0	
Antimony	0	0.006	0	Not detected in Groundwater Samples collected at Site 16
Arsenic	0.007-0.034J	0.05	0	
Barium	0.017-9.9	2	3	Exceeds MSC at monitoring wells 16WW09,17,24
Beryllium	0.0006-0.0074	0.004	1	Exceeds MSC at monitoring well 16WW20
Cadmium	0.0011-0.00545	0.005	1	Exceeds MSC at monitoring well 122
Calcium	5.7-490	---		
Chromium	0.01-5.22	0.1	11	Exceeds MSC in wells 16WW12,14,16,20,24,26,32,34,37,38 and 16EW03
Cobalt	0.053-1.1	6.1	0	
Copper	0.021-0.484	1.3	0	
Iron	0.14-180	11 ¹	22	Exceeds MSC in wells 16WW12,13,14,16,20,23,24,25,26,27,28,29, 30,34,35,38 and 16EW02,05,06,07,08
Lead	0.003-0.057	0.015	5	Exceeds MSC at wells 16WW15,17,20,24,34
Magnesium	6.9-473	---	0	
Manganese	0.015-29.8	14	1	Exceeds MSC in monitoring well 16WW13
Mercury	0.0002-0.00086	0.002	0	
Nickel	0.015-1.63	0.1	11	Exceeds MSC in wells 16WW03,13,14,20,24,25,26,30,34 and 16EW03
Potassium	5.1-15	---	0	
Selenium	0.007-0.0156	0.05	0	
Silver	0.014-0.114	0.51	0	
Sodium	16-4400	---	0	
Strontium	0.058-10.4	22 ¹	0	
Thallium	0.012	0.002	1	Exceeds MSC in monitoring well 16WW30
Vanadium	0.097-0.146	0.72	0	
Zinc	0.021-37	31	1	Exceeds MSC in extraction well 16EW02

1. Values represented are EPA Region 6 Human Health Medium-Specific Screening Levels for Tap Water, no MSC's for this constituent were available from TNRCC.

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

Concentrations of iron exceeded the MSC value in groundwater samples collected from extraction wells 16EW05, 16EW06, 16EW07, and 16EW08) and monitoring wells 16WW23, 16WW25, 16WW27, 16WW29, and 16WW35 completed in the intermediate water bearing zone. Chromium exceeded the MSC value in a groundwater sample collected from monitoring well 16WW37 completed in the intermediate water bearing zone.

Concentrations of beryllium, chromium, iron, lead, and nickel exceeded MSC values in a groundwater sample collected from monitoring well 16WW20 completed in the upper portion of the deep water bearing zone. Groundwater samples collected from monitoring wells 16WW15 and 16WW17, completed in the lower portion of the deep water bearing zone, had lead concentrations that exceeded the MSC value. The groundwater sample collected from monitoring well 16WW17, completed in the lower portion of the deep water bearing zone, had a barium concentration that exceeded the MSC value.

Twenty-one dioxin/furan compounds were detected in the four groundwater samples submitted for analysis with nine compounds detected at concentrations greater than the US EPA Toxicity Equivalency Factor values. Eleven of the 21 detected dioxin/furan compounds were detected in only one groundwater sample collected from 16EW01. Table 4-22 provides a summary of the detected dioxin/furan associated with the groundwater sampling at Site 16. A summary of detected dioxin/furan compounds and respective concentrations are presented in Appendix V.

Each of the groundwater samples submitted for dioxin/furan analysis were collected from shallow monitoring wells with the exception of 16WW35 which is installed in the intermediate water zone. Only one dioxin/furan compound, OCDD, was detected in the groundwater sample collected from monitoring well 16WW35 at a concentration below the US EPA Toxicity Equivalency Factor value.

Table 4-22
Groundwater Analytical Summary - Dioxins/Furans

Metals	Number of Samples with Detectable Conc.	MSC Value (pg/l)	Number of Samples that Exceed MSC	Comments
2,3,7,8-TCDF	2	4.5	1	Exceeds MSC at monitoring well 16WW16
1,2,3,4,6,7,8-HpCDD	1	—	—	Detected in wells 16WW16 and 16WW36
1,2,3,4,7,8,9-HpCDF	1	45	0	Detected in well 16EW01
1,2,3,4,7,8-HxCDF	2	4.5	1	Detected in wells 16WW16 and 16EW01;at MSC value in well 16EW01
1,2,3,6,7,8-HxCDF	1	4.5	0	Detected in well 16EW01
1,2,3,4,6,7,8-HpCDF	1	45	0	Detected in well 16EW01
1,2,3,6,7,8-HxCDD	1	4.5	0	Detected in well 16EW01
1,2,3,7,8,9-HxCDD	2	4.5	1	Exceeds MSC at extraction well 16EW01
1,2,3,4,7,8-HxCDD	1	4.5	0	Detected in well 16EW01
Heptachlorodibenzo-p-dioxin	2	11	2	Exceeds MSC at monitoring well 16WW16 and 16WW36
1,2,3,7,8-PeCDD	1	0.9	1	Exceeds MSC in extraction well 16EW01
Tetrachlorodibenzo-p-dioxin	1	0.45	1	Exceeds MSC at extraction well 16EW01
PECDD	1	—	1	Detected in extraction well 16EW01
1,2,3,7,8,9-HxCDF	1	4.5	1	Exceeds MSC at extraction well 16EW01
HPCDF	1	—	0	Detected in well 16EW01
1,2,3,7,8-PeCDF	1	9	0	Detected in well 16EW01
Hexachlorodibenzo-p-dioxin	2	11	—	Detected in wells 16WW16 and 16EW01
OCDF	2	450	0	Detected in wells 16WW16 and 16EW01
OCDD	3	450	1	Exceeds MSC at monitoring well 16WW16
2,3,7,8-TCDD	1	—	0	Detected in well 16EW01
2,3,4,7,8-PeCDF	2	0.9	2	Exceeded MSC at monitoring wells 16WW16 and 16EW01

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

5.0 CONTAMINANT TRANSPORT AND FATE

This section presents the general methodology and a discussion of essential parameters used to evaluate potential transport mechanisms and environmental fate of constituents identified in samples collected at Site 16. The parameters listed below will be utilized to present a qualitative discussion on the potential fate and transport of constituents detected in the samples collected at the site and will be utilized in the identification of potential receptors.

5.1 PARAMETERS AFFECTING FATE AND TRANSPORT

The fate of chemicals in the environment will differ for each constituent depending upon two major groups of factors. The first group is the observed prevailing environmental conditions, including: temperature, presence and flow of water and air, and soil/solid matter composition. The second group includes the inherent physical properties of the chemicals, especially those properties that influence partitioning between phases and reaction tendencies. While these factors can be separated into the above groups to simplify the discussion, it should be noted that natural environments are complex. Variations in the chemical and physical parameters of individual constituents are often a function of the prevailing environmental conditions. Described below are important parameters that are fundamental in making predictions regarding the potential fate and transport of chemical constituents detected in environmental media collected at Site 16.

For the purpose of the following discussions, the prevailing environmental conditions are defined as those conditions that naturally exist at Site 16 and may have an influence upon the fate and transport of specific contaminants. The prevailing environmental conditions include climatic conditions, the hydrogeologic conditions, geology, and the physical properties and composition of the natural soil/solid matter at the facility. Section 3.0 of this report presents a generalized discussion of the physiologic conditions at Site 16 and includes information on the average climatic conditions based on local weather data. The following paragraphs briefly summarize the importance of a number of environmental conditions and parameters as they relate to the probable fate and transport of contaminants.

5.1.1 Soil Properties

Soils

Soil is a complex heterogeneous medium comprised of aqueous, gaseous, and mineral and organic solid components (Alloway, 1990). The minerals present are usually chemically decomposing rock fragments and secondary minerals such as clays, hydrous oxides of iron (Fe), aluminum (Al), manganese (Mn), and carbonates. The organic matter is comprised of living organisms (mesofauna and microorganisms), dead plant material (litter) and colloidal humus formed by the action of microorganisms on plant litter. The solid components are generally clustered together in the form of aggregates, which creates a system of interconnected voids that are filled with either water or air. Key soil properties which may influence the fate and transport of contaminants (e.g. by controlling adsorption of ions) include the mineralogical composition of the soil, soil pH, the organic matter, and oxidation and reduction (redox) potential. Soil can be described as a dynamic system, subject to short-term fluctuations in moisture content, pH, and redox conditions and undergoing gradual alterations in response to changes in environmental factors.

Soil Mineralogy

Soils evolve by the mechanical and chemical breakdown of the parent rock material. Primary minerals of parent rock (quartz, feldspars, micas, etc.) which were generally formed under conditions of high temperature and pressure, are unstable in the soil environment. Weathering of the primary minerals releases considerable amounts of alkali and alkaline earth cations (primarily sodium, potassium, magnesium, and calcium) during the initial transition from rock to soil. Weathering also releases considerable silica to the soil solution, some of which is immediately leached from the solution, and some of which reacts to form secondary minerals. As the concentration of the alkali and alkaline earth cations on the exchange complex and in the soil solution decreases, the soil becomes acidic (Bohn, et al., 1985).

Clay minerals are products of rock weathering/breakdown and have marked effects on both the physical and chemical properties of the soils. Their contribution to soil chemical properties results from their comparatively large surface area and permanent surface negative charge. Clay

minerals are sheet silicate structures formed most commonly from combinations of aluminum-hydroxide (Al-OH) octahedra (gibbsite sheet) and silica-oxygen (Si-O) tetrahedra (silica sheet). With the exception of the kaolinite, isomorphous substitution within the clay mineral lattice gives rise to a net negative charge on the surface of the mineral. Trivalent aluminum (Al) substituting for tetravalent silica (Si) and divalent magnesium (Mg) substituting for Al causes this. In kaolinite, the 1:1 units are tightly bonded together by hydrogen bonds between hydrogen and oxygen atoms of adjacent lamellae (Alloway, 1990).

Clays rarely exist in pure form in soils; they usually have humic colloids and hydrous oxide precipitates linked to them, or are present as coatings around the clay particles. The combined organo-mineral colloidal complex plays a very important role in controlling the concentrations of ions in the soil solution (Alloway, 1990).

As noted in Section 3.0, three surface soil types have been identified at Site 16. These soils consist of very fine sandy to silty clay loams. The upper geologic formation at Site 16 consists of unconsolidated sediments composed of interbedded sands, silts, and clays. The investigative evidence suggest that a high percentage of the soils at Site 16 are composed of clay minerals with large surface areas and a negative surface charge, and generally these soils have a low hydraulic conductivity. The significance of these properties as they relate to contaminant fate and transport phenomena is:

- cationic species are likely to be adsorbed onto the negatively charged surfaces of clay particles;
- there is generally a large surface area per soil mass available for adsorption; and
- solution migration through the soil to underlying groundwater will be limited due to the low hydraulic conductivity of the clayey soils.

Soil pH

Soil pH is an important variable for controlling ion exchange, dissolution/precipitation, reduction/oxidation, adsorption, and complexation reactions (McBride, 1994). The pH of a soil

applies to the concentration of hydrogen (H^+) ions in the solution present in the soil pores. This solution is in dynamic equilibrium with the predominantly negatively charged surfaces of soil particles noted above. Hydrogen (H^+) ions are strongly attracted to the negatively charged surfaces and have the propensity to replace most other cations that may be attached to the surfaces (Bohn, et al., 1985).

Soil that becomes water saturated periodically will experience variations in the pH because of changing redox conditions. Reducing conditions cause an increase in the pH and oxidation brings about a similar reduction in the pH (Alloway, 1990).

Soils have several mechanisms which serve to buffer the pH to varying extents including hydroxyaluminum ions, carbon dioxide (CO_2), carbonates and cation exchange capacity reactions (Bohn, et al., 1985). In temperate climates, soils generally exhibit pH in the range of 4 to 8.5 owing to the buffering action of aluminum ions at the low end and calcium carbonate ($CaCO_3$) at the upper end (Alloway, 1990).

The soils present at Site 16 are slightly basic (7.3 pH) to moderately acidic (4.5 pH), with the pH decreasing with depth until the saturated zone is reached. Broad generalizations concerning the effect of the noted pH conditions on the fate and transport of contaminants can not be made, as the effects will vary between constituents.

Reduction/Oxidation Potential

Soils are subject to variations in the oxidation/reduction (redox) status by fluctuation in water content. Redox conditions primarily affect the elements carbon (C), nitrogen (N), oxygen (O), sulfur (S), iron (Fe), and manganese (Mn), although silver (Ag), arsenic (As), chromium (Cr), copper (Cu), mercury (Hg), and lead (Pb) can also be affected (Alloway, 1990). In well-aerated soil, elements exist in oxidized states; examples of naturally occurring elements include ferric iron (Fe^{+3}), manganic manganese (Mn^{+4}), nitrate (NO_3^-), and sulfate (SO_4^{-2}). While in poorly aerated soils (such as water saturated sediments), the reduced forms of elements are present, ferrous iron (Fe^{+2}), manganous manganese (Mn^{+2}), ammonium (NH_4^+), and sulfides (S_2^-) (Brady, 1990). Soil redox potential is critical in controlling elemental mobility. Some elements are

much more soluble and mobile in one oxidation state than another is (e.g. chromium (Cr), manganese (Mn), and selenium (Se). The elements classified as chalcophiles (e.g. mercury (Hg), copper (Cu), lead (Pb), cadmium (Cd), zinc (Zn), arsenic (As), and selenium (Se) form insoluble sulfide minerals in reducing environments where sulfide (S^{2-}) is generated via sulfate reduction (McBride, 1994). Mobility for chalcophiles is then extremely low unless oxidizing conditions are restored in the soil.

Soil redox potential (E_h) is a measure of the tendency of a soil group to reduce or oxidize chemicals and is typically measured in millivolts. Large positive values of E_h (ranging from + 300 to + 800 mV) are indicative of aerobic conditions, while low or negative values of E_h (+ 118 to - 414 mV) are associated with anaerobic (or reduced) conditions (Alloway, 1990). Observation of soil color can provide a general indication of soil redox conditions. Red, brown, reddish-brown, and orange color mixtures are typically indicative of oxidized iron and manganese; therefore, aerobic conditions would exist. Blue-green, gray, and blue-gray colors typically denote the presence of reduced copper or sulfur, indicative of anaerobic conditions. Of note however, is that strong-colored parent materials may mask these color changes in some soils.

Organic Matter

The primary features that distinguish soil from parent bedrock are the presence of living organisms and organic material. All soils contain organic matter, although the amount and type may vary considerably. Colloidal soil organic matter can be divided into humic and non-humic substances and can have a significant influence on the chemical properties of soil. Non-humic substances are comprised of unaltered biochemicals such as amino acids, carbohydrates, organic acids, fats, and waxes that have not changed from the form in which they were synthesized by living organisms (Alloway, 1990). Humic substances are a series of acidic, yellow to black colored polyelectrolytes of moderately high molecular weight. They are formed by secondary synthesis reactions involving microorganisms and have characteristics which are dissimilar to any compounds in living organisms. The humic substances have a variety of functional groups, including carboxyl, phenolic hydroxyl, carbonyl, ester, and possibly quinone and methoxy groups. While predominantly composed of humic substances, soil humus also contains some

biochemicals bound to the humic polymers (Alloway, 1990).

Organic matter contains about 58 to 60% organic carbon (C) ($\% \text{ org C} \times 1.67 = \% \text{ OM}$) (McBride, 1994). Within the soil profile, the organic matter content is always highest in the surface horizon but some soils may have some translocated humic material at deeper depths of the profile. Well-drained soils formed under grasslands (Mollisols) may typically have up to 7.5% organic matter at the soil surface, decreasing with depth to 1.5% at 80 cm. While well-drained soils formed under forest vegetation (Alfisols) may typically have up to 13% organic matter at the soil surface, decreasing to 1.5% at a depth of only 15 cm (Brady, 1990).

5.1.2 Climatological Influences

Hydrology/Precipitation

The hydrologic conditions can exert a strong influence upon the eventual fate and transport of contaminants. The amount and intensity of precipitation that the site receives can have a profound effect on the movement of surface contamination via direct transport of contaminated media by overland flow. Other effects include:

- influence of moisture on the weathering of soil and transformation of mineral species which may be more receptive to the adsorption of specific chemicals;
- effects that soil moisture may have on soil pH which can influence the speciation of chemicals (including contaminants) within the soil;
- the degradation rates of specific chemicals by creating an environment more suitable to certain microorganisms and for the degradation of vegetation into humic material;
- transport of dissolved chemicals to groundwater;
- transpiration and evaporation (and subsequent removal) of moisture and entrained contaminants into the atmosphere;
- influences on the oxidation and reduction zones within the soil/rock profiles which can influence the speciation of chemicals within the soil; and
- the type and density of vegetation capable of growing on the site.

Site 16 is located in a region that can be described as temperate to humid and receives an average of 46.9 in. of precipitation per year. These conditions are considered favorable for the rapid weathering of soils and degradation and decay of vegetative matter and for sustaining a variety of vegetation. Seasonal variations in rainfall may result in corresponding changes in the degree of soil saturation.

Barometric Pressure

Barometric pressure can have an influence upon the volatilization of constituents within the soil. High atmospheric pressure will reduce the volatilization of organic compounds. The mean barometric pressure at Longhorn Army Ammunition Plant (LHAAP) is 29.76 in. mercury (Hg).

Wind Speed and Direction

Wind can play a part in the fate and transport of chemicals by direct transport (airborne) or by facilitating volatilization of organic compounds. The prevailing wind is from the south and the average wind speed in spring is 13 mph.

Temperature

Temperature plays an important role in environmental fate and transport mechanisms. Higher temperatures generally act as a catalyst to chemical reactions whereas lower temperatures may retard chemical and biological activity. Temperature plays a role in phase changes and the vaporization of a number of organic materials and is a measurement that can be used to predict the fate and transport. The average monthly temperatures at LHAAP range from a high of 81° F to an average low of 46° F.

Given the annual temperature ranges for the vicinity of Site 16, the maximum rates of vaporization and biological activity should occur during June through August and the lowest rates should occur in December and January.

5.1.3 Chemical Properties

Water Solubility

Chemical solubility in water is a "saturation" property; the saturation concentration of a compound in water at a given temperature and pressure (Montgomery and Welkom, 1991). For chemicals that ionize, the pH of the solution is important because the extent of ionization will affect its solubility (Mackay et al., 1992). The solubility of a chemical in water is one of the most important properties to predict fate and transport potential. Chemicals with high water solubilities tend to desorb from soils and sediments, are less likely to volatilize from water, and are susceptible to biodegradation. Conversely, chemicals with low solubilities tend to adsorb to soils and sediments, volatilize more readily from water, and bioconcentrate in aquatic organisms (Montgomery and Welkom, 1991). Some reactions which may affect fate processes can be altered by a chemical's water solubility, such as: photolysis, hydrolysis, and oxidation (Howard, 1990). For evaluation purposes, a chemical may be considered potentially mobile in the environment if its water solubility is greater than 1 mg/L (Garten et. al., 1983).

Vapor Pressure

Vapor pressure is also a "saturation" type of property, and is defined as the pressure exerted by the vapor (gas) of a substance when it is under equilibrium conditions (Montgomery and Welkom, 1991). The vapor pressure of a chemical is required to predict the rate at which it may volatilize from soil and/or water. The volatility of the chemical is dependent upon the vapor pressure, and its volatilization from water is dependent upon the vapor pressure and water solubility (Howard, 1990). The vapor pressure of a contaminating chemical may be considered low if it is less than 1 mm Hg at temperatures of 10 ° to 40 ° C, under natural conditions (Lyman et al., 1990).

Henry's Law Constant

Henry's Law Constant (K_H) provides an indication of a chemical's tendency to partition between air and water at equilibrium, and also is used to calculate the rate of evaporation from water (Howard, 1990). It is defined as the ratio of the partial pressure of a compound in air to the concentration of the compound in water at a given temperature under equilibrium conditions

(Montgomery, 1991). Henry's law constant provides an indication of the relative volatility of a substance. If the K_H value of a chemical is less than 10^{-7} atmosphere (atm) m^3/mol , the chemical has a low volatility. A chemical with a K_H value between 10^{-7} and 10^{-5} atm m^3/mol will volatilize slowly, and volatilization becomes a very important transfer mechanism with K_H values above 10^{-5} atm m^3/mol (Lyman et al., 1990). In consideration of volatilization, molecular weight is also an important criterion. Compounds with molecular weights greater than 200 g/mol do not easily volatilized.

Octanol/Water Partition Coefficient

The octanol/water partition coefficient (K_{ow}) is an important parameter in predicting the environmental fate of organic compounds. This parameter is defined as the ratio of the solute concentration in the water-saturated *n*-octanol phase to the solute concentration in the *n*-octanol-saturated water phase (a unitless parameter), and is often reported as $\log K_{ow}$ (Montgomery, 1991). The $\log K_{ow}$ of a chemical provides a direct estimate of hydrophobicity or of the partitioning tendency from the chemical in water to an organic medium, such as lipids, waxes, and natural organic matter (MacKay et al., 1992). In determining fate and transport potential for chemical contaminants, the $\log K_{ow}$ provides an estimate of a chemical's tendency to be associated with the natural soil organic matter. This limits the transport of a chemical through soil, as well as the chemical's tendency to be absorbed by aquatic organisms. Chemicals with $\log K_{ow}$ values less than 1 are relatively hydrophilic and tend to have high water solubilities, low soil/sediment partition coefficients, and low bioconcentration factors (Lyman et al., 1990). Hydrophilic chemicals have a greater tendency to migrate with soil water and are not as likely to be absorbed by aquatic organisms. Chemicals with high $\log K_{ow}$ values (greater than 3.5) are very hydrophobic and will have the tendency to be sorbed to soil organic matter. This results in limited transport potential of a chemical with soil water and the chemical is more likely to be absorbed (bioconcentrated) by aquatic organisms (Lyman et al., 1990).

Organic Carbon Partition Coefficient

The organic carbon partition coefficient (K_{oc} , often reported as $\log K_{oc}$) provides an estimation of a chemical's ability to partition between particles containing organic carbon and water. The K_{oc} is defined as the ratio of adsorbed chemical per unit weight of organic carbon to the aqueous

solute concentration (Montgomery and Welkom, 1991). Generally, the $\log K_{oc}$ reflects the tendency of the chemical to be sorbed to soil and therefore, the transport potential of the chemical will be dependent upon soil properties. Chemicals with a $\log K_{oc}$ value less than 3.0 is considered to be potentially mobile in the environment (Garten et al., 1983). While high $\log K_{oc}$ values reflect a chemical's preferred tendency to sorb to soil compounds and bioconcentrate in aquatic organisms (Lyman et al., 1990).

Soil/Water Partition Coefficient

Soil water partition coefficients (K_d) often used to describe the sorption potential of chemical contaminants from water to soil. The K_d values defined as the concentration of the chemical in soil divided by the concentration of the chemical in water usually expressed in units of ml/g. The value of K_d will be dependent upon the soil properties, as well as the chemical properties. In general, K_d values have been shown inversely proportional to soil particle size (clay content) and directly proportional to the organic content of the soil. The higher the K_d value, the greater the tendency of the organic chemical to be sorbed by soil (Manahan, 1984).

Boiling and Melting Points

The boiling point of a chemical is the temperature at which the chemical undergoes a phase change to a gas, typically reported at the standard pressure of 1 atm. The melting point of a chemical is the temperature at which the chemical undergoes a phase change to a liquid, typically reported at the standard pressure of 1 atm. While the melting and boiling points of a chemical are not directly related to predicting the fate and behavior of chemicals in the environment, they provide information as to the most likely state the chemical will be found under specific environmental conditions.

Specific Density

The specific density of a chemical is the ratio of its density (g/mL) to that of the density of distilled water (g/mL), typically reported at a specific temperature. The density of hydrophobic chemicals is especially important in evaluating chemical behavior in aqueous environments, such as migrating through the unsaturated zones of soils and encountering aquifers. Generally, phase separate liquids that have densities less than water (light non-aqueous phase liquids

(NAPL)) will be found at the uppermost levels of aquifers while those that have densities greater than water are commonly found at the base of aquifers (dense NAPLs). Hydrophilic chemicals behave differently however. For example, some hydrophilic chemicals that have densities less than water do not remain in the uppermost levels of aquifers because they are freely miscible/soluble in water. Therefore, water solubility must be considered along with specific density when evaluating a chemical's behavior in the subsurface (Montgomery and Welkom, 1991).

Bioconcentration Factor

Some chemical contaminants, due to their hydrophobic character, have the tendency to partition from water and bioconcentrate in aquatic organisms. This tendency is referred to as the bioconcentration factor (BCF) and is defined as the concentration of the chemical in the organism at equilibrium divided by the concentration of the chemical in water (unitless) (Howard, 1990). The BCF of a chemical contaminant is an important parameter that provides information as to the potential threat which may exist to aquatic organisms as well as to other predators which consume them (including wildlife and humans).

Environmental Half-Life

The environmental half-life of a chemical contaminant is the length of time necessary to degrade the initial chemical concentration by one-half (USEPA, 1979). The half-life will be dependent upon the media in which the contaminant exists as well as the specific degradation processes involved. Degradation of chemical contaminants can be the result of both biotic and abiotic processes. Biotic degradation results from microbially mediated processes under either aerobic or anaerobic conditions, again dependent upon the specific environmental conditions. Some examples of abiotic processes include photolysis, hydrolysis, oxidation/reduction, etc.

5.2 PROPERTIES OF SITE SPECIFIC CONTAMINANTS

The following section presents a discussion of the environmental fate and transport properties for constituents detected in various environmental media collected at Site 16. The constituents have been grouped into two major subdivisions, namely inorganic compounds and organic

compounds. This grouping has been performed in an effort to streamline the RI presentation of the fate and transport properties. The organic compounds have been further subdivided into the following groups:

- Halogenated Hydrocarbons (i.e. TCE)
- Phthalate Esters
- Organo-Halide Pesticides (i.e. aldrin)
- Chlorinated dibenzo-*p*-dioxins
- Chlorinated Dibenzofurans

Grouping compounds according to structural similarity allows for a presentation of the general environmental fate and transport properties for each group. The subsequent "behavioral profiles" of each group will be used to assess and/or predict the fate and transport of the detected compounds. A notable exception to this approach exists for inorganic compounds. A wide range of possible parametric values exists among different ionic species of specific inorganic element.

Table 5-1 presents a list of the available environmental fate and transport parameters for the compounds detected and the media sampled from Site 16. Sources of information utilized in the generation of this table are included in the footnotes.

5.2.1 Inorganic Compounds

In order to understand the fate and transport of inorganic contaminants in soil, their chemical and physical characteristics must be considered along with the prevailing environmental conditions of the existing soil matrix. In characterization of inorganics, analytical procedures typically used involve the near complete destruction of the soil/solid matrix to result in a total concentration. However, the total fraction does not provide information as to the particular species of the inorganics that predominate under individual site conditions, nor is it a good indicator of the mobility or availability for uptake by plants or animals. The discussion below presents information about the forms of the inorganic elements found under varying environmental conditions and the subsequent interpretation in terms of their fate and transport. Some inorganic

Table 5-1
Chemical and Physical Properties of
Compounds Detected During Investigations

Chemical (Name)	PHYSICAL									
	Molecular Weight (g/mole)	Ref. No.	Density (g/ml)	Ref. No.	Melting Point (C)	Ref. No.	Boiling Point (C)	Ref. No.	Flash Point (C)	Deg Point (C)
Dibenzo-p-dioxins										
Dibenzo-p-dioxin	184	(8)			123	(8)	283.5	(8)		
1-Chloro-p-dioxin	218.5	(8)			105.5	(8)	315.5	(8)		
2-Chloro-p-dioxin	218.5	(8)			89	(8)	316	(8)		
2,3-Dichloro-p-dioxin	253	(8)			164	(8)	358	(8)		
2,7-Dichloro-p-dioxin	253	(8)			210	(8)	373.5	(8)		
2,8-Dichloro-p-dioxin	253	(8)			151	(8)		(8)		
1,2,4-Trichloro-p-dioxin	287.5	(8)			129	(8)	375	(8)		
1,2,3,4-Tetrachloro-p-dioxin	322	(8)			190	(8)	419	(8)		
1,2,3,7-Tetrachloro-p-dioxin	322	(8)			172	(8)	438.3	(8)		
1,3,6,8-Tetrachloro-p-dioxin	322	(8)			219	(8)	438.3	(8)		
2,3,7,8-Tetrachloro-p-dioxin	322	(8)			305	(8)	446.5	(8)		
1,2,3,4,7-Pentachloro-p-dioxin	356.4	(8)			195	(8)	464.7	(8)		
1,2,3,4,7,8-Hexachloro-p-dioxin	391	(8)			273	(8)	487.7	(8)		
1,2,3,4,6,7,8-Heptachloro-p-dioxin	425.2	(8)			265	(8)	507.2	(8)		
Octachloro-p-dioxin	460	(8)			322	(8)	510	(8)		
Dibenzofurans										
Dibenzofuran	168.2	(8)			86.5	(8)	287	(8)		
2,8-Dichloro-dibenzofuran	237.1	(8)			184	(8)	375	(8)		
2,3,7,8-Tetra-dibenzofuran	306	(8)			227	(8)	438.3	(8)		
2,3,4,7,8-Penta-dibenzofuran	340.42	(8)			196	(8)	464.7	(8)		
1,2,3,4,7,8-Hexa-dibenzofuran	374.87	(8)			225.5	(8)	487.7	(8)		
1,2,3,6,7,8-Hexa-dibenzofuran	374.87	(8)			232	(8)	487.7	(8)		
1,2,3,4,6,7,8-Hepta-dibenzofuran	409.31	(8)			236	(8)	507.2	(8)		
1,2,3,4,7,8,9-Hepta-dibenzofuran	409.31	(8)			221	(8)	507.2	(8)		
Octachloro-dibenzofuran	443.8	(8)			258	(8)	537	(8)		
Halogenated Hydrocarbons										
1,1-Dichloroethane	98.96	(1)	1.2 @ 20 C	(13)	96.9	(13)	57.4	(13)	-5.6	(12)
1,2-Dichloroethane	98.96	(1)	1.2 @ 20 C	(13)	35.5	(13)	83.5	(13)	12.8	(12)
1,2-Dichloroethene	96.90	(13)	1.3 @ 20 C	(13)	4.0	(13)	45	(13)	3.9	(12)
1,1-Dichloroethene	96.90	(13)	1.2 @ 20 C	(13)	-122.5	(13)	31.6	(13)	-17.8	(12)
cis-1,2-Dichloroethylene	96.90	(13)	1.3 @ 20 C	(13)	-80	(13)	60.1	(13)		
trans-1,2-Dichloroethene	96.90	(13)	1.3 @ 20 C	(13)	-49.8	(13)	48.7	(13)	2.0	(12)
Methylene chloride	84.93	(1)	1.3 @ 20 C	(13)	-95.1	(13)	40	(13)	NC	(12)
1,1,2-Trichloroethane	133.4	(1)	1.4 @ 20 C	(13)	-36.6	(13)	113.8	(13)	NC	(12)
Trichloroethene	131.39	(1)	1.46	(13)	-84.8	(13)	87	(13)	32	(12)
Vinyl chloride	62.5	(1)	0.91 @ 20 C	(13)	-153.7	(13)	-13.3	(13)	-78	(12)
Organo-Halide Pesticides										
Aldrin	364	(13)	1.7	(13)	104	(13)	145	(13)	NC	(12)
Phthalate Esters										
Bis(2-ethylhexyl)phthalate	390.54	(14)	0.98 @ 25 C	(13)	-55	(13)	384	(13)	218	(12)
Inorganics - Metals										
Barium	137.33	(1)	3.5 @ 20 C	(13)	725	(13)	1640	(13)	NC	(12)
Beryllium	9.01218	(1)	1.8 @ 20 C	(13)	1278	(13)	2970	(13)	NC	(12)
Cadmium	112.41	(1)	8.7 @ 20 C	(13)	320.9	(13)	765	(13)	NC	(12)
Chromium	51.99	(1)	7.1	(13)	1900	(13)	2642	(13)	NC	(12)
Cobalt	58.93	(13)	8.9	(13)	1493	(13)	3100	(13)		
Lead	207.2	(1)	11 @ 16 C	(13)	327.4	(13)	1740	(13)	NC	(12)
Manganese	54.94	(60)	7.2	(13)	1244	(13)	1962	(13)	NC	(12)
Nickel	58.69	(1)	8.90	(13)	1455	(13)	2735	(13)	NC	(12)

Table 5-1
Chemical and Physical Properties of
Compounds Detected During Investigations

Chemical (Name)	MOBILITY						BIOACCUMULATION							
	Water Solubility (mg/L)	Ref. No.	Henry's Law Constant (Pa·m ³ /mol)	Ref. No.	Vapor Pressure (mm Hg)	Ref. No.	Koc (L/kg)	Ref. No.	Kd	Ref. No.	Log Kow Unitless	Ref. No.	Log BCF Unitless	Ref. No.
Dibenzo-p-dioxins														
Dibenzo-p-dioxin	865 (8)		11.7 (8)		4.13E-04 (8)						4.3 (8)			
1-Chloro-p-dioxin	417 (8)		6.288 (8)		9.00E-05 (8)						4.75 (8)			
2-Chloro-p-dioxin	295 (8)		12.59 (8)		1.28E-04 (8)						5 (8)			
2,3-Dichloro-p-dioxin	14.9 (8)		6.622 (8)		2.93E-06 (8)						5.6 (8)			
2,7-Dichloro-p-dioxin	3.75 (8)		8.096 (8)		9.00E-07 (8)						5.75 (8)			
2,8-Dichloro-p-dioxin	16.7 (8)		2.121 (8)		1.05E-06 (8)						5.6 (8)			
1,2,4-Trichloro-p-dioxin	8.41 (8)		3.419 (8)		7.50E-07 (8)						6.35 (8)			
1,2,3,4-Tetrachloro-p-dioxin	0.55 (8)		3.747 (8)		4.80E-08 (8)						6.6 (8)			
1,2,3,7-Tetrachloro-p-dioxin	0.42 (8)		0.767 (8)		7.50E-09 (8)						6.9 (8)			
1,3,6,8-Tetrachloro-p-dioxin	0.32 (8)		0.704 (8)		5.25E-09 (8)						7.1 (8)			
2,3,7,8-Tetrachloro-p-dioxin	0.0193 (8)		3.337 (8)		1.50E-09 (8)						6.8 (8)			
1,2,3,4,7-Pentachloro-p-dioxin	0.118 (8)		0.266 (8)		6.60E-10 (8)						7.4 (8)			
1,2,3,4,7,8-Hexachloro-p-dioxin	0.00442 (8)		1.084 (8)		3.83E-11 (8)						7.8 (8)			
1,2,3,4,6,7,8-Heptachloro-p-dioxin	0.0024 (8)		1.273 (8)		5.63E-12 (8)						8 (8)			
Octachloro-p-dioxin	0.000074 (8)		0.684 (8)		8.25E-13 (8)						8.2 (8)			
Dibenzofurans														
Dibenzofuran	4750 (8)		10.62 (8)		2.25E-03 (8)						4.31 (8)			
2,8-Dichloro-dibenzofuran	14.5 (8)		6.38 (8)		2.93E-06 (8)						5.44 (8)			
2,3,7,8-Tetra-dibenzofuran	0.419 (8)		1.46 (8)		1.50E-08 (8)						6.1 (8)			
2,3,4,7,8-Penta-dibenzofuran	0.236 (8)		0.51 (8)		2.63E-09 (8)						6.5 (8)			
1,2,3,4,7,8-Hexa-dibenzofuran	0.00825 (8)		1.45 (8)		2.40E-10 (8)						7 (8)			
1,2,3,6,7,8-Hexa-dibenzofuran	0.0177 (8)		0.74 (8)		2.63E-10 (8)						7.4 (8)			
1,2,3,4,6,7,8-Hepta-dibenzofuran	0.00135 (8)		1.43 (8)		3.53E-11 (8)						8 (8)			
1,2,3,4,7,8,9-Hepta-dibenzofuran	(8)		(8)		4.65E-11 (8)						(8)			
Octachloro-dibenzofuran	0.00116 (8)		0.19 (8)		3.75E-12 (8)						8 (8)			
Halogenated Hydrocarbons														
1,1-Dichloroethane	5.50E+03 (15)		5.87E-03 (17)		2.34E+02 (15)		40 (24)		NA		1.8 (15)		1.13 (24)	
1,2-Dichloroethane	3.50E+03 (4)		1.18E-03 (17)		7.90E+01 (15)		32 (39)		NA		1.45 (15)		1.95 (40)	
1,2-Dichloroethene	6.30E+03 (4)				1.80E+02 (4)				NA					
1,1-Dichloroethene	2.30E+03 (4)		2.60E-02 (4)		6.00E+02 (4)		58.9 (2)		NA		2.1 (9)		1.72 (11)	
cis-1,2-Dichloroethylene	3.50E+03 (41)		4.08E-03 (42)		2.03E+02 (35)		50 (24)		NA		1.9 (21)		1.18 (24)	
trans-1,2-Dichloroethene	6.30E+03 (41)		9.39E-03 (42)		3.33E+03 (35)		35 (29)		NA		2.1 (9)		1.36 (24)	
Methylene chloride	1.30E+04 (4)		2.20E-03 (15)		4.29E+02 (15)		8.8 (41)		NA		1.25 (15)		NA	
1,1,2-Trichloroethane	4.42E+03 (15)		9.61E-04 (17)		2.50E+01 (15)		79 (30)		NA		2.05 (35)		<1.00 (58)	
Trichloroethene	1.10E+03 (15)		1.17E-02 (15)		7.70E+01 (15)		105 (54)		NA		2.53 (15)		1.23 (25)	
Vinyl chloride	2.8E+03 (4)		2.78E-02 (15)		2.58E+03 (15)		135 (39)		NA		0.6 (15)		<1.00 (20)	
Organo-Halide Pesticides														
Aldrin	1.80E-01 (4)		1.70E-04 (4)		6.06E-06 (4)		2450000 (2)		NA		6.5 (9)		5.15 (11)	
Phthalate Esters														
Bis(2-ethylhexyl)phthalate	3.40E-01 (4)		1.0E-07 (15)		6.50E-06 (15)		87420 (32)		NA		7.3 (15)		2.93 (33)	
Inorganics - Metals														
Barium	hydrolyzes (15)		NA		1 @ 860 C (15)				41 (3)		NA			
Beryllium	insoluble (15)		NA		1 (1)				790 (3)		NA		1.28 (11)	
Cadmium	insoluble (15)		NA		1 @ 394 C (15)				1.3-2.7 (3)		NA		1.91 (11)	
Chromium	insoluble (3)		NA		1 @ 1616 C (15)		NA		1.2-1.5E+05 (3)		NA		1.2 (11)	
Cobalt	insoluble (3)										NA			
Lead	insoluble (15)		NA		1 @ 973 C (15)		NA		7640 (3)		NA		1.69 (11)	
Manganese	decomposes (60)		NA		1 @ 1292 C (15)		NA		0.2-10000 (3)		NA			
Nickel	insoluble (15)		NA		1 (15)		NA				NA		1.67 (11)	

Table 5-1
Chemical and Physical Properties of
Compounds Detected During Investigations

Chemical (Name)	PERSISTENCE						
	Hydrolysis (days)	Ref. No.	Volatility (days)	Ref. No.	Biodegradation (days)	Ref. No.	Photolysis (days)
Dibenzo-p-dioxins							
Dibenzo-p-dioxin							
1-Chloro-p-dioxin							
2-Chloro-p-dioxin							
2,3-Dichloro-p-dioxin							
2,7-Dichloro-p-dioxin							
2,8-Dichloro-p-dioxin							
1,2,4-Trichloro-p-dioxin							
1,2,3,4-Tetrachloro-p-dioxin							
1,2,3,7-Tetrachloro-p-dioxin							
1,3,6,8-Tetrachloro-p-dioxin							
2,3,7,8-Tetrachloro-p-dioxin							
1,2,3,4,7-Pentachloro-p-dioxin							
1,2,3,4,7,8-Hexachloro-p-dioxin							
1,2,3,4,6,7,8-Heptachloro-p-dioxin							
Octachloro-p-dioxin							
Dibenzofurans							
Dibenzofuran							
2,8-Dichloro-dibenzofuran							
2,3,7,8-Tetra-dibenzofuran							
2,3,4,7,8-Penta-dibenzofuran							
1,2,3,4,7,8-Hexa-dibenzofuran							
1,2,3,6,7,8-Hexa-dibenzofuran							
1,2,3,4,6,7,8-Hepta-dibenzofuran							
1,2,3,4,7,8,9-Hepta-dibenzofuran							
Octachloro-dibenzofuran							
Halogenated Hydrocarbons							
1,1-Dichloroethane	22000 (6)		87 (6)		150 (5)		
1,2-Dichloroethane	72 (6)		87 (6)		180 (5)		
1,2-Dichloroethene							
1,1-Dichloroethene	44 (6)		87 (6)		180 (5)		
cis-1,2-Dichloroethylene			87 (6)				
trans-1,2-Dichloroethene			87 (6)				
Methylene chloride	210000 (6)		81 (6)		28 (5)		
1,1,2-Trichloroethane	5.1E+04 (6)		100 (6)		370 (5)		
Trichloroethene							
Vinyl chloride	3.7E+03 (6)		1.7E-01 (6)		1.8E+02 (5)		
Organo-Halide Pesticides							
Aldrin	800 (6)		170 (6)		590 (5)		
Phthalate Esters							
Bis(2-ethylhexyl)phthalate	1900 (6)		690 (6)		23 (5)		200 (4)
Inorganics - Metals							
Barium	NA						
Beryllium							
Cadmium	NA						
Chromium	NA						
Cobalt	NA						
Lead							
Manganese	NA						
Nickel							

Table 5-1

Chemical and Physical Properties of Compounds Detected During Investigations

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Table 5-1
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elements (calcium, magnesium, potassium, sodium, and iron) detected in media collected at Site 16 are not included in the discussion below. Typically, they are not deemed to be of environmental concern, are ubiquitous in the natural environment in relatively high concentrations, and/or are screened from further evaluation because they are considered essential nutrients.

Barium

Barium (Ba) is relatively abundant in natural soil systems, found in soils at total concentrations of 265 mg/kg to 835 mg/kg as a range of means in the United States (McBride, 1994). Ba occurs only in the +2 oxidation state, associating geochemically with feldspars and biotite micas in soils. As soil weathers, the released Ba^{+2} is generally immobilized by precipitation with sulfate or carbonate, or fixed on highly-negative-charged layer silicate clays, such as vermiculites (McBride, 1994). Because clay exchange sites and humus demonstrate high cation exchange selectivity for Ba^{+2} , barium is considered a rather immobile element in soils.

Beryllium

Like barium, beryllium (Be) only exists in soils in the +2 oxidation state. Its chemistry in soil solution parallels that of Al^{+3} . In soils below pH 6, the free cation, Be^{+2} predominates, but as the pH is increased, soluble Be-hydroxy species form (e.g. $BeOH^{+}$, $Be(OH)_2^0$, $Be_3(OH)_3^{+3}$) as $Be(OH)_2$ begins to precipitate (McBride, 1994). In low pH soils, Be chemisorbs on surfaces as the cation and is known to complex particularly strongly with organic matter. Because Be is the smallest of all metal cations, it has the potential to form a very strong ionic bond with the abundant negatively charged organic matter functional groups (McBride, 1994). In soils of neutral to slightly alkaline pH, hydrolysis reactions of Be^{+2} form hydroxy-cations and solid $Be(OH)_2$, further reducing Be solubility, and thereby limiting its mobility (McBride, 1994). The total concentrations of Be in soils of the United States has been found to range between 1.2 mg/kg to 2.1 mg/kg (McBride, 1994).

Cadmium

The average concentration of cadmium (Cd) in soils is found to range from 0.06 mg/kg to 1.1 mg/kg (worldwide) (McBride, 1994). Primarily Cd is present in soils as associated

geochemically with Zn in the sulfide minerals of rocks. Anthropogenic sources of Cd include the mining and smelting of Cd and Zn; atmospheric deposition from the metallurgical industries; the disposal of wastes containing Cd; sewage sludge application to land; the burning of fossil fuels; and as an impurity in phosphate fertilizers (Alloway, 1990).

The oxidizing conditions of weathering in soils releases Cd as the soluble and mobile Cd^{+2} ion (McBride, 1994). Cd is more soluble than Zn^{+2} in acidic oxidizing solutions, and is considered to be of medium to high mobility in well-drained, acid soils. The high mobility is attributable to the weak adsorption of Cd^{+2} on organic matter, silicate clays, and oxides unless the pH is higher than 6. Above pH 7, Cd^{+2} can co-precipitate with CaCO_3 or precipitate as CdCO_3 . Phosphates may limit Cd solubility via formation of CdPO_4 . Thus, mobility and bioavailability of Cd in neutral to alkaline soils is low (McBride, 1994). Cd bioavailability appears to be more prevalent under aerobic redox conditions as uptake into rice plants has been shown to be limited when grown under reducing (anaerobic) conditions (Alloway, 1990).

Chromium

Chromium (Cr) is found in average concentrations of 20 mg/kg to 85 mg/kg at total concentrations in US soils (McBride, 1994). Cr may occur in soils in the +3 (chromic) oxidation state as the Cr^{+3} cation and in the +6 oxidation state as chromate, CrO_4^{-2} (McBride, 1994). However, typical soil conditions favor the Cr^{+3} form which is a very immobile cation that complexes strongly with organic matter and chemisorbs on oxides and silicate clays, even at quite low pH. The solubility of Cr^{+3} decreases above pH 4 and complete precipitation occurs above pH 5.5 (McGrath and Smith, 1990). At the higher pH conditions Cr is immobilized by its substitution for Fe^{+3} in mineral structures, thereby precipitating as insoluble $\text{Cr}(\text{OH})_3$ (McBride, 1994).

At $\text{pH} > 6$, the presence of Mn oxides can promote the oxidation of some of the Cr^{+3} in soils to chromate (CrO_4^{-2}), a more toxic, soluble, and mobile form of Cr (McBride, 1994; McGrath and Smith, 1990). However, Cr^{+6} possesses a positive reduction potential making it a strong oxidizer, and in the presence of soil organic matter, Cr^{+6} is readily reduced back to the less toxic and mobile Cr^{+3} (McGrath and Smith, 1990). This reduction process is more rapid in acid soils than

alkaline soils. Thus, in the majority of soils, the relatively insoluble and less mobile Cr^{+3} form predominates and generally occurs as insoluble hydroxides and oxides (McGrath and Smith, 1990).

Lead

Lead (Pb) is ubiquitous in the soils and rocks of the surface of the earth. Average total Pb concentrations (worldwide) have been found to range from 10 mg/kg to 84 mg/kg (McBride, 1994). Pb occurs primarily as PbS in rocks and becomes very insoluble in reduced soils because of its precipitation by sulfide generated via sulfate reduction (McBride, 1994). Under oxidizing conditions, the Pb^{2+} ion becomes less soluble as soil pH rises. At higher pH, Pb complexation with organic matter, chemisorption on oxides and silicate clays, and precipitation as carbonate, hydroxide, or phosphate are favored. In alkaline soils, Pb solubility may increase by formation of soluble Pb-organic and Pb-hydroxy complexes. The Pb^{+2} ion has a high affinity for Mn oxides, an insoluble association. Lead is the least mobile heavy metal in soils, especially under reducing or nonacid conditions (McBride, 1994).

Manganese

Manganese (Mn) is found to range between 260 mg/kg and 840 mg/kg in United States soils (McBride, 1994). Mn has three possible oxidation states in soils, +2, +3, and +4. The most reduced form, Mn^{+2} ion, is the only stable form in soil solution. Mn^{+3} and Mn^{+4} form insoluble oxide and hydroxide minerals of variable structure and oxidation state (e.g. MnO_2 , MnOOH). The Mn^{+2} ion is released from these solids by spontaneous dissolution or cation exchange, primarily under acidic or reducing conditions (McBride, 1994).

Redox potential and pH of the soil control Mn solubility. Soluble Mn^{+2} forms hydroxide and carbonate precipitates only at high pH (> 7). However, at pH above 6, Mn^{+2} bonds with organic matter, oxides, and silicates reducing its solubility. Low pH or low redox potential (E_h) favors the reduction of insoluble Mn oxides and an increased solubility of Mn^{+2} . Mn solubility therefore, within any particular soil can fluctuate greatly over time (McBride, 1994). The mobility of Mn defies classification because it is extremely sensitive to soil conditions, such as acidity, wetness, microbial activity, etc. To further add complication, total Mn in soils is highly

variable and not closely related to the Mn content of the parent bedrock. This is most likely because of the tendency for cyclical reduction-oxidation to rapidly mobilize, then reprecipitate Mn as oxides in nodules and other deposits. In these deposits, Mn tends to associate with ferric iron (McBride, 1994).

Nickel

Nickel (Ni) is a naturally occurring element found to range in average concentrations from 13 to 30 mg/kg in soils of the US (McBride, 1994). The chemistry of nickel (Ni) in the environment is the simplest of all the elements as the +2 oxidation state is the only stable form of Ni in the environment (McBride, 1994; McGrath and Smith, 1990). The electron structure of Ni, and its high electronegativity, favors the formation of complexes with organic matter that are similar in stability to Cu^{+2} . Ni can bioaccumulate in humus, bonding to organic ligands containing nitrogen and sulfur. Because it is the smallest of the divalent transition metal cations, Ni^{+2} fits easily into octahedral sites, co-precipitating readily into Mn and Fe oxides in soils (McBride, 1994). Ni is rated as medium in its mobility in acid soils and very low in neutral to alkaline soils. In reduced soils, Ni is incorporated into sulfides making it immobile.

5.2.2 Organic Compounds

Halogenated Hydrocarbons

The halogenated hydrocarbons in this group are aliphatic hydrocarbons with a halogen family functional group consisting of either chlorine and/or bromine. These compounds are also known as alkyl halides. Aliphatic hydrocarbons are essentially the non-aromatic hydrocarbons (i.e. open-chain hydrocarbons and non-planar cyclic hydrocarbons). Aliphatics differ from aromatics in that they principally undergo addition and free-radical substitution reaction instead of heterolyphic substitution reactions common with aromatics. Alkyl halides are capable of forming organometallic compounds. The halogenated hydrocarbons detected above the Medium Specific Concentrations (MSC) value in samples collected at Site 16 include 1,1-dichloroethane, 1,2-dichloroethane, 1,2-dichloroethene, 1,1-dichloroethene, cis-1,2-dichloroethene, trans-1,2-dichloroethylene, methylene chloride, 1,1,2-trichloroethane, trichloroethene (TCE), and vinyl chloride.

Calculations presented in Mackay, et al. (1992) indicate that this group of chemicals will almost totally partition into the atmosphere with only minor amounts into the other compartments. This is supported by typical vapor pressures ranging in value from 25 to 3,330 mm Hg, K_H values ranging from 0.000961 to 0.0117 atm m³/mol, and molecular weights ranging from 62.5 to 133.4 g/mol as presented in Table 5-1. However, chemicals with higher K_{ow} , will tend to partition slightly into soil. Other calculations presented in Mackay, et al. (1992) indicate the dominance of atmospheric advection and, in some cases, reaction. Therefore, these chemicals tend to become widely distributed. Mackay, et al., noted that the chemicals discharged into air exhibit very little tendency to enter soil or water because the rates of loss by advection and reaction in air greatly exceed the rates of absorption or deposition. The overall residence times are generally about 3 days as controlled by the assumed advection rate. When the chemical is discharged to water there is usually competition between evaporation, advection from water, and reaction in water. The more hydrophobic chemicals tend to partition into sediments. The overall residence time is much longer (e.g. 1 to 2 weeks) because of slower reaction and advection in water and the constraint imposed by evaporation. When the chemical is discharged to the soil, most of the chemical evaporates and diffusion processes at the soil-air interface limit the rate of loss. In summary, the halogenated hydrocarbons display high mobility and are likely to volatilize rapidly.

Phthalate Esters

Two ester groups bonded to two carbons of a benzene ring characterize Phthalate esters. An ester is characterized by one of the carbonyl group's carbon molecule bonded with an alkoxy group and an aliphatic or aromatic hydrocarbon. The alkoxy group consists of an oxygen molecule singly bonded to an aliphatic or aromatic hydrocarbon. The phthalate ester compound detected above the MSC value in samples collected at Site 16 is bis(2-ethylhexyl)phthalate.

Phthalate esters, according to Mackay, et. al. (1992), are notable because of their low solubilities, high K_{ow} , and low vapor pressures. For bis(2-ethylhexyl)phthalate as indicated in Table 5-1, the vapor pressure is well below 1.0 mm Hg and the log K_{ow} value is above 3.5. The water solubilities of bis(2-ethylhexyl)phthalate is below and marginally exceeds 1 mg/l, thereby limiting movement.

The phthalate esters, being generally more hydrophobic (due to the elevated K_{ow} values), tend to partition more to soils and sediments, and consequently, reactions in these media are more important. In addition, there is a great tendency for bioconcentration. In summary, bis(2-ethylhexyl)phthalate may be potentially mobile, but exhibits a tendency to persist in soil due to a low vapor pressure and hydrophobic characteristic.

Organo-Halide Pesticides

The only organo-halide pesticide detected in samples from Site 16 was aldrin. Based on reported values for aldrin's water solubility, Henry's Law Constant, vapor pressure, K_{oc} , and log K_{ow} listed in Table 5-1, aldrin is expected to be generally immobile, potentially available for volatilization, and persistent in soil.

Chlorinated Dibenzo-*p*-Dioxins

The dibenzo-*p*-dioxins molecule is a fused triple-ring polycyclic structure consisting of two benzene (aromatic) rings interconnected to each other through two oxygen atoms. Chlorine atoms in chlorinated dibenzo-*p*-dioxins produce up to 75 isomers. Chlorinated dibenzo-*p*-dioxins were detected in samples collected at LHAAP.

Calculations pertaining to chlorinated dibenzo-*p*-dioxins presented in Mackay, et. al (1992) indicate that an increase in molecular weight (resulting from the addition of chlorine atoms) results in a decrease in water solubility, vapor pressure, and Henry's Law Constant, and a decrease in log K_{ow} . Properties of chlorinated dibenzo-*p*-dioxins are listed on Table 5-1.

In summary, chlorinated dibenzo-*p*-dioxins are sufficiently volatile and water soluble and thus environmentally mobile with a tendency to remain in soil or water.

Chlorinated Dibenzofurans

The dibenzofurans molecule is a fused triple-ring polycyclic structure consisting of two benzene (aromatic) rings interconnected to each other through a single oxygen atom to form a central, third, heterocyclic ring. The middle ring has the structure of furan, a five member heterocyclic compound consisting of four carbon and one oxygen atoms. Dibenzofurans are of particular

interest to environmental scientists due to the toxicity of chlorinated dibenzofurans and due to their structural similarity to the highly toxic chlorinated dibenzo-*p*-dioxins. Dibenzofurans were detected in samples collected at LHAAP.

Calculations pertaining to dibenzofurans presented in Mackay, et. al (1992) indicate that an increase in molecular weight (resulting from the addition of chlorine atoms) results in a decrease in water solubility, vapor pressure, and Henry's Law Constant, and a decrease in log K_{ow} . Properties of dibenzofurans are listed on Table 5-1.

In summary, dibenzofurans are sufficiently volatile and water soluble and thus environmentally mobile with a tendency to remain in soil or water.

5.3 POTENTIAL ROUTES OF MIGRATION

This section describes the potential transport pathways by which contaminants of concern (COC) could potentially migrate from Site 16 to other portions of the LHAAP installation or to offsite areas. In Section 4.0 of this report, the COCs within the various environmental media sampled at the site were presented. Pathways by which contaminants could migrate from Site 16 include airborne transport, dissolved or suspended transport in surface water runoff, erosional transport of surface soil and sediment, and leaching to groundwater and subsequent groundwater migration.

5.3.1 Airborne Transport

The soil analytical results for detectable concentrations of metals are discussed in Section 4.0 of this report and the physical/chemical characteristics of detected compounds are presented in the previous sections. Metals, with the exception of mercury, have no propensity to volatilize from the native or adsorbed states, therefore, the transport of metals or metal compounds in vapor form is not a significant route of transport. However, because of the potential for contaminants adsorbed to soil components, dusts generated by wind erosion or trafficking (human or endemic wildlife) constitutes a potential role for transporting metals to nearby receptors.

Vapors are discharged to the atmosphere as the result of volatilization of VOCs. VOCs detected in contaminated media at Site 16 could migrate along two possible pathways:

- VOCs could volatilize in the subsurface from the adsorbed soil phase or the above phases and migrate as vapors, through permeable subsurface material, until they are discharged to the atmosphere at the ground surface; and
- VOCs could migrate from the subsurface as non-aqueous phase separate liquids (NAPLs) or dissolved phase (groundwater) and discharged to the ground surface (seep) or into surface water bodies followed by volatilization from these surface areas.

Subsurface vapor migration in the landfill is evidenced by detectable concentrations of VOCs obtained during soil gas sampling of the landfill vadose zone. Surface emissions, with respect to volatilization from surface discharge seeps and surface water was evaluated through surface water sampling along Harrison Bayou.

5.3.2 Surface Water Transport

Metals present at Site 16 could potentially be transported to other on-site or off-site areas via surface water runoff from the landfill. Transport with precipitation runoff would include both dissolved phase transport and suspended phase (adsorbed) transport within the precipitation runoff into surface water receptors such as Harrison Bayou and Caddo Lake.

Volatiles in surface waters at Site 16 could potentially be transported via precipitation runoff from seeps where groundwater containing COCs reemerges. This has been historically observed east of the monitoring well 16WW22, which is adjacent to Harrison Bayou. Transport of COCs within the runoff and stream flow could include dissolved phase, NAPLs, or adsorbed (suspended solids) phase into surface water receptors, such as Harrison Bayou and Caddo Lake.

5.3.3 Sediment Transport

Erosional transport of soil and sediment from Site 16 is also a potential migration pathway. Potential sediment transport pathways include surface drainage channels and erosion of sediment from the landfill. With respect to VOCs, potential adsorbed concentrations were evaluated by analyses of sediment samples at Site 16. It is presumed that the adsorbed concentrations of VOCs bound to sediments originated from the wastes deposited in the landfill or VOC migration from the landfill to adjacent areas.

5.3.4 Groundwater Transport

Analytical results of groundwater samples collected from Site 16 monitoring wells and extraction wells indicate that groundwater contains COCs in the dissolved phase. The observed horizontal and vertical extent of the contaminated groundwater has been evaluated and is discussed in Section 4.0. The primary migration route from the landfill subsurface is through source dissolution into groundwater (leachate) followed by groundwater flow to downgradient locations. Predictions of the extent of contaminant transport and fate, via modeling efforts, is presented later in this section.

5.4 CONTAMINANT PERSISTENCE PROPERTIES

The primary subsurface COCs detected in groundwater at Site 16 consist of VOCs detected in groundwater and vapor phase samples from various depths. Contaminant concentrations of both the vapor phase and dissolved phase were measured to characterize the proliferation of VOC contaminants. As described above, the physical/chemical properties of a compound and the conditions of the soil environment will determine the degree of phase partitioning. The concentrations of volatile vapor phase COCs and their extents were evaluated from data collected during the soil gas investigation using a Geoprobe. The soil gas data is used to quantify potential source areas within the landfill in order to characterize and assess the partitioning of COCs into the dissolved phase. Unknown or unidentified localized vadose zone soil contamination can adversely affect the interpretation of the soil gas data. The partitioning of VOCs into the vapor

phase has not been distinguished from potential localized vadose zone contamination sources and the major dissolved phase contaminant concentrations. Soil gas investigations could have intercepted laterally diffusing VOCs from vadose zone soil source as well as vertically diffusing VOCs from contaminated groundwater. Contaminant concentrations observed in the soil gas data from 16 Site could be anomalously high relative to the dissolved phase concentrations detected in the groundwater samples from the monitoring wells.

VOCs, depending on their properties and on the subsurface soil conditions, may be present at Site 16 as immiscible liquids (phase separate), dissolved phase (soluble), or vapor phase (gas). Phase separate liquids, if present, may be flowing or immobilized by subsurface stratigraphic barriers. The dissolved components may move freely within saturated soil or may be adsorbed to soil surfaces and/or to any stationary organic matter present. Soluble VOCs identified at Site 16 in the vapor and dissolved phases include 1,1-dichloroethane, 1,2-dichloroethane, 1,2-dichloroethene, 1,1-dichloroethene, cis-1,2-dichloroethene, trans-1,2-dichloroethylene, methylene chloride, 1,1,2-trichloroethane, TCE, and vinyl chloride. With the exception of vinyl chloride these compounds have a density greater than 1.0 g/ml and would have the ability to migrate vertically downward from the source area. These compounds possess low aqueous solubility, high vapor pressures, high diffusion coefficients, and are resistant to degradation processes in most soils. If these compounds were present in the subsurface at Site 16 as NAPLs, they would have the potential to partition into the dissolved phase over time and migrate further downgradient with groundwater flow.

Soluble VOC contaminants migrate or move by convection within flowing groundwater at Site 16. Movement is attenuated to varying degrees in part by adsorption-desorption reactions with stationary organic matter and soil particle surfaces. Since the adsorption processes are largely reversible, the dissolved VOCs do not readily immobilize in saturated soil media. They are persistent in the soluble phase and will migrate or move as long as groundwater is under the influence of a hydraulic gradient (see Section 3.0). Unless a particular VOC is completely degraded by microorganisms or chemical reactions, it may reside temporarily in the vadose zone above groundwater, which receives or received a net input of water (precipitation infiltration), and will migrate to groundwater bearing zones at Site 16.

The primary processes governing transport, versus persistence, of dissolved phase VOCs through the subsurface soil at Site 16 are convection of VOCs with flowing solution in soil (mass flow) and the spreading migration of VOCs in the soil media by movement around the soil particles (hydrodynamic dispersion). VOCs are attenuated to varying degrees by reversible adsorption to stationary soil and organic matter as stated above. One method of indexing adsorption is the distribution coefficient (K_d) which is the ratio of adsorbed concentration to dissolved concentration (at equilibrium). Another index is the distribution coefficient per unit soil organic carbon fraction and is referred to as the organic carbon distribution coefficient (K_{oc}). K_{oc} has been documented in research literature to vary less between soils than K_d for a given VOC, thus it can represent the adsorption potential of a particular VOC. Utilizing bulk concentrations of VOCs in the aquifer, specific porosity, water flux, bulk density and soil organic carbon fraction for the saturated aquifer, with available K_{oc} values, the average travel times of VOCs can be estimated to receptors at a given distance from the inferred source point. Individual VOCs identified in groundwater samples from Site 16 were not evaluated for specific solutions herein due to the complex discontinuity of increased permeable sand deposits of varying degrees of intrinsic permeability (Section 3.0). An understanding of the processes affecting contaminant migration rates, hence persistence in the subsurface media, was presented here for insight into the magnitude of site characterization and prediction of contaminant migration over time as required under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Groundwater modeling efforts were used to estimate the migration, fate, and persistence of detected TCE concentrations over time.

6.0 BASELINE RISK ASSESSMENT

The Baseline Risk Assessment and Ecological Risk Assessments for Site 16 have been provided under separate cover.

7.0 SUMMARY AND CONCLUSIONS

7.1 Summary

The following section provides a summary of the nature and extent of contamination at Site 16 in the soil, sediment, surface water, and groundwater. This summary is based on the analytical results for samples collected from these media with respect to the Media Specific Concentration (MSC) and Texas Water Quality Standards (TQWS) values. This section will be updated and revised as needed when the Baseline Risk Assessment is completed and reviewed. Conclusions are presented in Section 7.2.

7.1.1 Nature and Extent of Contamination

Source Area Soil

Trichloroethene, and vinyl chloride were detected with concentrations exceeding MSC values at two of the locations (16SB02 and 16SB04). Table 7-1 presents a summary of the samples collected and compounds that exceeded MSCs values. Samples collected from soil boring 16SB02 had concentrations exceeded MSC values for trichloroethene at depth interval of 16'-17', and vinyl chloride at depth interval of 20'-22'. Samples collected from soil boring 16SB04 had concentrations exceeded MSC values for vinyl chloride at depth intervals of 0'-4' and 15'-17'. Soil samples collected from the source area did not contain concentrations that exceeded MSC values for semi-volatile organic compounds (SVOC), or metals.

Non-Source Area Soil

Analytical results for surface and subsurface soil samples collected at Site 16 from outside of the source area had no detected concentrations exceeding MSC values for VOCs, SVOCS, anions, metals or dioxins/furans as presented in Table 7-2. Some soil samples contained detected metal concentrations that exceeded the Longhorn Army Ammunition Plant (LHAAP) soil background levels.

TABLE 7-1

Source Area Soil Samples Exceeding MSC Values at Site 16

Compound	Location	Depth Interval (ft)
Volatile Organics		
Trichloroethene	16SB02	(16-17)
Vinyl chloride	16SB02	(20-22)QC
	16SB04	(0-4), (15-17)
Semi-Volatile Organics		
No Samples Exceeded MSC	---	---
Metals		
No Samples Exceeded MSC	---	---

TABLE 7-2

Non-Source Area Soil Samples Exceeding MSC Values at Site 16

Compound	Location	Depth Interval (ft)
Volatile Organics		
No Samples Exceeded MSC	---	---
Semi-Volatile Organics		
No Samples Exceeded MSC	---	---
Anions		
No Samples Exceeded MSC	---	---
Metals		
No Samples Exceeded MSC	---	---
Dioxin/Furan		
No Samples Exceeded MSC		

Sediment

Sediment samples were collected at points along the drainage pathways of the landfill and along Harrison Bayou. Analytical results for the sediment samples collected at Site 16 had no detected concentrations exceeding MSC values for VOCs, anions, or metals as presented in Table 7-3. Sediment samples collected at Site 16 had eight dioxin/furan compounds that were detected at concentrations exceeding the MSC values as summarized in Table 7-3. Some sediment samples

contained detected metal concentrations that exceeded the background levels from the five perimeter sediment samples.

TABLE 7-3
Sediment Samples Exceeding MSC Values at Site 16

Compound	Location
Volatile Organics	
No Samples Exceeded MSC	---
Semi-Volatile Organics	
No Samples Exceeded MSC	---
Anions	
No Samples Exceeded MSC	---
Metals	
No Samples Exceeded MSC	---
Dioxins/Furans	
1,2,3,6,7,8-HxCDD	16SD33,16SD35
1,2,3,7,8,9-HxCDD	16SD33,16SD35
Heptachlorodibenzo-p-dioxin	16SD31,16SD32,16SD33,16SD35
Hexachlorodibenzo-p-dioxin	16SD31,16SD32,16SD33,16SD34,16SD35
OCDD	16SD31,16SD32,16SD33,16SD34,16SD35
2,3,4,7,8-PeCDF	16SD32,16SD33
1,2,3,7,8-PeCDD	16SD33
Tetrachlorodibenzo-p-dioxin	16SD31,16SD32,16SD33,16SD35

Surface Water

Surface water samples were collected at points along the drainage pathways of the landfill and along Harrison Bayou. Surface water samples collected from Site 16 had three metals that were detected at concentrations exceeding the TWQS values. Surface water samples also contained nine dioxin/furan compounds at concentrations exceeding the MSC values. Table 7-4 presents a summary of detected compounds and sample locations that contain concentrations exceeding TWQS and MSC values. Copper exceeded the TWQS value in samples 16SW01, 16SW02, 16SW06 – 16SW13, 16SW17 – 16SW20, and 16SW31. Lead exceeded the TWQS value in samples 16SW06, 16SW31, 16SW32, and 16SW34. Zinc exceeded the TWQS value in samples 16SW01, 16SW02, 16SW06, 16SW07, 16SW09 – 16SW11, 16SW14, and 16SW31 – 16SW34 (see Figure 2-4 in Appendix I for sample locations). 1,2,3,4,7,8-HxCDF exceeded the MSC

value in samples 16SW31 and 16SW33. 1,2,3,6,7,8-HxCDD exceeded the MSC value in samples 16SW31, 16SW32 16SW33, and 16SW34. 1,2,3,7,8,9-HxCDD exceeded the MSC value in samples 16SW31 and 16SW33. Heptachlorodibenzo-p-dioxin exceeded the MSC value in samples 16SW31, 16SW32 16SW33, 16SW34, and 16SW35. Hexachlorodibenzo-p-dioxin exceeded the MSC value in samples 16SW31, 16SW32 16SW33, and 16SW34. OCDD exceeded the MSC value in samples 16SW31, 16SW32 16SW33, 16SW34, and 16SW35. 2,3,4,7,8-PeCDF exceeded the MSC value in samples 16SW31 and 16SW33. 1,2,3,7,8-PeCDD exceeded the MSC value in samples 16SW33. Tetrachlorodibenzo-p-dioxin exceeded the MSC value in samples 16SW33.

TABLE 7-4

Surface Water Samples Exceeding MSC Values at Site 16

Compound	Location
Volatile Organics	
No Samples Exceeded MSC	---
Semi-Volatile Organics	
No Samples Exceeded MSC	---
Anions	
No Samples Exceeded MSC	---
Metals	
Copper	16SW01, 16SW02, 16SW06 - 16SW13, 16SW17 - 16SW20, and 16SW31 *
Lead	16SW06, 16SW31*, 16SW32*, and 16SW34*
Zinc	16SW01, 16SW02, 16SW06, 16SW07, 16SW09 - 16SW11, 16SW14, 16SW31*, 16SW32*, 16SW33*, 16SW34*
Dioxins/Furans	
1,2,3,4,7,8-HxCDF	16SW31, 16SW33
1,2,3,6,7,8-HxCDD	16SW31, 16SW32, 16SW33, 16SW34
1,2,3,7,8,9-HxCDD	16SW31, 16SW33
Heptachlorodibenzo-p-dioxin	16SW31, 16SW32, 16SW33, 16SW34, 16SW35
Hexachlorodibenzo-p-dioxin	16SW31, 16SW32, 16SW33, 16SW34
OCDD	16SW31, 16SW32, 16SW33, 16SW34, 16SW35
2,3,4,7,8-PeCDF	16SW31, 16SW33
1,2,3,7,8-PeCDD	16SW33
Tetrachlorodibenzo-p-dioxin	16SW33

* - Location covered during landfill cap installation

Groundwater

Groundwater samples collected from wells at Site 16 had concentrations of 9 VOCs, 10 metals, 1 pesticide, 1 SVOC, and 9 dioxins/furans that exceeded MSC values. Table 7-5 presents a summary of detected compounds and sample locations that exceeded the MSCs.

VOCs that had the highest frequency of detections at concentrations above MSC values were trichloroethene, vinyl chloride, and cis-1,2-dichloroethene. The remaining VOCs detected at concentrations that exceeded MSC values were 1,1,2-trichloroethane, 1,1-dichloroethene, 1,2-dichloroethane, 1,2-dichloroethene, trans-1,2-dichloroethene and methylene chloride. Groundwater samples collected from monitoring wells completed in the shallow water bearing zone with VOC concentrations above MSC values are 16WW01, 16WW03, 16WW12 – 16WW14, 16WW16, 16WW22, 16WW26, 16WW30, 16WW34, 16WW36, and 16WW38. Groundwater samples from collected monitoring wells completed in the intermediate water bearing zone with VOC concentrations above MSC values are 16WW02, 16WW04, 16WW10, 16WW11, 16WW29, 16WW35, and 16WW37. Groundwater samples collected from monitoring wells completed in the upper portion of the deep water bearing zone with VOC concentrations above MSC values are 16WW 20 and 16WW21.

Metals that were detected in groundwater samples at concentrations exceeding MSC values are barium, beryllium, cadmium, chromium, iron, lead, manganese, nickel, thallium and zinc. Iron, chromium, and nickel were the metals most frequently exceeding MSC values. Groundwater samples collected from monitoring wells completed in the shallow water bearing zone with metal concentrations above MSC values are 16WW03, 16WW09, 16WW12 – 16WW14, 16WW16, 16WW24, 16WW26, 16WW28, 16WW30, 16WW32, 16WW34, and 16WW38. Groundwater samples from collected monitoring wells completed in the intermediate water bearing zone with metal concentrations above MSC values are 16WW23, 16WW25, 16WW27, 16WW29, 16WW35, and 16WW37. Groundwater samples collected from monitoring wells completed in the deep water bearing zone with metal concentrations above MSC values are 16WW20 (upper portion) and 16WW17 (lower portion).

TABLE 7-5

Groundwater Samples Exceeding MSC Values at SITE 16

Compound	Location
Volatile Organics	
1,1,2-Trichloroethane	16WW16
1,1-Dichloroethene	16WW16
1,2-Dichloroethane	16WW12,16WW16,16WW22,16EW01
1,2-Dichloroethene	16WW01,16WW16,16EW01
cis-1,2-Dichloroethylene	16WW12, 16WW13, 16WW16, 16WW21, 16WW22, 16WW26, 16WW36, 16WW37, 16WW38, 16EW01, 16EW02, 16EW05, and 16EW06
trans-1,2-Dichloroethene	16WW16
Methylene chloride	16WW03,04,16EW01
Trichloroethene	16WW01, 16WW02, 16WW03, 16WW04, 16WW10, 16WW11, 16WW12, 16WW13, 16WW14, 16WW16, 16WW20, 16WW21, 16WW22, 16WW26, 16WW29, 16WW30, 16WW34, 16WW35, 16WW36, 16WW37, 16WW38, 16EW01, 16EW02, 16EW03, 16EW04, 16EW05, 16EW06, and 16EW08
Vinyl chloride	16WW01, 16WW04, 16WW11, 16WW12, 16WW13, 16WW16, 16WW21, 16WW22, 16WW26, 16WW35, 16WW38, 16EW01, and 16EW06
Semi-Volatile Organics	
Bis(2-ethylhexyl)phthalate	16EW02
Pesticides	
Aldrin	16EW01
Metals	
Barium	16WW09, 16WW17, and 16WW24
Beryllium	16WW20
Chromium	16WW12, 16WW14, 16WW16, 16WW20, 16WW24, 16WW26, 16WW32, 16WW34, 16WW37, 16WW38, and 16EW03
Iron	16WW12, 16WW13, 16WW14, 16WW16, 16WW20, 16WW23, 16WW24, 16WW25, 16WW26, 16WW27, 16WW28, 16WW29, 16WW30, 16WW34, 16WW35, 16WW38, 16EW02, 16EW05, 16EW06, 16EW07, and 16EW08
Lead	16WW15, 16WW17, 16WW20, 16WW24, and 16WW34
Manganese	16WW13
Nickel	16WW03, 16WW13, 16WW14, 16WW20, 16WW24, 16WW25, 16WW26, 16WW30, 16WW34, and 16EW03
Thallium	16WW30
Zinc	16EW02

TABLE 7-5 (Continued)
Groundwater Samples Exceeding MSC Values at SITE 16

Compound	Location
Dioxin/Furan	
2,3,7,8-TCDF	16WW16,16WW35
1,2,3,4,7,8-HxCDF	16EW01
1,2,3,7,8,9-HxCDD	16EW01
Heptachlorodibenzo-p-dioxin	16WW16,16WW36
1,2,3,7,8-PeCDD	16EW01
Tetrachlorodibenzo-p-dioxin	16EW01
1,2,3,7,8,9-HxCDF	16EW01
OCDD	16WW16
2,3,4,7,8-PeCDF	16WW16,16EW01

A total of nine dioxin/furan compounds were detected in the groundwater samples collected at Site 16 at concentrations which exceed MSC values. Five dioxin/furan compounds, 1,2,3,4,7,8-HxCDF, 1,2,3,7,8,9-HxCDD, 1,2,3,7,8-PeCDD, Tetrachlorodibenzo-p-dioxin and 1,2,3,7,8,9-HxCDF were detected in only one monitoring well sample 16EW01 at concentrations exceeding MSC values. 2,3,4,7,8-PeCDF exceeded the MSC value in samples 16WW16 and 16EW01. 2,3,7,8-TCDF exceeded the MSC value in samples 16WW16 and 16ww35. Heptachlorodibenzo-p-dioxin exceeded the MSC value in samples 16WW16 and 16WW36. OCDD exceeded the MSC value in samples 16WW16.

Analytical results for the groundwater samples collected at Site 16 had no detected concentrations exceeding MSC values for polychlorinated biphenyls (PCB) or high explosives (HE).

7.1.2 Fate and Transport Summary

The following section provides a summary of fate and transport mechanisms for contaminants of concern (COC) at Site 16 in the soil, sediment, surface water, and groundwater. This section will be updated and revised as needed when the Baseline Risk Assessment is completed and reviewed.

Source Area Soil

COCs detected within landfill materials could be transported through infiltration of water and subsequent migration into the groundwater beneath the landfill and through surface water runoff into the surrounding drainage paths. The landfill cap was completed at Site 16 at about the same time as the Phase III Remedial Investigation (RI). The cap is constructed of compacted clay layers, an impermeable geomembrane liner followed by topsoil and vegetative cover. The landfill cap prevents the infiltration of precipitation and surface runoff into the landfill, thereby reducing the amount of water moving through the buried waste material. The placement and design of the landfill cap is such that it covers the surface soils within the source area, thereby preventing the transportation of contaminated soils away from the landfill via surface runoff. Groundwater in contact with the buried waste material still provides a mechanism for transportation of contaminants away from the landfill.

Non-Source Area Soil

Soil samples collected from various depth intervals and locations outside the limits of the landfill did not contain COCs at concentrations exceeding MSC values. Therefore, under the present conditions, based on the data presented in this report soils outside the limits of the landfill do not present a migration pathway.

Sediment

Sediment samples collected had concentrations exceeding MSC values for eight dioxin/furan compounds. The landfill cap covers four of the sample locations. Although one sample location with concentrations of dioxin/furan compounds exceeding MSC values is located outside the coverage of the landfill cap, the placement of the landfill cap should minimize transportation of sediment borne COCs along drainage pathways.

Surface Water

Surface water samples collected at Site 16 had concentrations exceeding MSC values for copper, lead, and zinc at locations upgradient and downgradient of the landfill. The landfill cap covered five of the sampling locations. Four of the samples with copper concentrations exceeding the TWQS value were collected at locations along Harrison Bayou, in southern portion of LHAAP

near Plant Road. Samples from these locations are classified as background samples and are used for comparison purposes. The remaining samples with concentrations exceeding TWQS values have also been addressed through the installation landfill cap. Although some of the samples with concentrations of metals (primarily copper and zinc) exceeding TWQS are located outside the coverage of the landfill cap, the placement of the landfill cap should minimize migration of surface water borne COCs along drainage pathways.

Five surface water samples collected and analyzed for dioxin/furan compounds had concentrations exceeding MSC values for nine compounds. The landfill cap covers four of the sample locations. Although one sample location with concentrations of dioxin/furan compounds exceeding MSC values is located outside the coverage of the landfill cap, the placement of the landfill cap should minimize migration of surface water borne COCs along drainage pathways.

A single "seep" water sample was collected from an exposed bank in the northeast portion of Site 16 above Harrison Bayou. Concentrations of trichloroethene, cis-1,2-dichloroethene and vinyl chloride were detected in this sample at concentrations of 1,020, 609 and 65 µg/l. There are no TWQS values for the VOCs detected in this water sample.

Groundwater

Groundwater samples collected from wells at Site 16 had 9 VOCs, 1 SVOC, 10 metals, 1 pesticides compound, and 9 dioxin/furan compounds detected at concentrations exceeding MSC values. These contaminants are transported by infiltration of precipitation and surface runoff through landfill materials into the groundwater and by groundwater in contact with the buried waste material, and are transported away from the landfill by advection. Groundwater flow is primarily away from the landfill to the north-northeast and has resulted in the migration of COCs to areas outside and downgradient of the landfill boundary. The placement of the landfill cap prevents the infiltration of precipitation and surface runoff into the landfill, thereby reducing the amount of water moving through the buried waste material. Groundwater in contact with the buried waste material still provides a mechanism for transportation of contaminants away from the landfill. COCs are present in the shallow, intermediate, and to a lesser extent deep water

bearing zones at concentrations exceeding MSC values, making groundwater advection the primary migration pathway at Site 16.

7.2 Conclusions

7.2.1 Data Limitations

In general, quality assurance (QA)/quality control (QC) samples collected during the Phase I, II, and III RI indicated that analytical results meet the definitive data standards, are of known quality, and are acceptable for the uses as intended with the required qualifications. Nineteen non-detect results for antimony in samples collected during Phase II field activities were deemed unusable due to QC deficiencies. Nineteen non-detect results for HE compounds in samples collected during Phase III field activities were deemed unusable due to QC deficiencies. The data were qualified as rejected (R) because of these QC deficiencies. QC data demonstrated that the QA mechanisms were effective at ensuring measurement reliability within the expected limits of sampling and analytical error. Therefore the analytical results are considered, as qualified, to be representative of actual site conditions at the time the samples were collected.

Additional details concerning data limitations for Site 16 analytical results are presented in the Final Sampling and Data Results Reports prepared after each phase of the RI.

7.2.2 Site 16 Media Conclusions

Source Area Soil

Based on the analytical results of source area samples collected during RI field activities, the specific fate and transport parameters, the completion of the landfill cap, and the current site use, no further investigation is recommended for source area surface soils at this time. However, additional information regarding the buried source area materials may be necessary in order to develop a comprehensive remedial approach to address groundwater contamination and the evaluation of groundwater treatment alternatives. Additionally, the landfill cap should be monitored to ensure its integrity.

Non-Source Area Soil

Based on the analytical results of non-source area samples collected during the RI field activities, the specific fate and transport parameters, the completion of the landfill cap, and the current site use, no further investigation is recommended at this time. Additionally, the landfill cap should be monitored to ensure its integrity.

Sediment

Based on the analytical results of sediment samples collected during the RI field activities, the specific fate and transport parameters, the completion of the landfill cap and the current site use, no further investigation is recommended at this time. Additionally, the landfill cap should be monitored to ensure its integrity.

Surface Water

Based on the analytical results of surface water samples collected during the RI field activities, the specific fate and transport parameters, the completion of the landfill cap and the current site use, no further investigation is recommended at this time. Additionally, the landfill cap should be monitored to ensure its integrity.

The single seep water collected from an exposed bank in the northeast portion of Site 16 above Harrison Bayou contained 3 VOCs. The seep water is likely a result of an exposure of a more hydraulically conductive sand body that has been deposited in this area. The groundwater flow direction in this sand seam is towards the northeast.

Groundwater

Based on the analytical results of groundwater water samples collected during the RI field activities, COCs from the source area have partitioned into a dissolved phase and are migrating downgradient of the landfill by advection. Groundwater samples collected from wells completed in the shallow, intermediate and deep water bearing zones have detected COCs (predominately halogenated hydrocarbons) concentrations above MSC values. In addition, metals concentrations exceeding MSC values are present in groundwater samples collected from 9 of the monitoring wells completed in the shallow water bearing zone, 10 of the monitoring wells completed in the

intermediate water bearing zone, and 2 of the monitoring wells completed in the deep water bearing zone. The groundwater samples collected from wells completed in the shallow and intermediate water bearing zones exhibited the highest frequency of VOCs concentrations exceeding MSC values. Groundwater samples collected from 2 monitoring wells completed in the deep water bearing zone had concentrations of VOCs above MSC values. The extraction wells, installed as part of the treatability study, are exerting a degree of hydraulic control on the groundwater system at Site 16 and removing COCs by intercepting groundwater flow thus limiting the continued migration of contaminated groundwater toward Harrison Bayou.

The completion of the landfill cap should minimize the infiltration of water through landfill material thus reducing the release of COCs to the groundwater system. However, at present, the concentrations and extent of contamination in shallow, intermediate, and to a lesser extent deep water bearing zones warrant remedial action.

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**Final
REMEDIAL INVESTIGATION REPORT
Volume 2: Appendix I - Figures**

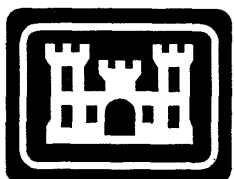
for the

**SITE 16 LANDFILL REMEDIAL
INVESTIGATION and FEASIBILITY
STUDY**



At the

**Longhorn Army Ammunition Plant
(LHAAP)
Karnack, Texas**



Submitted to

**U.S. Army Corps of Engineers
Tulsa District**

Contract No. DACA56-97-D-0001

October, 2000

Jacobs Engineering Group, Inc
St. Louis, Missouri

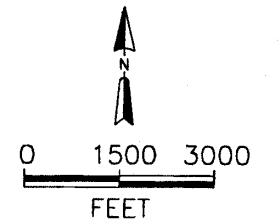
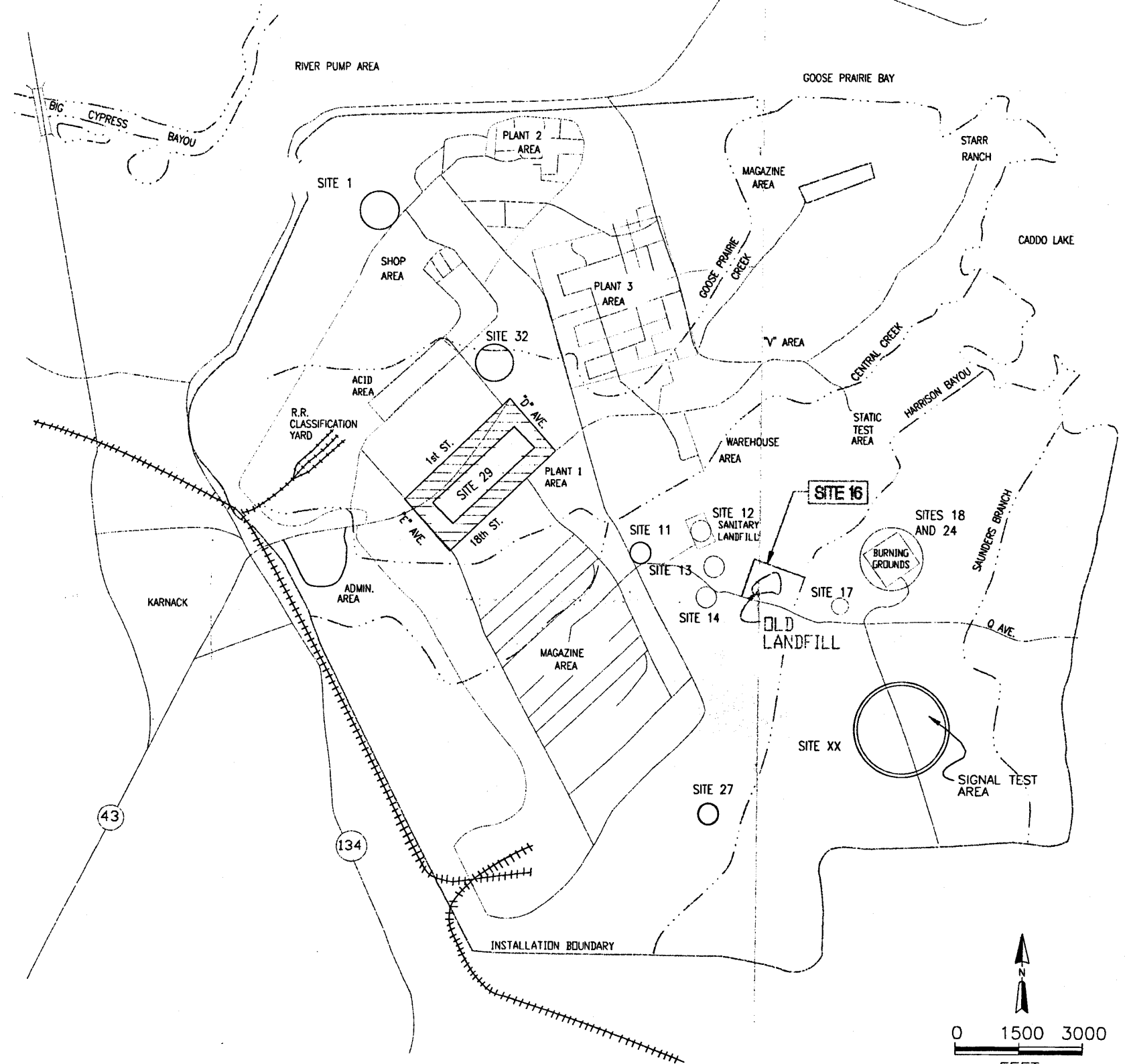
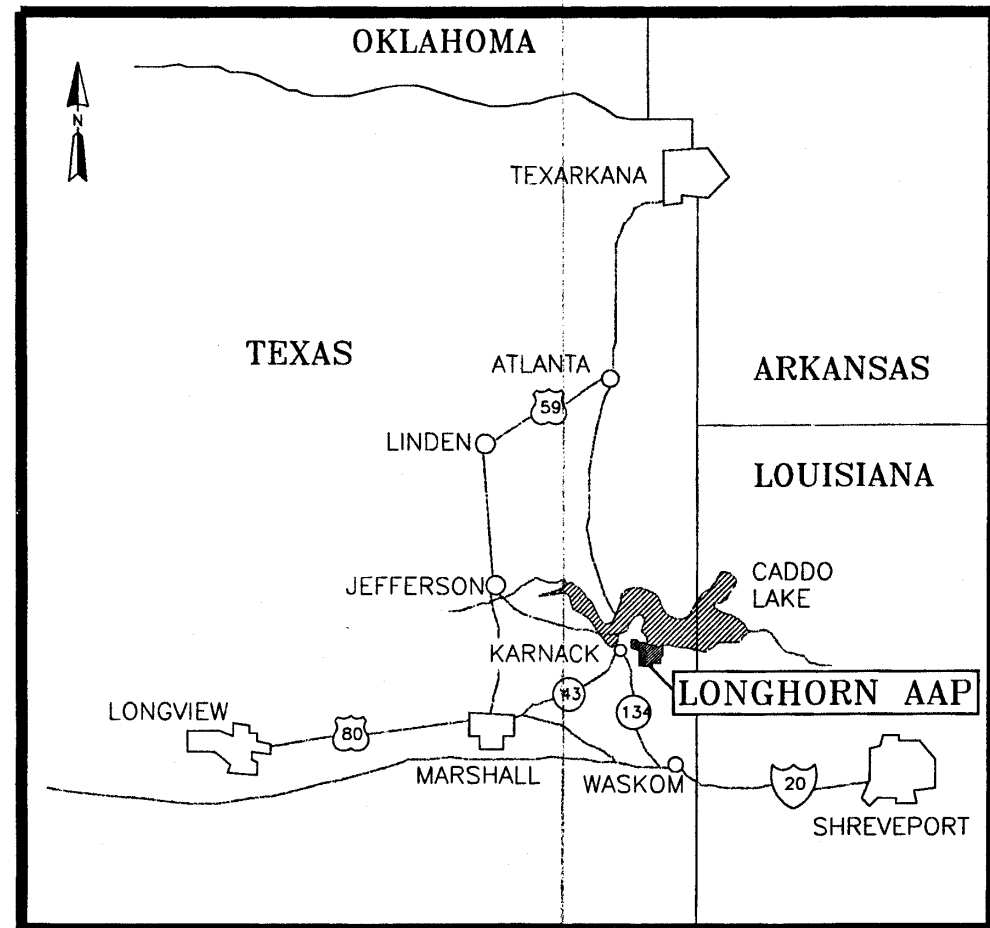
APPENDIX I

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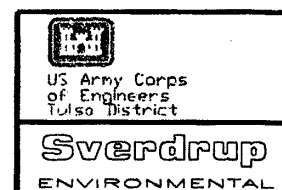
<u>Figure No.</u>	<u>Description</u>
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1-2	Site Map (22x34))
1-3	Pre-Phase I Sampling Locations (22x34)
2-1	Phase I, II, and III Soil Boring, Monitoring Well, Extraction Well, and Piezometer Locations (22x34)
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- 4-10 Deep Zone Chloride Concentration (22x34)

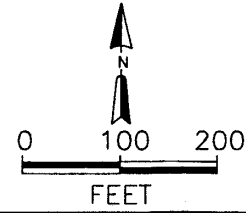


LONGHORN AAP



SITE LOCATION MAP
SITE 16 REMEDIAL INVESTIGATION
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

DWN: BSM	DES.:	PROJECT NO.:
CHKD: SJB	APPD.:	000187
DATE: FEB 97	REV.:	FIGURE NO.:
		1-1



 US Army Corps of Engineers Tulsa District Sverdrup ENVIRONMENTAL	PROJECT NO.: 000187	DWN: BSM	DES.:	SITE MAP SITE 16 REMEDIAL INVESTIGATION LONGHORN ARMY AMMUNITION PLANT KARNACK, TEXAS	FIGURE NO.: 1-2
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		DATE: FEB 99	REV.:		

NOTE:
SOME LOCATIONS WERE TRANSFERRED TO THIS BASE MAP FROM A "NOT TO SCALE" SKETCH
PRESENTED IN EPS-8 - FINAL REMEDIAL INVESTIGATION REPORT, DATED MAY 1988, FIGURE 3b - SITE 1,
OLD LANDFILL, (RETAIL SALES AREA), (SAMPLE LOCATION GEOMETRY).

APPROXIMATE LOCATIONS

THE SURFACE WATER AND SEDIMENT SAMPLES SW017/SED017
COMPOSITE SOIL SAMPLES 1 THROUGH 10 IN QUADRANTS I AND IV
COMPOSITE SOIL SAMPLES 3 THROUGH 12 IN QUADRANTS II AND III
SURFACE SOIL SAMPLES 1 THROUGH 10
THE BACKGROUND SAMPLE LOCATION

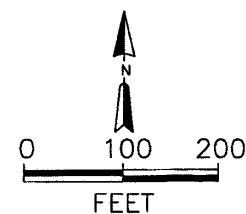
SURVEYED LOCATIONS

SOIL BORINGS 701 THROUGH 705
MONITORING WELLS 122, AND BH12 THROUGH BH16
ONLY SURVEYED LOCATIONS SHOULD BE ASSUMED ACCURATE.

LEGEND

- "BH" SERIES WELLS
- SOIL BORING
- ⊕ SHALLOW MONITORING WELL
- ⊕ SEDIMENT SAMPLE
- ⊕ SURFACE WATER SAMPLE
- COMPOSITE SOIL SAMPLE
- SURFACE SOIL SAMPLE
- ✱ BACKGROUND SAMPLE

A/P = ABANDONED/PLUGGED WELLS



US Army Corps
of Engineers
Tulsa District

Sverdrup
ENVIRONMENTAL

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**PRE-PHASE I INVESTIGATIONS SAMPLING
LOCATION MAP
SITE 16 REMEDIAL INVESTIGATION
LHAAP - KARNACK, TEXAS**

FIGURE NO.:

-3

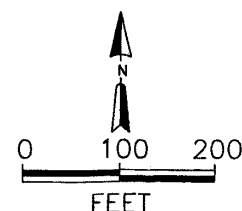
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Shallow Zone				Intermediate Zone			
16-122	25.23	184.26	8.5 - 23.5	16WW02	50.10	181.37	27.5 - 47.5
16WW01	19.31	181.49	6.5 - 16.5	16WW04	52.51	191.68	30.0 - 50.0
16WW03	26.58	191.65	12.5 - 24.5	16WW06	62.10	202.56	47.0 - 59.0
16WW05	33.26	202.60	15.5 - 30.5	16WW08	41.37	187.76	27.0 - 40.0
16WW07	10.40	187.79	3.5 - 8.0	16WW10	48.25	180.88	26.0 - 46.0
16WW09	12.25	200.07	7.0 - 9.0	16WW11	60.85	184.59	34.0 - 59.0
16WW12	26.76	185.98	14.0 - 24.0	16WW23	34.00	177.77	24.0 - 34.0
16WW13	22.63	175.59	14.0 - 24.0	16WW25	49.00	188.39	39.0 - 49.0
16WW14	29.98	195.02	17.0 - 27.0	16WW27	36.00	177.09	26.0 - 36.0
16WW16	31.31	193.04	19.0 - 29.0	16WW29	42.00	177.94	37.0 - 42.0
16WW22	31.00	199.81	21.0 - 31.0	16WW31	49.00	202.44	39.0 - 49.0
16WW24	16.00	177.72	11.0 - 16.0	16WW33	49.00	202.64	39.0 - 49.0
16WW26	17.50	188.48	13.0 - 18.0	16WW35	43.50	190.53	34.0 - 44.0
16WW28	21.00	176.67	16.0 - 21.0	16WW37	45.50	201.72	41.0 - 46.0
16WW30	30.00	178.12	25.0 - 30.0	16EW05	55.00	197.26	47.0 - 55.0
16WW32	32.00	202.53	22.0 - 32.0	16EW06	58.00	194.93	50.0 - 58.0
16WW34	32.00	202.60	27.0 - 32.0	16EW07	49.00	184.23	41.0 - 46.0
16WW36	21.50	190.85	17.0 - 22.0	16EW08	42.00	178.49	34.0 - 39.0
16WW38	29.00	201.69	19.0 - 29.0	16PZ01	50.00	198.61	45.0 - 50.0
16EW01	42.00	197.49	31.0 - 36.0	16PZ03	50.00	198.61	45.0 - 50.0
16EW02	42.00	195.21	22.0 - 27.0	16PZ05	55.00	198.31	50.0 - 55.0
16EW03	21.00	184.80	13.0 - 18.0	16PZ07	50.00	200.10	44.0 - 49.0
16EW04	22.00	179.37	14.0 - 19.0	16PZ09	56.00	196.49	51.0 - 56.0
16PZ02	32.00	199.75	27.0 - 32.0	16PZ11	52.00	198.88	44.0 - 45.0
16PZ04	31.00	198.81	26.0 - 31.0	16PZ13	52.00	193.63	45.0 - 50.0
16PZ06	28.00	198.61	23.0 - 28.0	16PZ15	51.00	188.85	44.5 - 49.5
16PZ08	33.00	199.93	28.0 - 33.0	16PZ17	46.00	183.78	39.5 - 44.5
16PZ10	27.00	196.65	22.0 - 27.0	16PZ19	42.00	181.19	35.5 - 40.5
16PZ12	32.00	199.00	27.0 - 32.0				
16PZ14	28.50	192.23	22.0 - 27.0				
16PZ16	22.00	187.92	16.0 - 21.0				
16PZ18	26.00	182.81	19.0 - 24.0				
16PZ20	22.50	180.31	16.5 - 21.5				
Upper Deep Zone				Lower Deep Zone			
16WW19	95.00	181.87	85.0 - 95.0	16WW15	307.00	19.00	297 - 307
16WW20	110.00	198.93	100 - 110	16WW17	225.00	195.04	215 - 225
16WW21	100.00	194.52	90.0 - 100	16WW18	283.00	180.73	272 - 282

1 - Wells that have been abandoned and plugged.



LEGEND

- | | |
|--------------------------------|--------------------------------|
| ● SHALLOW MONITORING WELL | ● SHALLOW PIEZOMETER |
| ● INTERMEDIATE MONITORING WELL | ● INTERMEDIATE PIEZOMETER |
| ● UPPER DEEP ZONE MW | ● SHALLOW EXTRACTION WELL |
| ● LOWER DEEP ZONE MW | ● INTERMEDIATE EXTRACTION WELL |
| ● SOIL BORING | ● A/P ABANDONED AND PLUGGED |

US Army Corps
of Engineers
Tulsa DistrictSverdrup
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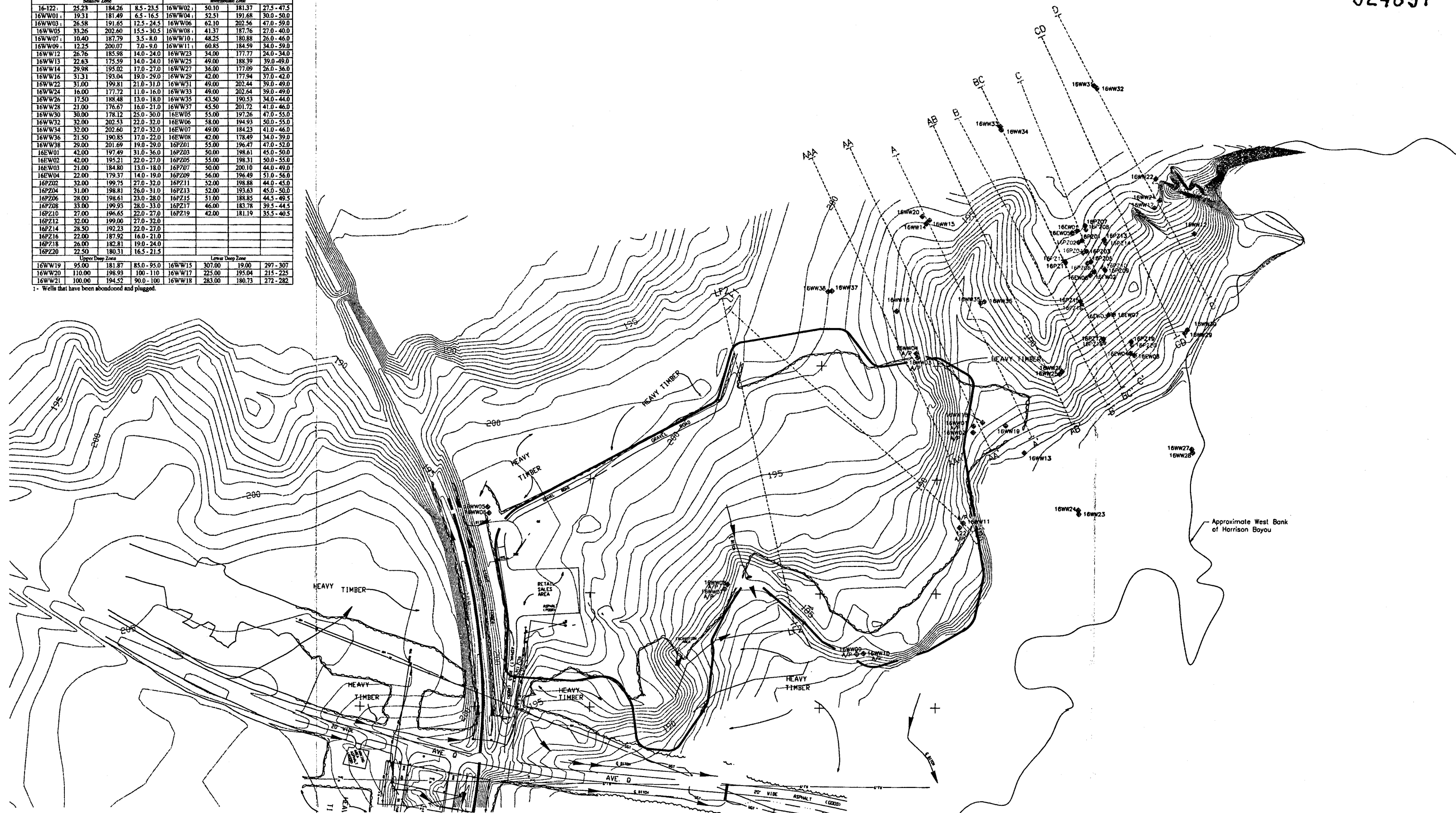
PHASE I, II, & III SOIL BORINGS, MW's,
EW's AND PIEZOMETERS LOCATION MAP
SITE 16 REMEDIAL INVESTIGATION
LHAAP - KARNACK, TEXAS

FIGURE NO.:

2-1

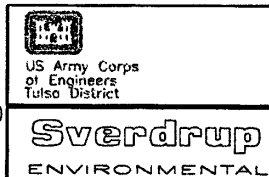
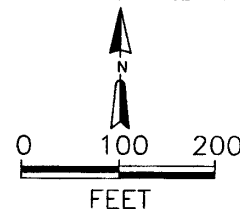
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16WW09	12.25	200.07	7.0 - 9.0	16WW11	60.85	184.59	34.0 - 59.0
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16WW28	21.00	176.67	16.0 - 21.0	16WW37	45.50	201.72	41.0 - 46.0
16WW30	30.00	178.12	25.0 - 30.0	16EW05	55.00	197.26	47.0 - 55.0
16WW32	32.00	202.53	22.0 - 32.0	16EW06	58.00	194.93	50.0 - 55.0
16WW34	32.00	202.60	27.0 - 32.0	16EW07	49.00	184.23	41.0 - 46.0
16WW36	21.50	190.85	17.0 - 22.0	16EW08	42.00	178.49	34.0 - 39.0
16WW38	29.00	201.69	19.0 - 29.0	16P201	55.00	196.47	47.0 - 52.0
16EW01	42.00	197.49	31.0 - 36.0	16P203	50.00	198.61	45.0 - 50.0
16EW02	42.00	195.21	22.0 - 27.0	16P205	55.00	198.31	50.0 - 55.0
16EW03	21.00	184.80	13.0 - 18.0	16P207	50.00	200.10	44.0 - 49.0
16EW04	22.00	179.37	14.0 - 19.0	16P209	56.00	196.49	51.0 - 56.0
16P202	32.00	199.75	27.0 - 32.0	16P211	52.00	198.88	44.0 - 45.0
16P204	31.00	198.81	26.0 - 31.0	16P213	52.00	193.63	45.0 - 50.0
16P206	28.00	198.61	23.0 - 28.0	16P215	51.00	188.85	44.5 - 49.5
16P208	33.00	199.93	28.0 - 33.0	16P217	46.00	183.78	39.5 - 44.5
16P210	27.00	196.65	22.0 - 27.0	16P219	42.00	181.19	35.5 - 40.5
16P212	32.00	199.00	27.0 - 32.0				
16P214	28.50	192.23	22.0 - 27.0				
16P216	22.00	187.92	16.0 - 21.0				
16P218	26.00	182.81	19.0 - 24.0				
16P220	22.50	180.31	16.5 - 21.5				
Upper Deep Zone				Lower Deep Zone			
16WW19	95.00	181.87	85.0 - 95.0	16WW15	307.00	19.00	297 - 307
16WW20	110.00	198.93	100 - 110	16WW17	225.00	195.04	215 - 225
16WW21	100.00	194.52	90.0 - 100	16WW18	283.00	180.73	272 - 282

1 - Wells that have been abandoned and plugged.



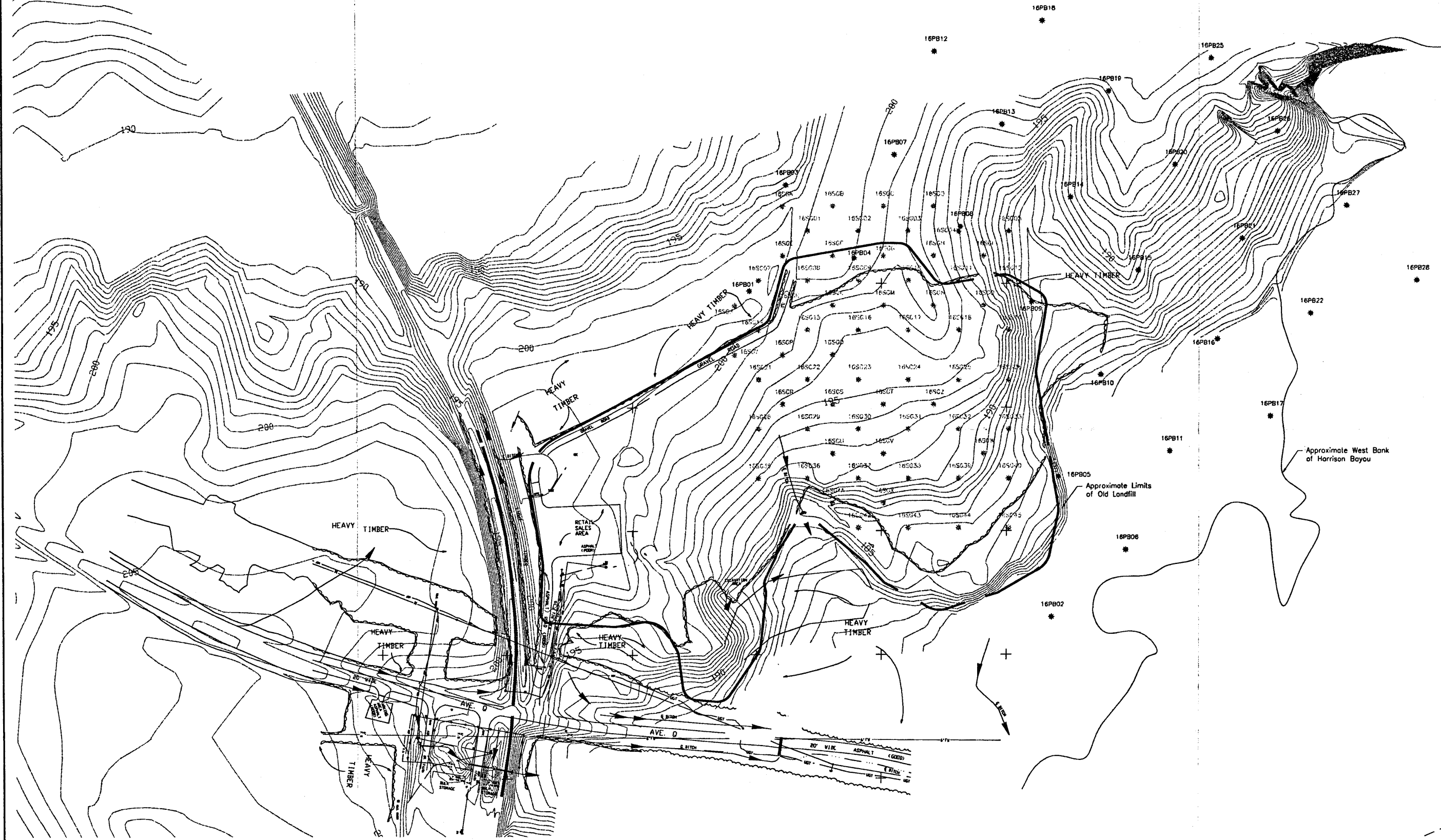
LEGEND

- | | |
|--------------------------------|--------------------------------|
| ◆ SHALLOW MONITORING WELL | ◆ SHALLOW PIEZOMETER |
| ◆ INTERMEDIATE MONITORING WELL | ◆ INTERMEDIATE PIEZOMETER |
| ◆ UPPER DEEP ZONE MW | ◆ SHALLOW EXTRACTION WELL |
| ◆ LOWER DEEP ZONE MW | ◆ INTERMEDIATE EXTRACTION WELL |
| | ◆ A/P ABANDONED AND PLUGGED |



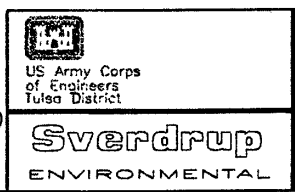
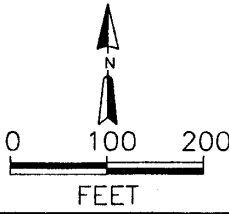
SURFACE RESISTIVITY SURVEY
ARRAY LINES
SITE 16 REMEDIAL INVESTIGATION
LONGHORN ARMY AMMUNITION PLANT - KARNACK, TEXAS

DWN:	BSM	DES.:		PROJECT NO.:
CHKD:	SJB	APPD:		000187
DATE:	DEC 98	REV.:		FIGURE NO.:
				2-2



LEGEND

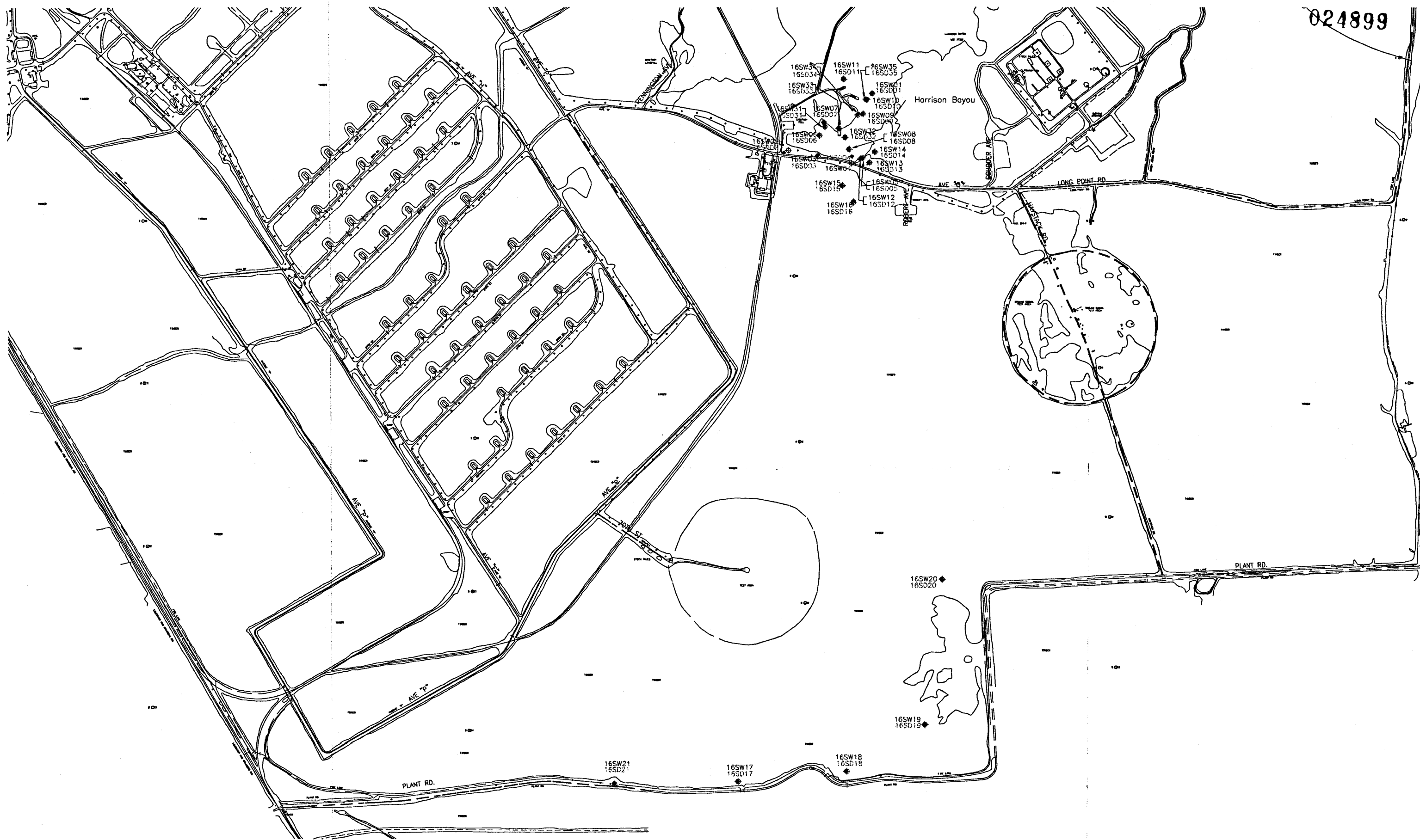
- * GEOPROBE
- * SOIL GAS



PHASE I, II, & III SOIL GAS AND GEOPROBE LOCATION MAP
SITE 16 REMEDIAL INVESTIGATION
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

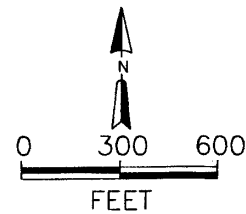
OWN:	BSM	DES.:		PROJECT NO.:
CHKD:	PTS	APPD:		000187
DATE:	FEB 99	REV.:		FIGURE NO.:
				2-3

024899



LEGEND

- ⊕ SURFACE WATER SAMPLE
- ◆ SEDIMENT SAMPLE



US Army Corps
of Engineers
Tulsa District

Sverdrup
ENVIRONMENTAL

PROJECT NO.:	DWN:	DES.:
000187	BSM	
	CHKD:	APPD:
	PTS	
	DATE:	REV.:
	FEB 99	

PHASE I, II, & III SURFACE WATER/SEDIMENT
SAMPLE LOCATION MAP
SITE 16 REMEDIAL INVESTIGATION
LHAAP KARNACK, TEXAS

FIGURE NO.:
2-4

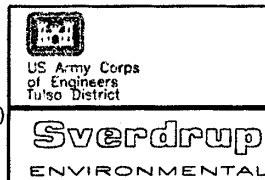
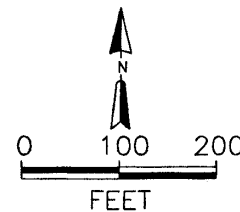
Well Identification No.	Total Depth of Well ft	Ground Surface Elevation ft	Depth of Screen Interval ft	Well Identification No.	Total Depth of Well ft	Ground Surface Elevation ft	Depth of Screen Interval ft
Shallow Zone				Intermediate Zone			
16-122	25.23	184.26	8.5 - 23.5	16WW02	50.10	181.37	27.5 - 47.5
16WW01	19.31	181.49	6.5 - 16.5	16WW04	52.51	191.68	30.0 - 50.0
16WW03	26.58	191.65	12.5 - 24.5	16WW06	62.10	202.56	47.0 - 59.0
16WW05	33.26	202.60	15.5 - 30.5	16WW08	41.37	187.76	27.0 - 40.0
16WW07	10.40	187.79	3.5 - 8.0	16WW10	48.25	180.88	26.0 - 46.0
16WW09	12.25	200.07	7.0 - 9.0	16WW11	60.85	184.59	34.0 - 59.0
16WW12	26.76	185.98	14.0 - 24.0	16WW23	34.00	177.77	24.0 - 34.0
16WW13	22.63	175.59	14.0 - 24.0	16WW25	49.00	188.39	39.0 - 49.0
16WW14	29.98	195.02	17.0 - 27.0	16WW27	36.00	177.09	26.0 - 36.0
16WW16	31.31	193.04	19.0 - 29.0	16WW29	42.00	177.94	37.0 - 42.0
16WW22	31.00	199.81	21.0 - 31.0	16WW31	49.00	202.44	39.0 - 49.0
16WW24	16.00	177.72	11.0 - 16.0	16WW33	49.00	202.64	39.0 - 49.0
16WW26	17.50	188.48	13.0 - 18.0	16WW35	43.50	190.53	34.0 - 44.0
16WW28	21.00	176.67	16.0 - 21.0	16WW37	45.50	201.72	41.0 - 46.0
16WW30	30.00	178.12	25.0 - 30.0	16EW05	55.00	197.26	47.0 - 55.0
16WW32	32.00	202.53	22.0 - 32.0	16EW06	58.00	194.93	50.0 - 58.0
16WW34	32.00	202.60	27.0 - 32.0	16EW07	49.00	184.23	41.0 - 46.0
16WW36	21.50	190.85	17.0 - 22.0	16EW08	42.00	178.49	34.0 - 39.0
16WW38	29.00	201.69	19.0 - 29.0	16PZ01	55.00	196.47	47.0 - 52.0
16EW01	42.00	197.49	31.0 - 36.0	16PZ03	50.00	198.61	45.0 - 50.0
16EW02	42.00	195.21	22.0 - 27.0	16PZ05	55.00	198.31	50.0 - 55.0
16EW03	21.00	184.80	13.0 - 18.0	16PZ07	50.00	200.10	44.0 - 49.0
16EW04	22.00	179.37	14.0 - 19.0	16PZ09	56.00	196.49	51.0 - 56.0
16PZ02	32.00	199.75	27.0 - 32.0	16PZ11	52.00	198.88	44.0 - 45.0
16PZ04	31.00	198.81	26.0 - 31.0	16PZ13	52.00	193.63	45.0 - 50.0
16PZ06	28.00	198.61	23.0 - 28.0	16PZ15	51.00	188.85	44.5 - 49.5
16PZ08	33.00	199.93	28.0 - 33.0	16PZ17	46.00	183.78	39.5 - 44.5
16PZ10	27.00	196.65	22.0 - 27.0	16PZ19	42.00	181.19	35.5 - 40.5
16PZ12	32.00	199.00	27.0 - 32.0				
16PZ14	28.50	192.23	22.0 - 27.0				
16PZ16	22.00	187.92	16.0 - 21.0				
16PZ18	26.00	182.81	19.0 - 24.0				
16PZ20	22.50	180.31	16.5 - 21.5				
Upper Deep Zone				Lower Deep Zone			
16WW19	95.00	181.87	85.0 - 95.0	16WW15	307.00	19.00	297 - 307
16WW20	110.00	198.93	100 - 110	16WW17	225.00	195.04	215 - 225
16WW21	100.00	194.52	90.0 - 100	16WW18	283.00	180.73	272 - 282

1 - Wells that have been abandoned and plugged.



LEGEND

- SHALLOW MONITORING WELL
- INTERMEDIATE MONITORING WELL
- UPPER DEEP ZONE MW
- LOWER DEEP ZONE MW
- SHALLOW PIEZOMETER
- INTERMEDIATE PIEZOMETER
- SHALLOW EXTRACTION WELL
- INTERMEDIATE EXTRACTION WELL
- A/P ABANDONED AND PLUGGED



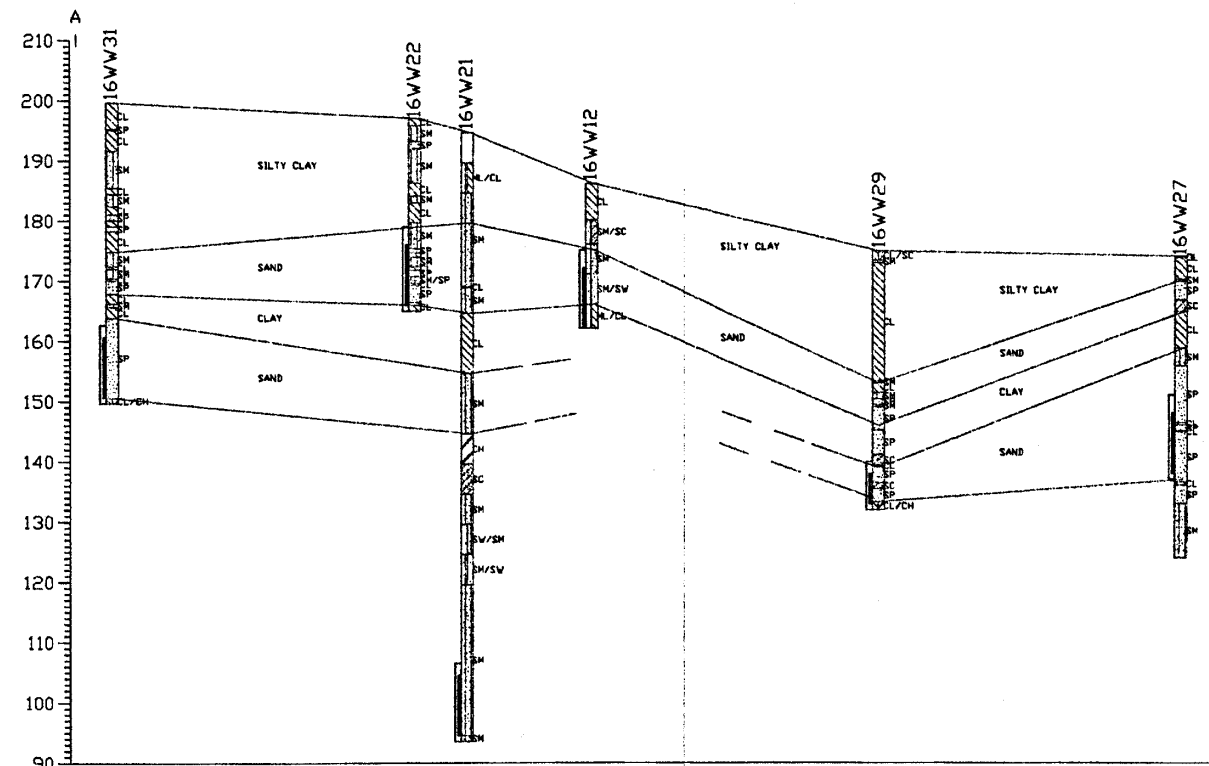
POST PHASE III INTERIM REMEDIAL ACTION LANDFILL CAP
SITE 16 REMEDIAL INVESTIGATION
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

DWN: BSM	DES.:	PROJECT NO.: 000187
CHKD: PTS	APPD.:	FIGURE NO.: 2-5
DATE: FEB 99	REV.:	

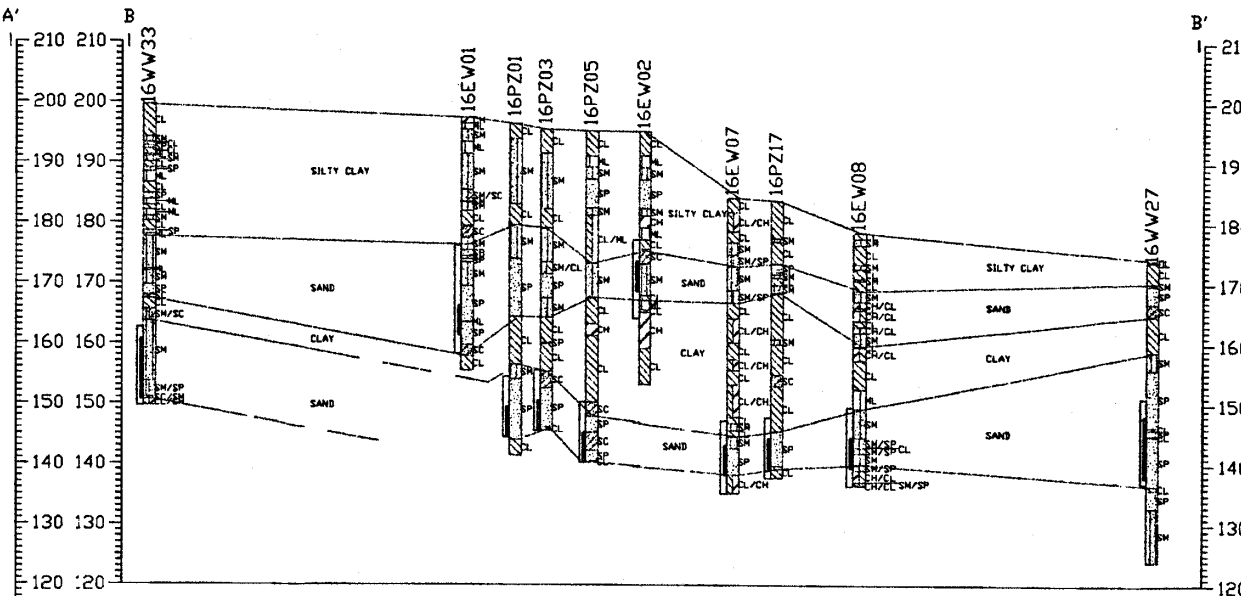
Generalized Stratigraphic Column

STRATIGRAPHIC UNITS			
SYSTEM	SERIES	GROUP	FORMATION
QUATERNARY	RECENT	ALLUVIUM	Topstratum
			Substratum
	PLEISTOCENE	TERRACE DEPOSITS	undifferentiated
TERTIARY	EOCENE	WILCOX	undifferentiated
	PALEOCENE	MIDWAY	undifferentiated
CRETACEOUS	GULFIAN	NAVARRO	Upper Navarro Clay
			Upper Navarro Maral
			Nacatoch Sand
			Lower Navarro Fm.
		TAYLOR	Upper Taylor Fm.
			Pecan Gap Chalk
			Wolfe City Sand
			Lower Taylor Fm.

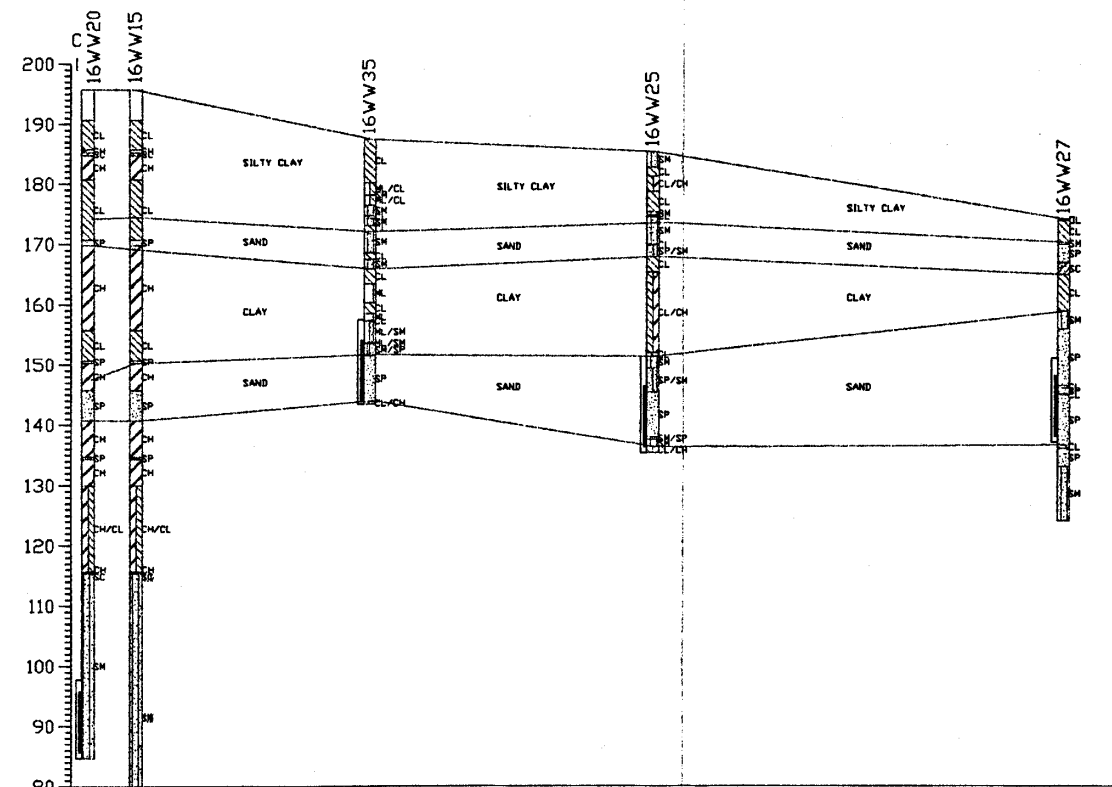
Source: Regional Structural Cross Sections and General
Stratigraphy, East Texas Basin. Bureau of Economic Geology, 1981



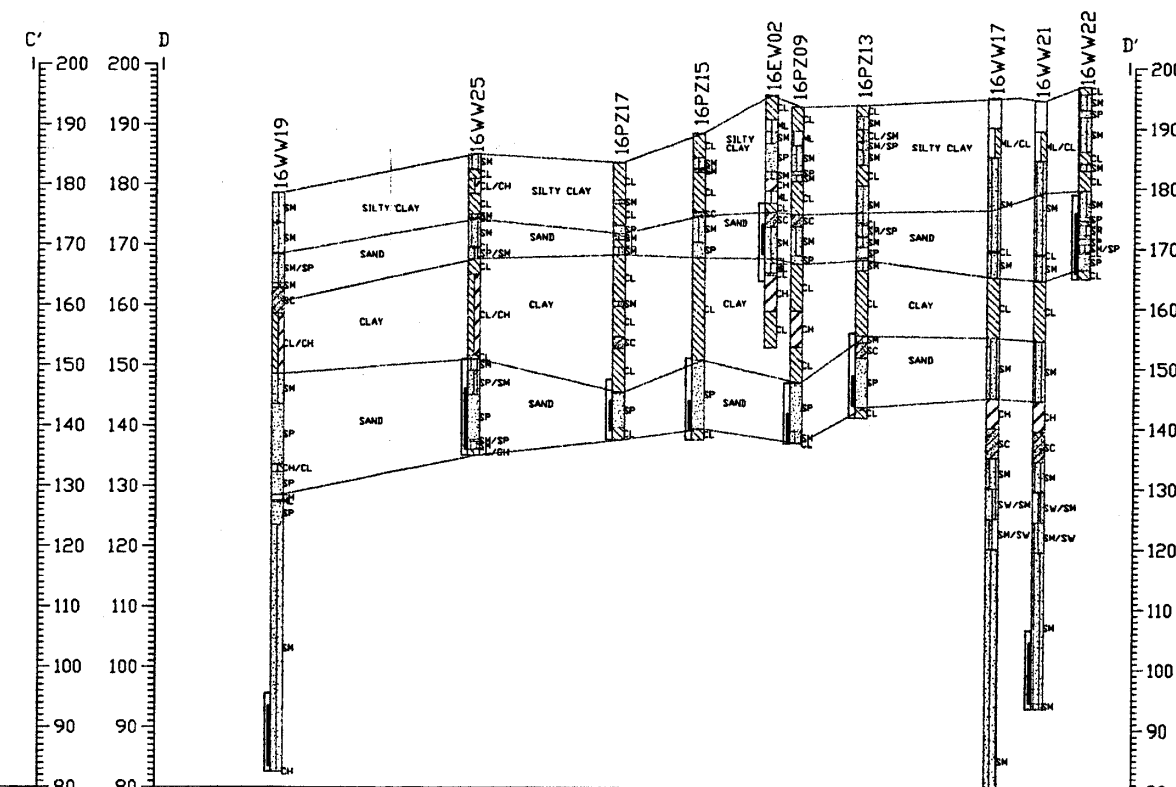
CROSS SECTION A-A'



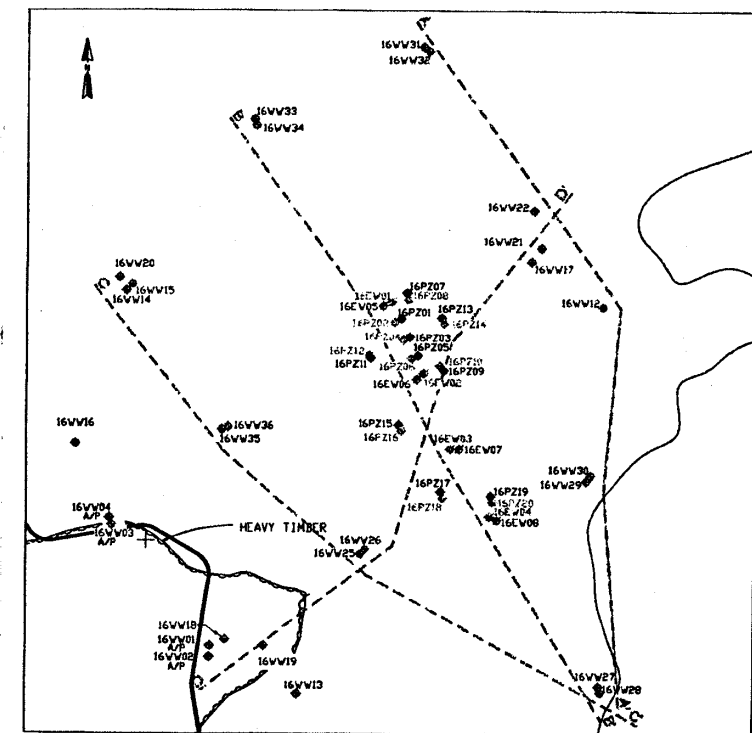
CROSS SECTION B-B'



CROSS SECTION C-C'



CROSS SECTION D-D'

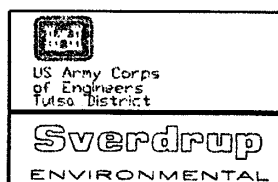


TRANSECT LOCATION KEYMAP
SCALE: 1"=120'

- LEGEND**
- SHALLOW MONITORING WELL
 - INTERMEDIATE MONITORING WELL
 - UPPER AQUIFER DEEP MW
 - LOWER AQUIFER DEEP MW
 - SHALLOW PIEZOMETER
 - INTERMEDIATE PIEZOMETER
 - SHALLOW EXTRACTION WELL
 - INTERMEDIATE EXTRACTION WELL
 - SCREENED INTERVAL OF WELLS

VERTICAL SCALE
0 8 16
FEET

HORIZONTAL SCALE
0 40 80
FEET

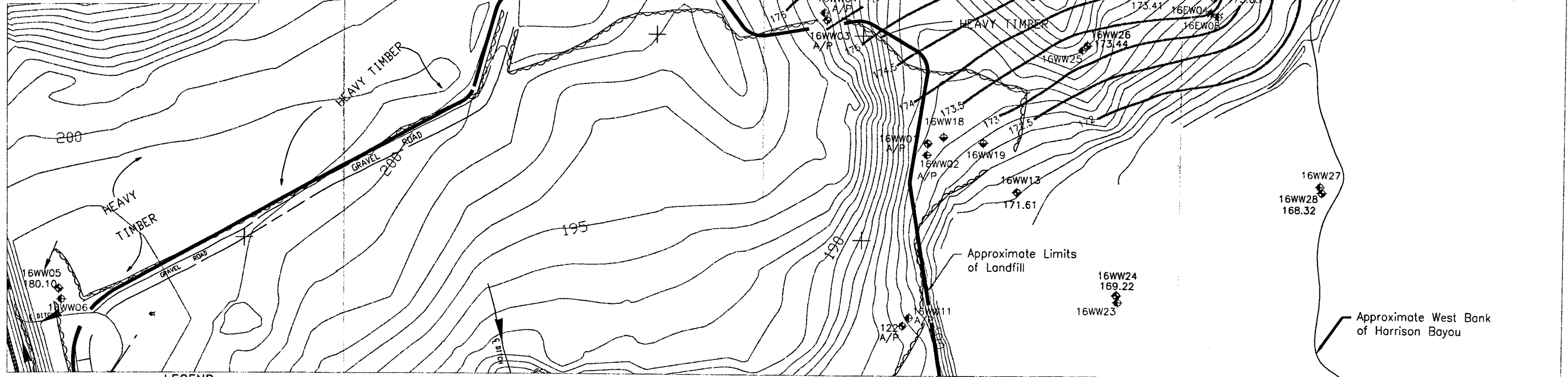


PROJECT NO.:	DWN:	DES.:
000187	BSM	
	CHKD:	APPD:
	PTS	
	DATE:	REV.:
	FEB 99	

GEOLOGIC CROSS SECTIONS
A-A', B-B', C-C' AND D-D'
SITE 16 REMEDIAL INVESTIGATION
LHAAP - KARNACK, TEXAS

Well Identification No.	Total Depth of Well ft	Ground Surface Elevation ft	Depth of Screen Interval ft
Shallow Zone			
16-122 ₁	25.23	184.26	8.5 - 23.5
16WW01 ₁	19.31	181.49	6.5 - 16.5
16WW03 ₁	26.58	191.65	12.5 - 24.5
16WW05 ₁	33.26	202.60	15.5 - 30.5
16WW07 ₁	10.40	187.79	3.5 - 8.0
16WW09 ₁	12.25	200.07	7.0 - 9.0
16WW12	26.76	185.98	14.0 - 24.0
16WW13	22.63	175.59	14.0 - 24.0
16WW14	29.98	195.02	17.0 - 27.0
16WW16	31.31	193.04	19.0 - 29.0
16WW22	31.00	199.81	21.0 - 31.0
16WW24	16.00	177.72	11.0 - 16.0
16WW26	17.50	188.48	13.0 - 18.0
16WW28	21.00	176.67	16.0 - 21.0
16WW30	30.00	178.12	25.0 - 30.0
16WW32	32.00	202.53	22.0 - 32.0
16WW34	32.00	202.60	27.0 - 32.0
16WW36	21.50	190.85	17.0 - 22.0
16WW38	29.00	201.69	19.0 - 29.0
16EW01	42.00	197.49	31.0 - 36.0
16EW02	42.00	195.21	22.0 - 27.0
16EW03	21.00	184.80	13.0 - 18.0
16EW04	22.00	179.37	14.0 - 19.0
16PZ02	32.00	199.75	27.0 - 32.0
16PZ04	31.00	198.81	26.0 - 31.0
16PZ06	28.00	198.61	23.0 - 28.0
16PZ08	33.00	199.93	28.0 - 33.0
16PZ10	27.00	196.65	22.0 - 27.0
16PZ12	32.00	199.00	27.0 - 32.0
16PZ14	28.50	192.23	22.0 - 27.0
16PZ16	22.00	187.92	16.0 - 21.0
16PZ18	26.00	182.81	19.0 - 24.0
16PZ20	22.50	180.31	16.5 - 21.5

1 - Wells that have been abandoned and plugged.



 SHALLOW MONITORING WELL
 INTERMEDIATE MONITORING WELL
 UPPER DEEP ZONE MW
 LOWER DEEP ZONE MW
 SHALLOW EXTRACTION WELL
 INTERMEDIATE EXTRACTION WELL

SHALLOW PIEZOMETER
INTERMEDIATE PIEZOMETER
A/P ABANDONED AND PLUGGED
PIEZOMETRIC SURFACE CONTOURS



US Army Corps
of Engineers
Tulsa District

Sverdrup
ENVIRONMENTAL

SHALLOW ZONE PIEZOMETRIC SURFACE MAP - 10-20-97
SITE 16 REMEDIAL INVESTIGATION
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

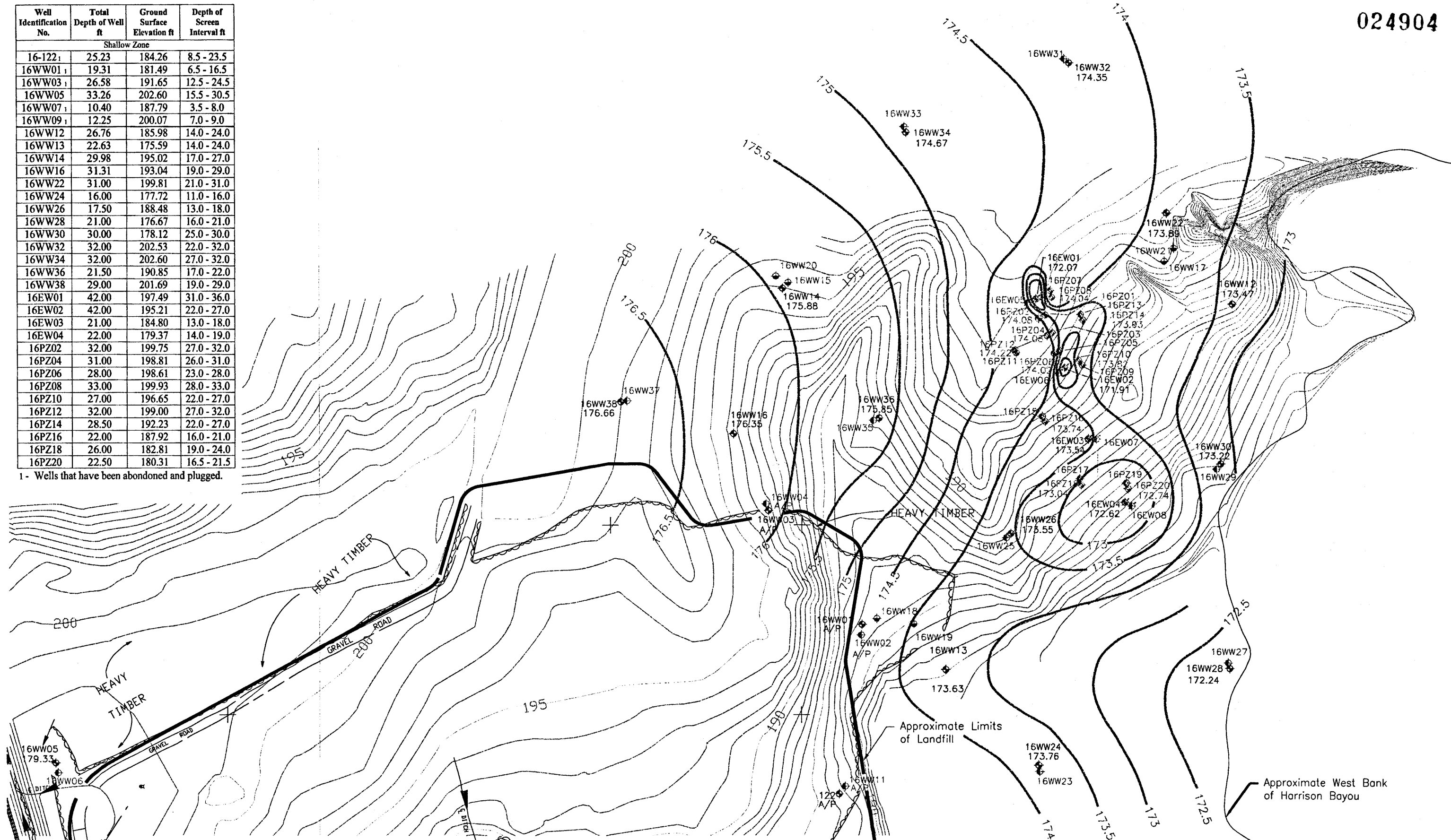
DWN:	BSM
CHKD:	PTS
DATE:	FEB 99

DES.:
APPD:
REV.:

PROJECT NO.:	00
FIGURE NO.:	3

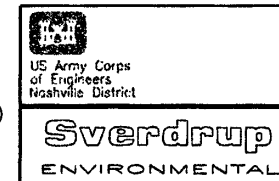
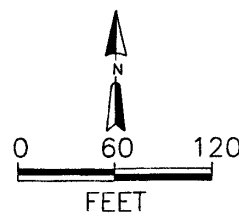
Well Identification No.	Total Depth of Well ft	Ground Surface Elevation ft	Depth of Screen Interval ft
Shallow Zone			
16-122 ₁	25.23	184.26	8.5 - 23.5
16WW01 ₁	19.31	181.49	6.5 - 16.5
16WW03 ₁	26.58	191.65	12.5 - 24.5
16WW05 ₁	33.26	202.60	15.5 - 30.5
16WW07 ₁	10.40	187.79	3.5 - 8.0
16WW09 ₁	12.25	200.07	7.0 - 9.0
16WW12	26.76	185.98	14.0 - 24.0
16WW13	22.63	175.59	14.0 - 24.0
16WW14	29.98	195.02	17.0 - 27.0
16WW16	31.31	193.04	19.0 - 29.0
16WW22	31.00	199.81	21.0 - 31.0
16WW24	16.00	177.72	11.0 - 16.0
16WW26	17.50	188.48	13.0 - 18.0
16WW28	21.00	176.67	16.0 - 21.0
16WW30	30.00	178.12	25.0 - 30.0
16WW32	32.00	202.53	22.0 - 32.0
16WW34	32.00	202.60	27.0 - 32.0
16WW36	21.50	190.85	17.0 - 22.0
16WW38	29.00	201.69	19.0 - 29.0
16EW01	42.00	197.49	31.0 - 36.0
16EW02	42.00	195.21	22.0 - 27.0
16EW03	21.00	184.80	13.0 - 18.0
16EW04	22.00	179.37	14.0 - 19.0
16PZ02	32.00	199.75	27.0 - 32.0
16PZ04	31.00	198.81	26.0 - 31.0
16PZ06	28.00	198.61	23.0 - 28.0
16PZ08	33.00	199.93	28.0 - 33.0
16PZ10	27.00	196.65	22.0 - 27.0
16PZ12	32.00	199.00	27.0 - 32.0
16PZ14	28.50	192.23	22.0 - 27.0
16PZ16	22.00	187.92	16.0 - 21.0
16PZ18	26.00	182.81	19.0 - 24.0
16PZ20	22.50	180.31	16.5 - 21.5

1 - Wells that have been abandoned and plugged.



LEGEND

- SHALLOW MONITORING WELL
- INTERMEDIATE MONITORING WELL
- UPPER DEEP ZONE MW
- LOWER DEEP ZONE MW
- SHALLOW EXTRACTION WELL
- INTERMEDIATE EXTRACTION WELL
- SHALLOW PIEZOMETER
- INTERMEDIATE PIEZOMETER
- A/P ABANDONED AND PLUGGED
- PIEZOMETRIC SURFACE CONTOUR

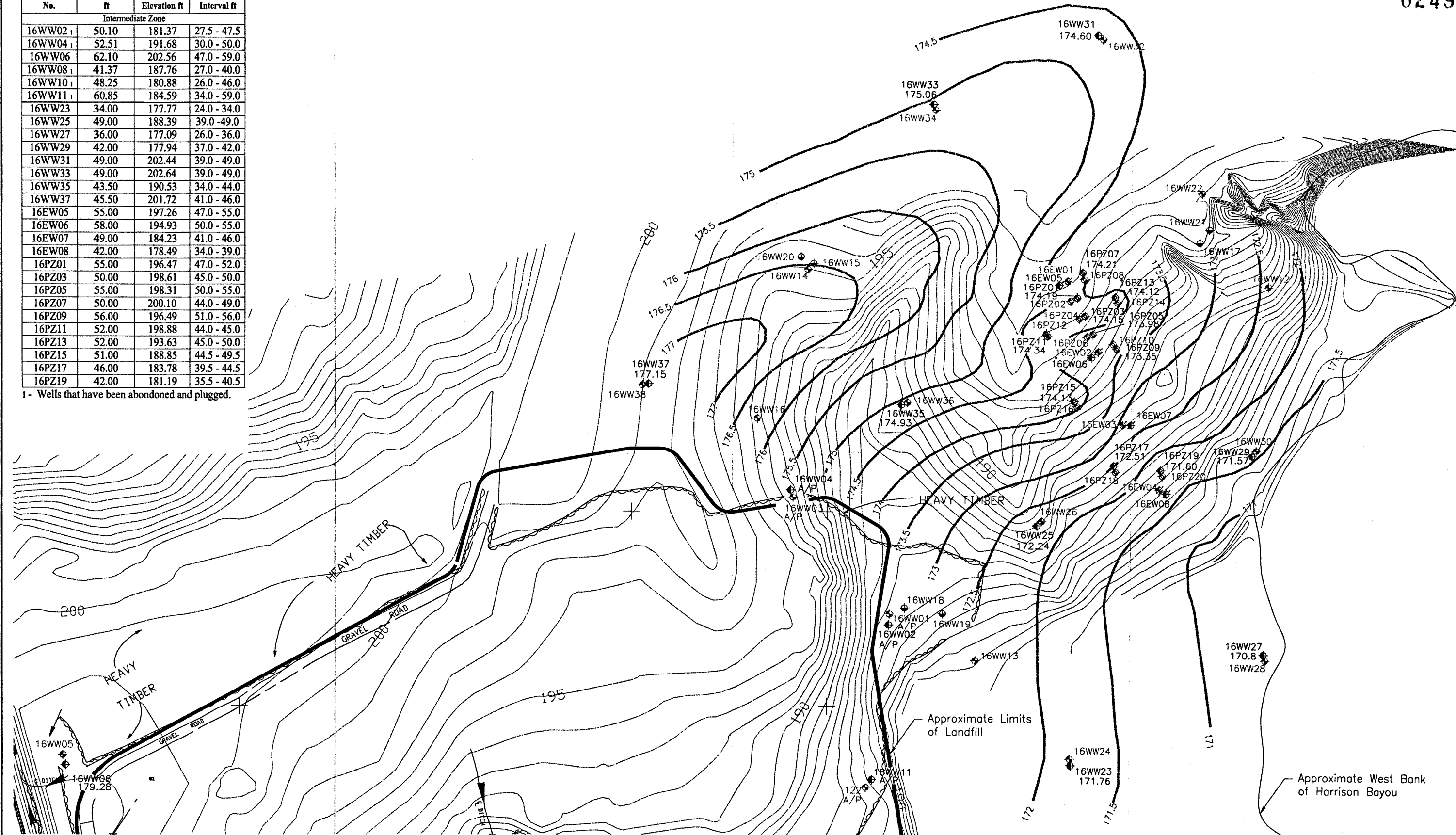


PROJECT NO.:	DWN:	DES.:
000187	BSM	
	CHKD:	APPD:
	PTS	
	DATE:	REV.:
	FEB 99	

SHALLOW ZONE PIEZOMETRIC SURFACE MAP - 10-28-98
 SITE 16 REMEDIAL INVESTIGATION
 LONGHORN ARMY AMMUNITION PLANT
 KARNACK, TEXAS

Well Identification No.	Total Depth of Well ft	Ground Surface Elevation ft	Depth of Screen Interval ft
Intermediate Zone			
16WW02	50.10	181.37	27.5 - 47.5
16WW04	52.51	191.68	30.0 - 50.0
16WW06	62.10	202.56	47.0 - 59.0
16WW08	41.37	187.76	27.0 - 40.0
16WW10	48.25	180.88	26.0 - 46.0
16WW11	60.85	184.59	34.0 - 59.0
16WW23	34.00	177.77	24.0 - 34.0
16WW25	49.00	188.39	39.0 - 49.0
16WW27	36.00	177.09	26.0 - 36.0
16WW29	42.00	177.94	37.0 - 42.0
16WW31	49.00	202.44	39.0 - 49.0
16WW33	49.00	202.64	39.0 - 49.0
16WW35	43.50	190.53	34.0 - 44.0
16WW37	45.50	201.72	41.0 - 46.0
16EW05	55.00	197.26	47.0 - 55.0
16EW06	58.00	194.93	50.0 - 55.0
16EW07	49.00	184.23	41.0 - 46.0
16EW08	42.00	178.49	34.0 - 39.0
16PZ01	55.00	196.47	47.0 - 52.0
16PZ03	50.00	198.61	45.0 - 50.0
16PZ05	55.00	198.31	50.0 - 55.0
16PZ07	50.00	200.10	44.0 - 49.0
16PZ09	56.00	196.49	51.0 - 56.0
16PZ11	52.00	198.88	44.0 - 45.0
16PZ13	52.00	193.63	45.0 - 50.0
16PZ15	51.00	188.85	44.5 - 49.5
16PZ17	46.00	183.78	39.5 - 44.5
16PZ19	42.00	181.19	35.5 - 40.5

1- Wells that have been abandoned and plugged.



LEGEND

- SHALLOW MONITORING WELL
- INTERMEDIATE MONITORING WELL
- UPPER DEEP ZONE MW
- LOWER DEEP ZONE MW
- SHALLOW EXTRACTION WELL
- INTERMEDIATE EXTRACTION WELL
- SHALLOW PIEZOMETER
- INTERMEDIATE PIEZOMETER
- ABANDONED AND PLUGGED
- PIEZOMETRIC SURFACE CONTOUR

US Army Corps of Engineers
Tulsa District

PROJECT NO.: 000187

DWN: BSM
CHKD: PTS
DATE: FEB 99

DES.:
APPD.:
REV.:

INTERMEDIATE ZONE PIEZOMETRIC SURFACE MAP - 10-20-97

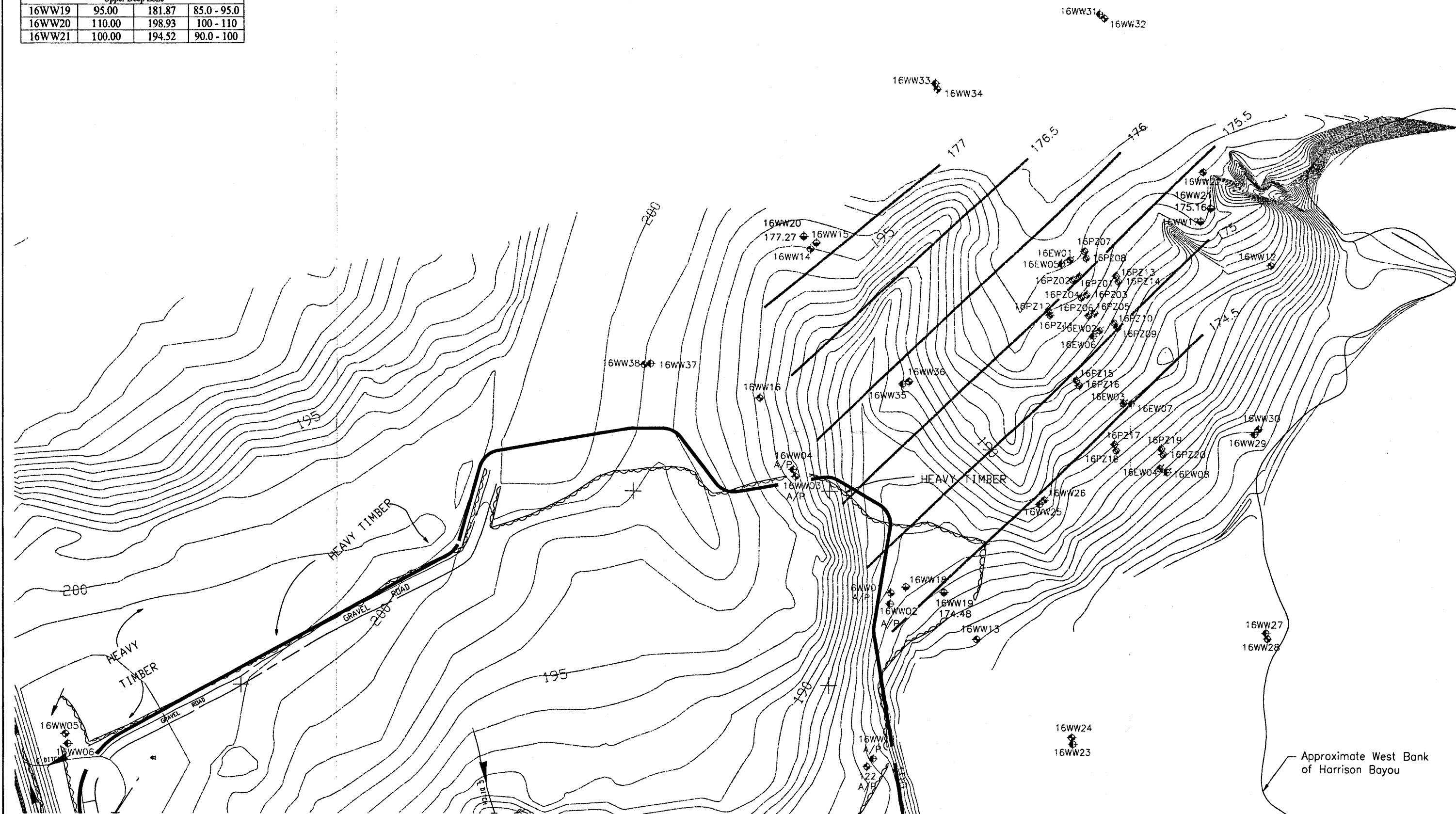
SITE 16 REMEDIAL INVESTIGATION

LONGHORN ARMY AMMUNITION PLANT

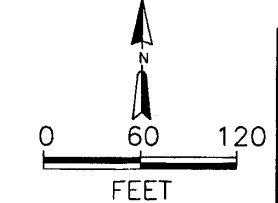
KARNACK, TEXAS

FIGURE NO.: 3-5

Well Identification No.	Total Depth of Well ft	Ground Surface Elevation ft	Depth of Screen Interval ft
Upper Deep Zone			
16WW19	95.00	181.87	85.0 - 95.0
16WW20	110.00	198.93	100 - 110
16WW21	100.00	194.52	90.0 - 100

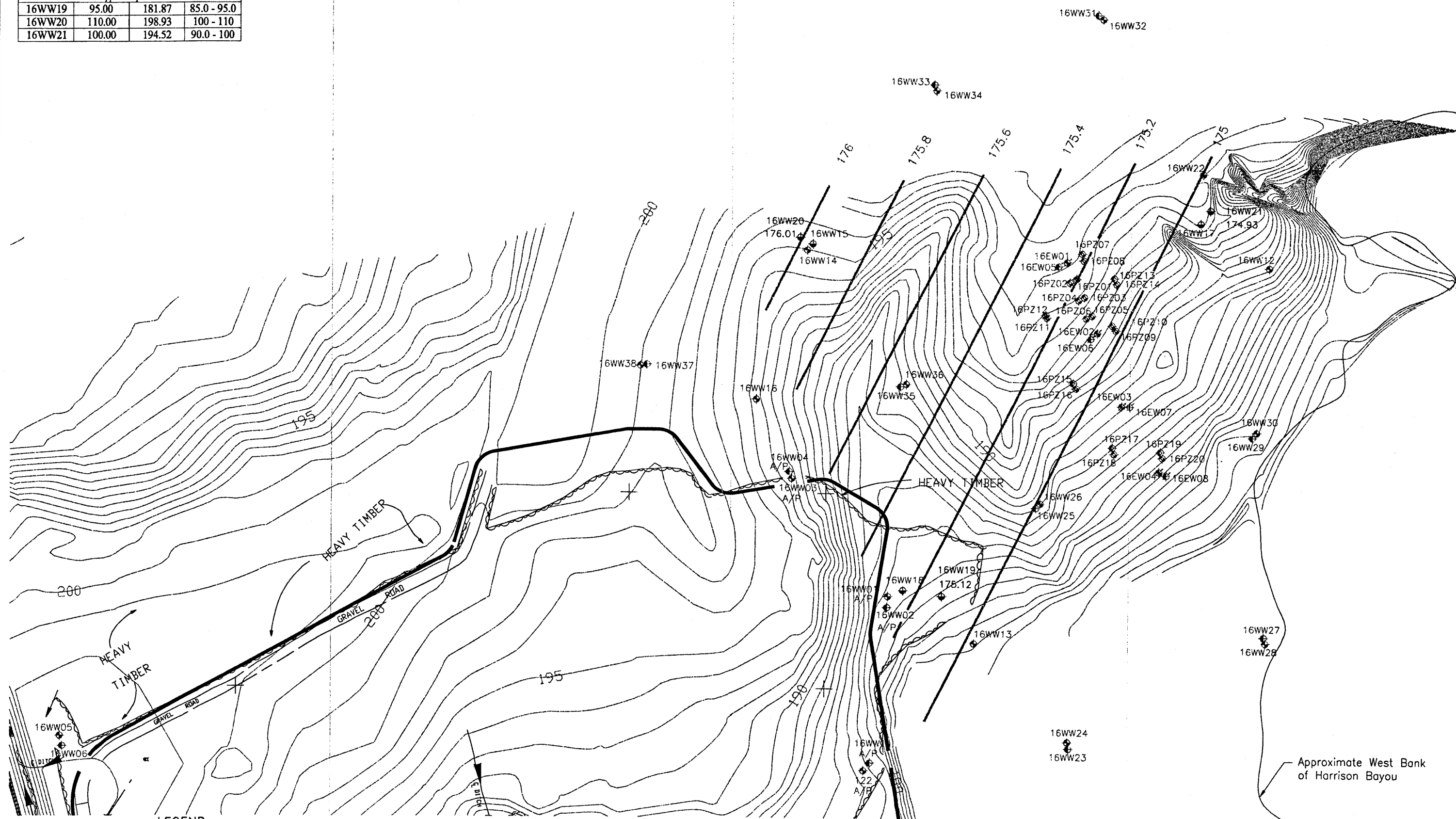


- LEGEND**
- SHALLOW MONITORING WELL
 - INTERMEDIATE MONITORING WELL
 - UPPER DEEP ZONE MW
 - LOWER DEEP ZONE MW
 - SHALLOW EXTRACTION WELL
 - INTERMEDIATE EXTRACTION WELL
 - SHALLOW PIEZOMETER
 - INTERMEDIATE PIEZOMETER
 - A/P ABANDONED AND PLUGGED
 - PIEZOMETRIC SURFACE CONTOUR

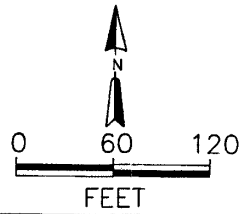


 US Army Corps of Engineers Tulsa District	PROJECT NO.:	DWN:	DES.:	UPPER DEEP ZONE PIEZOMETRIC SURFACE MAP - 10-20-97 SITE 16 REMEDIAL INVESTIGATION LONGHORN ARMY AMMUNITION PLANT KARNACK, TEXAS	FIGURE NO.: 3-7
	000187	BSM			
		PTS	APPD:		
	DATE:	FEB 99	REV.:		

Well Identification No.	Total Depth of Well ft	Ground Surface Elevation ft	Depth of Screen Interval ft
Upper Deep Zone			
16WW19	95.00	181.87	85.0 - 95.0
16WW20	110.00	198.93	100 - 110
16WW21	100.00	194.52	90.0 - 100



- LEGEND**
- SHALLOW MONITORING WELL
 - INTERMEDIATE MONITORING WELL
 - UPPER DEEP ZONE MW
 - LOWER DEEP ZONE MW
 - SHALLOW EXTRACTION WELL
 - INTERMEDIATE EXTRACTION WELL
 - SHALLOW PIEZOMETER
 - INTERMEDIATE PIEZOMETER
 - ABANDONED AND PLUGGED
 - PIEZOMETRIC SURFACE CONTOUR



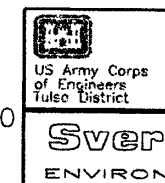
 US Army Corps of Engineers Tulsa District Sverdrup ENVIRONMENTAL	PROJECT NO.:	DWN:	DES.:	UPPER DEEP ZONE PIEZOMETRIC SURFACE MAP - 10-28-98 SITE 16 REMEDIAL INVESTIGATION LONGHORN ARMY AMMUNITION PLANT KARNACK, TEXAS	FIGURE NO.: 3-8
	000187	BSM			
		CHKD:	APPD:		
		PTS			
	DATE:	FEB 99	REV.:		

Well Identification No.	Total Depth of Well ft	Ground Surface Elevation ft	Depth of Screen Interval ft
Lower Deep Zone			
16WW15	307.00	19.00	297 - 307
16WW17	225.00	195.04	215 - 225
16WW18	283.00	180.73	272 - 282



LEGEND

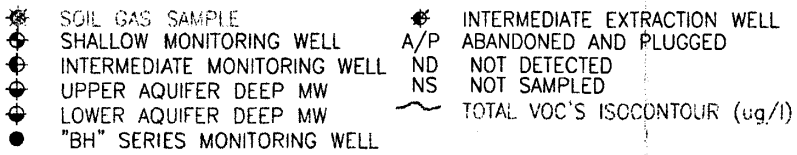
- SHALLOW MONITORING WELL
- INTERMEDIATE MONITORING WELL
- UPPER DEEP ZONE MW
- LOWER DEEP ZONE MW
- SHALLOW EXTRACTION WELL
- INTERMEDIATE EXTRACTION WELL
- SHALLOW PIEZOMETER
- INTERMEDIATE PIEZOMETER
- A/P ABANDONED AND PLUGGED
- PIEZOMETRIC SURFACE CONTOUR



PROJECT NO.:	DWN:	DES.:
000187	BSM	
CHKD:	PTS	APPD:
DATE:	FEB 99	REV.:

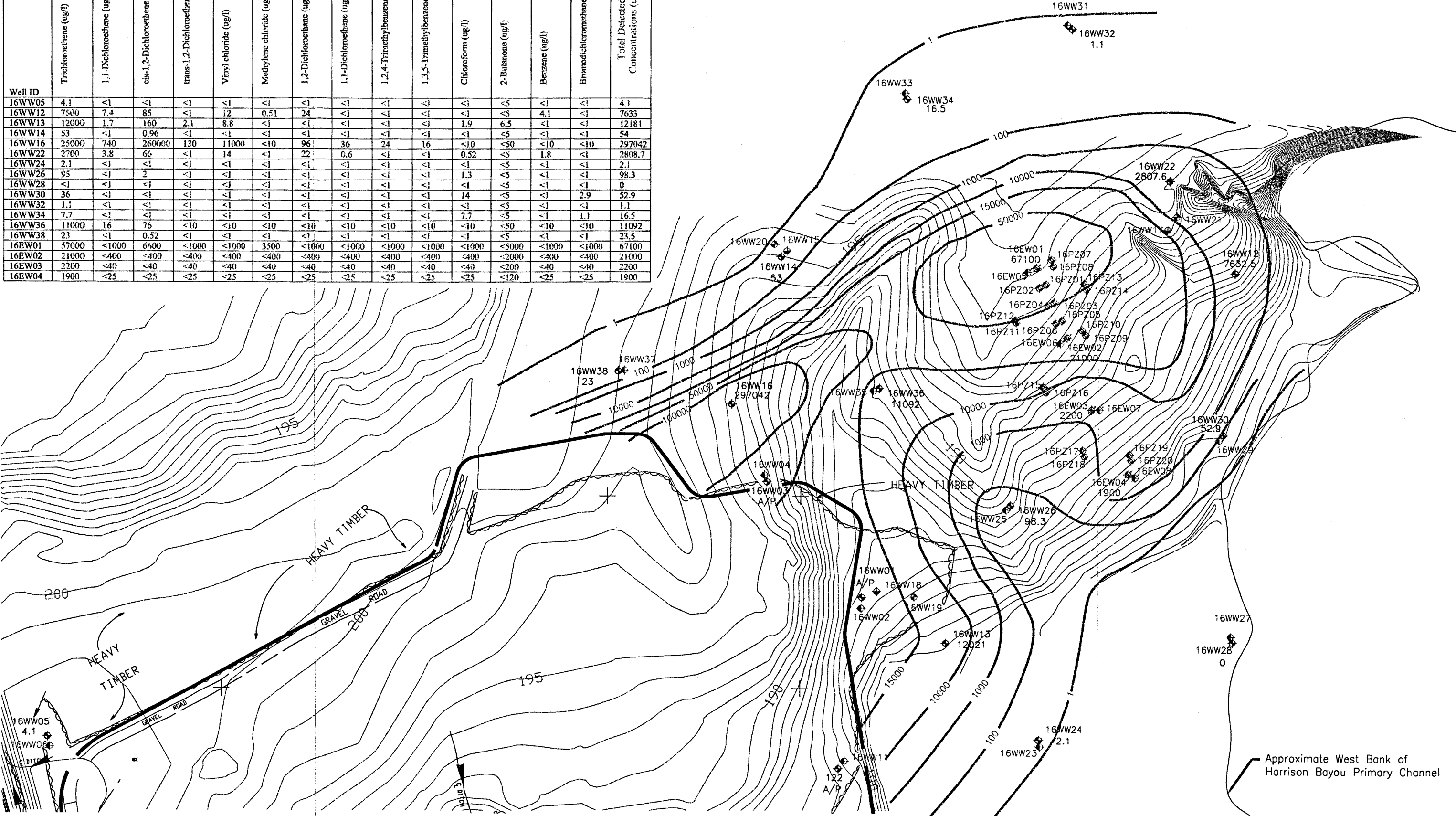
LOWER DEEP ZONE PIEZOMETRIC SURFACE MAP - 12-06-98
SITE 16 REMEDIAL INVESTIGATION
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

FIGURE NO.:
3-10



 US Army Corps of Engineers Tulsa District	PROJECT NO.:	DWN:	DES.:	SOIL GAS SURVEY - TOTAL VOCs SITE 16 REMEDIAL INVESTIGATION LONGHORN ARMY AMMUNITION PLANT KARNACK, TEXAS	FIGURE NO. 4-1
	000187	CHKO:	APPD:		
		DATE:	REV.:		
 Sverdrup ENVIRONMENTAL		BSM			
		SKR			
		MAY 99			

Well ID	Trichloroethene (ug/l)	1,1-Dichloroethene (ug/l)	cis-1,2-Dichloroethene (ug/l)	trans-1,2-Dichloroethene (ug/l)	Vinyl chloride (ug/l)	Methylene chloride (ug/l)	1,2-Dichloroethane (ug/l)	1,1-Dichloroethane (ug/l)	1,2,4-Trimethylbenzene (ug/l)	1,3,5-Trimethylbenzene (ug/l)	Chloroform (ug/l)	2-Butanone (ug/l)	Benzene (ug/l)	Bromodichloromethane (ug/l)	Total Detected Concentrations (ug/l)
16WW05	4.1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	4.1
16WW12	7500	7.4	85	<1	12	0.51	24	<1	<1	<1	<1	<5	4.1	<1	7633
16WW13	12000	1.7	160	2.1	8.8	<1	<1	<1	<1	<1	1.9	6.5	<1	<1	12181
16WW14	53	<1	0.96	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	54
16WW16	25000	740	260000	130	11000	<10	96	36	24	16	<10	<50	<10	<10	297042
16WW22	2700	3.8	66	<1	14	<1	22	6.6	<1	<1	0.52	<5	1.8	<1	2808.7
16WW24	2.1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	2.1
16WW26	95	<1	2	<1	<1	<1	<1	<1	<1	<1	1.3	<5	<1	<1	98.3
16WW28	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	0
16WW30	36	<1	<1	<1	<1	<1	<1	<1	<1	<1	14	<5	<1	2.9	52.9
16WW32	1.1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	1.1
16WW34	7.7	<1	<1	<1	<1	<1	<1	<1	<1	<1	7.7	<5	<1	1.1	16.5
16WW36	11000	16	76	<10	<10	<10	<10	<10	<10	<10	<10	<50	<10	<10	11092
16WW38	23	<1	0.52	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	23.5
16EW01	57000	<1000	6500	<1000	<1000	3500	<1000	<1000	<1000	<1000	<1000	<5000	<1000	<1000	67100
16EW02	21000	<400	<400	<400	<400	<400	<400	<400	<400	<400	<400	<2000	<400	<400	21000
16EW03	2200	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<200	<40	<40	2200
16EW04	1900	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<120	<25	<25	1900



- LEGEND**

 - SHALLOW MONITORING WELL
 - INTERMEDIATE MONITORING WELL
 - UPPER DEEP ZONE MW
 - LOWER DEEP ZONE MW
 - SHALLOW EXTRACTION WELL
 - INTERMEDIATE EXTRACTION WELL
- SHALLOW PIEZOMETER
 - INTERMEDIATE PIEZOMETER
 - A/P ABANDONED AND PLUGGED
 - TOTAL VOC's ISOCONTOURS (ug/l)

US Army Corps of Engineers
Tulsa District

PROJECT NO.: 000187

DWN: BSM

CHKD: PTS

DATE: MAR 99

DES.:

APPD:

REV.:

SHALLOW ZONE MONITORING WELL

TOTAL VOC's - OCTOBER 1997

SITE 16 REMEDIAL INVESTIGATION

LHAAP - KARNACK, TEXAS

FIGURE NO.: 4-2

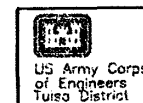
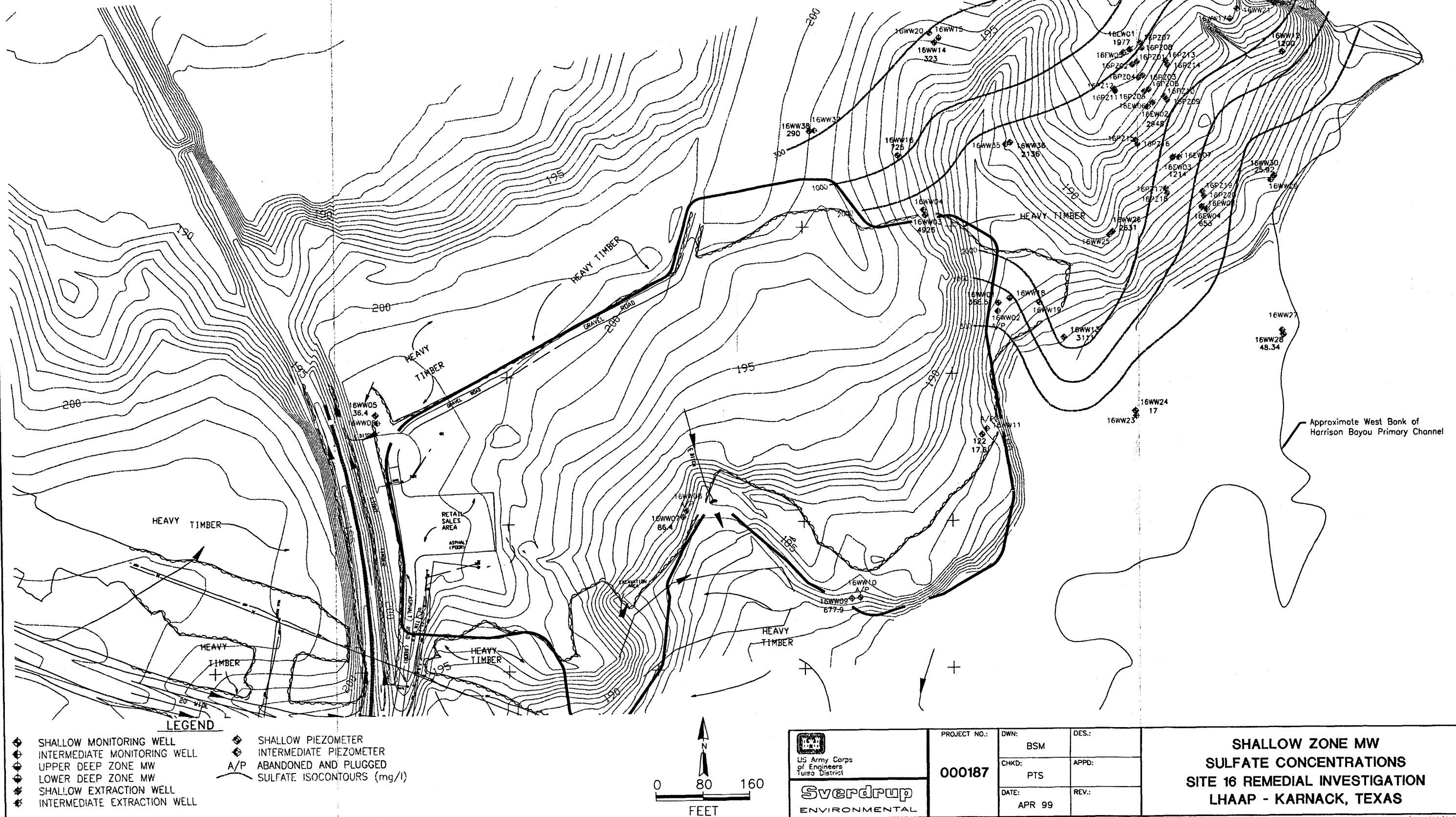




NOTE:

DATA FOR THE FOLLOWING WELLS IS FROM 6/93:
122, 16WW01, 16WW03, 16WW05, 16WW07, 16WW09

DATA FOR THE FOLLOWING WELLS IS FROM 10/97:
16WW12, 16WW13, 16WW14, 16WW16, 16WW22, 16WW24,
16WW26, 16WW28, 16WW30, 16WW32, 16WW34, 16WW36,
16WW38, 16EW01, 16EW02, 16EW03, 16EW04



Sverdrup
ENVIRONMENTAL

PROJECT NO.:
000187

DWN: BSM
CHKD: PTS
DATE: APR 99

DES.:
APPD.:
REV.:

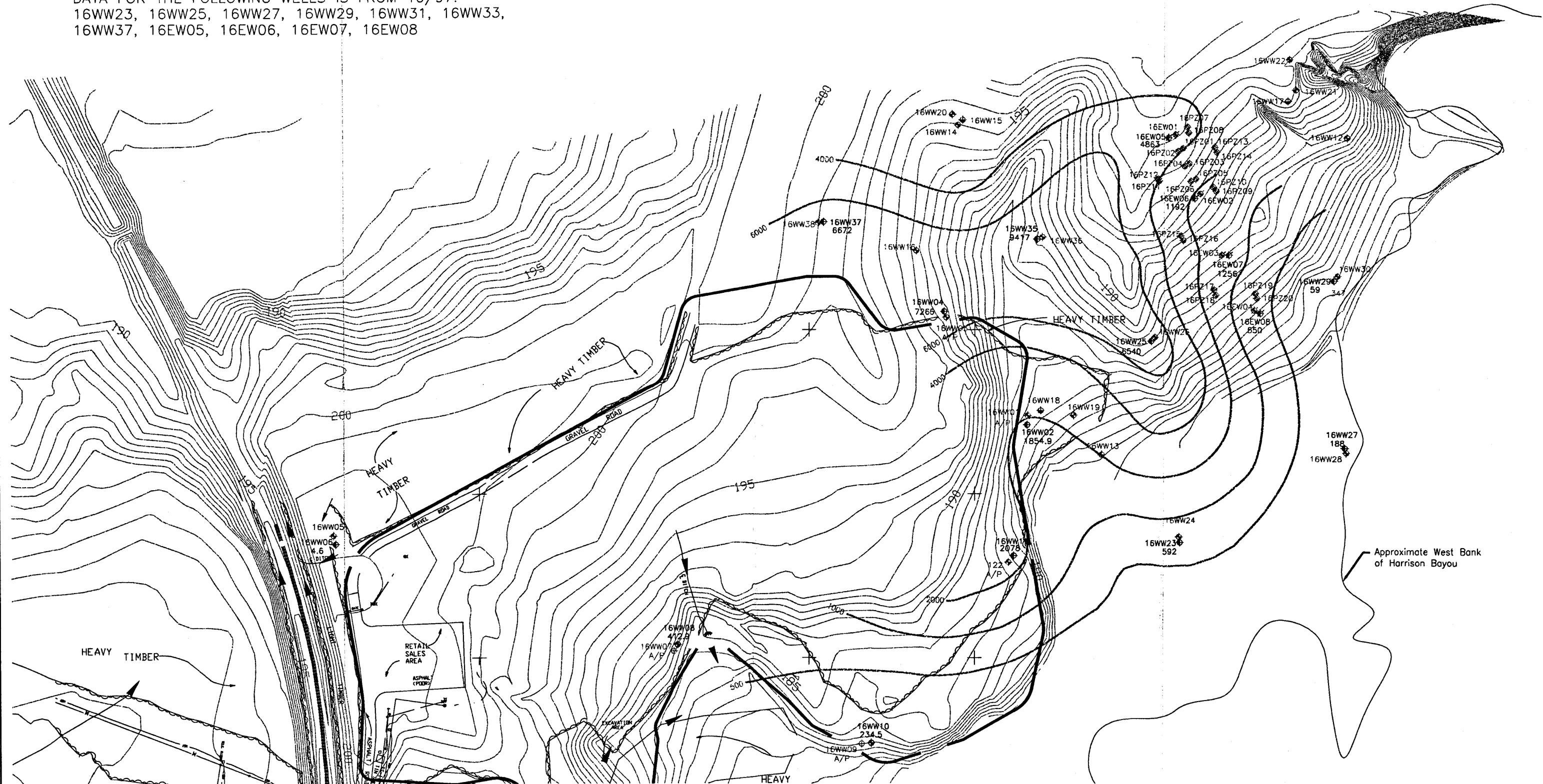
**SHALLOW ZONE MW
SULFATE CONCENTRATIONS
SITE 16 REMEDIAL INVESTIGATION
LHAAP - KARNACK, TEXAS**

FIGURE NO.:
4-5

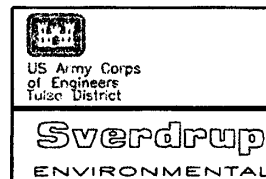
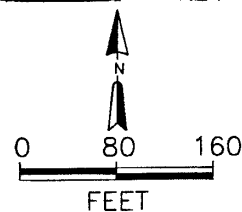
NOTE:

DATA FOR THE FOLLOWING WELLS IS FROM 6/93:
16WW02, 16WW04, 16WW06, 16WW08, 16WW10, 16WW11

DATA FOR THE FOLLOWING WELLS IS FROM 10/97:
16WW23, 16WW25, 16WW27, 16WW29, 16WW31, 16WW33,
16WW37, 16EW05, 16EW06, 16EW07, 16EW08

**LEGEND**

- | | |
|--------------------------------|-----------------------------|
| ● SHALLOW MONITORING WELL | ● SHALLOW PIEZOMETER |
| ● INTERMEDIATE MONITORING WELL | ● INTERMEDIATE PIEZOMETER |
| ● UPPER DEEP ZONE MW | ● A/P ABANDONED AND PLUGGED |
| ● LOWER DEEP ZONE MW | — Sulfate ISOCONTOURS |
| ● SHALLOW EXTRACTION WELL | |
| ● INTERMEDIATE EXTRACTION WELL | |



PROJECT NO.:	DWN:	DES.:
000187	BSM	
	CHKD:	APPD:
	PTS	
	DATE:	REV.:
	APR 99	

INTERMEDIATE ZONE MW SULFATE CONCENTRATIONS mg/l
SITE 16 REMEDIAL INVESTIGATION
LONGHORN ARMY AMMUNITION PLANT

FIGURE NO.:
4-6

NOTE:
SULFATE CONCENTRATIONS GATHERED OCT. 1997

021917



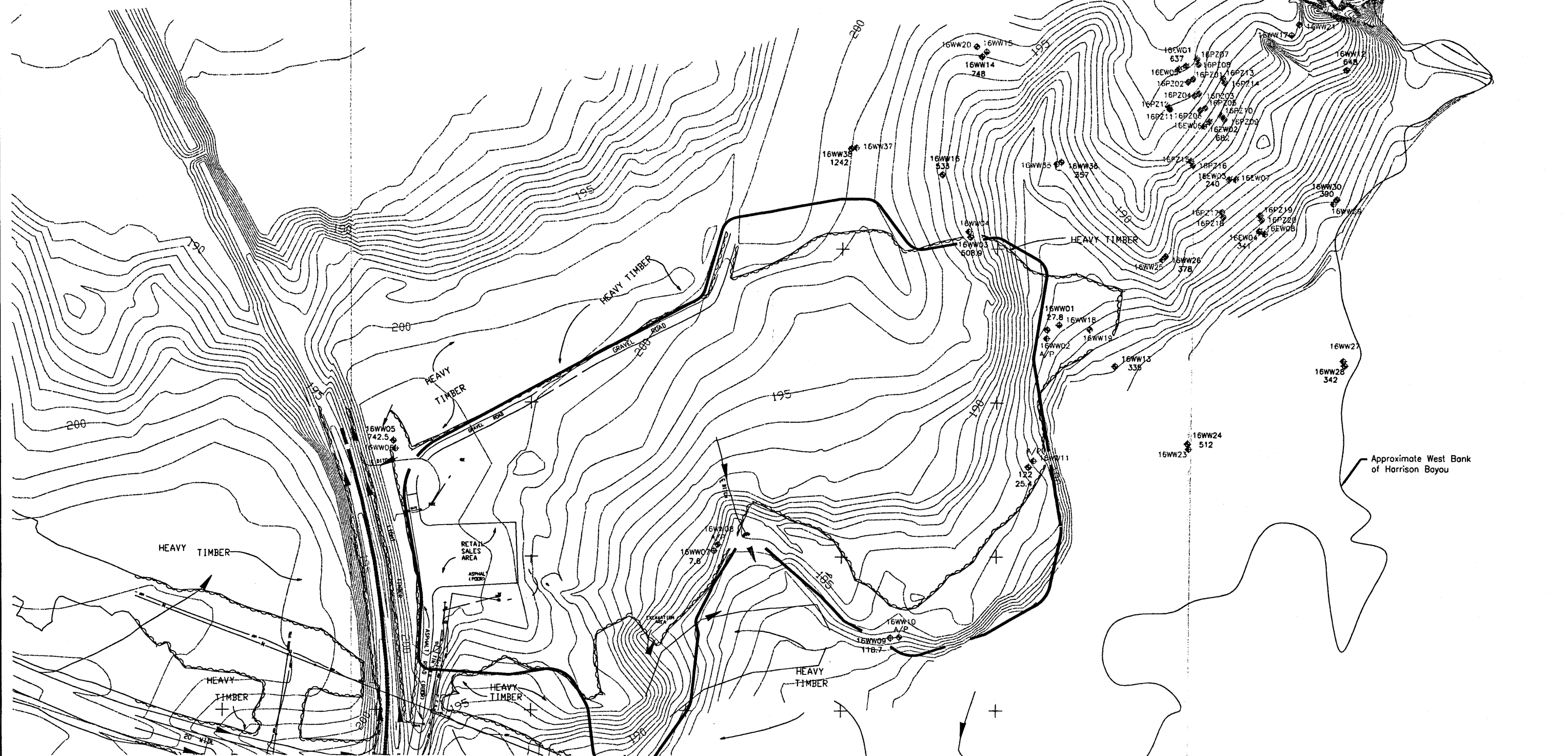
LEGEND		 0 80 160 FEET	 US Army Corps of Engineers Tulsa District Sverdrup ENVIRONMENTAL	PROJECT NO.: 000187	DWN: BSM	DES:	DEEP ZONE MONITORING WELLS SULFATE CONCENTRATIONS mg/l SITE 16 REMEDIAL INVESTIGATION LONGHORN ARMY AMMUNITION PLANT KARNACK, TEXAS	FIGURE NO.: 4-7
◆ SHALLOW MONITORING WELL	◆ SHALLOW PIEZOMETER			CHKD: PTS	APPD:			
◆ INTERMEDIATE MONITORING WELL	◆ INTERMEDIATE PIEZOMETER			DATE: APR 99	REV.:			
◆ UPPER DEEP ZONE MW	A/P ABANDONED AND PLUGGED							
◆ LOWER DEEP ZONE MW								
◆ SHALLOW EXTRACTION WELL								
◆ INTERMEDIATE EXTRACTION WELL								

NOTE:

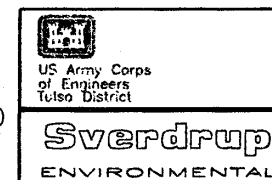
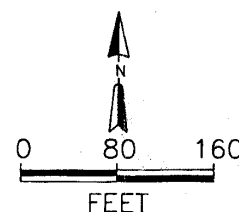
DATA FOR THE FOLLOWING WELLS IS FROM 6/93:
122, 16WW01, 16WW03, 16WW05, 16WW07, 16WW09

DATA FOR THE FOLLOWING WELLS IS FROM 10/97:
16WW12, 16WW13, 16WW14, 16WW16, 16WW22, 16WW24,
16WW26, 16WW28, 16WW30, 16WW32, 16WW34, 16WW36,
16WW38, 16EW01, 16EW02, 16EW03, 16EW04

021918



- LEGEND**
- ◆ SHALLOW MONITORING WELL
 - ◆ INTERMEDIATE MONITORING WELL
 - ◆ UPPER DEEP ZONE MW
 - ◆ LOWER DEEP ZONE MW
 - ◆ SHALLOW EXTRACTION WELL
 - ◆ INTERMEDIATE EXTRACTION WELL
 - ◆ SHALLOW PIEZOMETER
 - ◆ INTERMEDIATE PIEZOMETER
 - A/P ABANDONED AND PLUGGED



PROJECT NO.:	DWN:	DES.:
000187	BSM	-
	CHKD:	APPD:
	PTS	-
	DATE:	REV.:
	APR 99	-

SHALLOW ZONE MW CHLORIDE CONCENTRATIONS mg/l
SITE 16 REMEDIAL INVESTIGATION
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

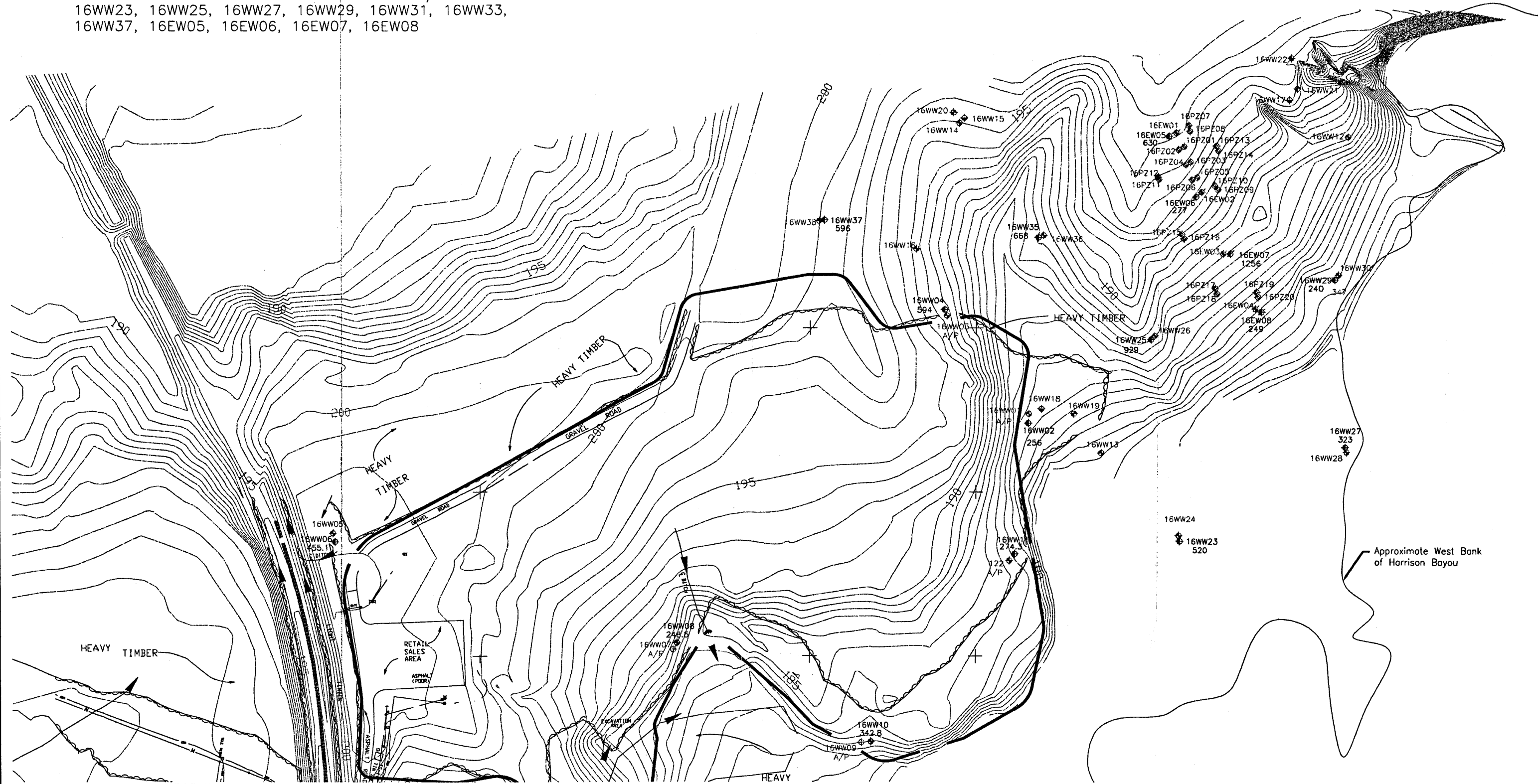
FIGURE NO.:
4-8

NOTE:

DATA FOR THE FOLLOWING WELLS IS FROM 6/93:
16WW02, 16WW04, 16WW06, 16WW08, 16WW10, 16WW11

DATA FOR THE FOLLOWING WELLS IS FROM 10/97:
16WW23, 16WW25, 16WW27, 16WW29, 16WW31, 16WW33,
16WW37, 16EW05, 16EW06, 16EW07, 16EW08

024919



- LEGEND**
- SHALLOW MONITORING WELL
 - INTERMEDIATE MONITORING WELL
 - UPPER DEEP ZONE MW
 - LOWER DEEP ZONE MW
 - SHALLOW EXTRACTION WELL
 - INTERMEDIATE EXTRACTION WELL
 - SHALLOW PIEZOMETER
 - INTERMEDIATE PIEZOMETER
 - A/P ABANDONED AND PLUGGED



PROJECT NO.:	DWN:	DES.:
000187	BSM	
	CHKD:	APPD:
	PTS	
	DATE:	REV.:
	APR 99	

INTERMEDIATE ZONE MW CHLORIDE CONCENTRATIONS mg/l
SITE 16 REMEDIAL INVESTIGATION
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

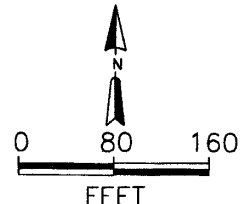
FIGURE NO.:
4-9

NOTE:
CHLORIDE CONCENTRATIONS GATHERED OCT. 1997

024920



- LEGEND**
- SHALLOW MONITORING WELL
 - INTERMEDIATE MONITORING WELL
 - UPPER DEEP ZONE MW
 - LOWER DEEP ZONE MW
 - SHALLOW EXTRACTION WELL
 - INTERMEDIATE EXTRACTION WELL
 - SHALLOW PIEZOMETER
 - INTERMEDIATE PIEZOMETER
 - A/P ABANDONED AND PLUGGED



US Army Corps of Engineers
Tulsa District
Sverdrup
ENVIRONMENTAL

PROJECT NO.:	OWN:	DES.:
000187	BSM	
	CHKD:	APPD:
	PTS	
	DATE:	REV.:
	APR 99	

DEEP ZONE MONITORING WELLS CHLORIDE CONCENTRATIONS mg/l
SITE 16 REMEDIAL INVESTIGATION
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

FIGURE NO.:
4-10