DEPARTMENT OF THE ARMY
LAKE CITY ARMY AMMUNITION PLANT
INDEPENDENCE MISSOURI 64051-1000

October 28, 2003

Operations Office

SUBJECT: Draft Final Explanation of Significant Differences to the Action Memorandum for the Area 16 Abandoned Landfill, Northeast Corner Operable Unit, Lake City AAP

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Lady and Gentlemen:

Enclosed for your review is the Draft Final Explanation of Significant Differences (ESD) to the Action Memorandum for the Area 16 Abandoned Landfill, Northeast Corner Operable Unit, Lake City AAP dated October 22, 2003. We have scheduled the 30-day Public Review Period for this document to begin November 17, 2003.

If you have any questions, please contact me at 816-796-7153.

Sincerely,

Thomas Buechler
Remedial Project Manager

Enclosure

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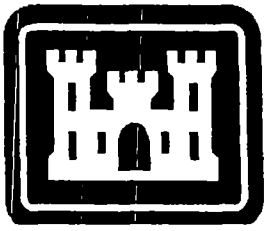

U.S. Army Corps of Engineers
Kansas City District

DRAFT FINAL – FOR REGULATORY REVIEW

Explanation of Significant Differences to the Action Memorandum for the Area 16 Abandoned Landfill Northeast Corner Operable Unit Lake City Army Ammunition Plant Independence, MO

October 28, 2003

Introduction

This Explanation of Significant Differences (ESD) addresses proposed changes to the Action Memorandum for Non-Time Critical Removal Action for the Northeast Corner Operable Unit Area 16 Abandoned Landfill, Lake City Army Ammunition Plant, Independence Missouri dated February 12, 2001. The removal action consists of regrading and selected placement of additional soil cover at the former landfill, installation of monitoring wells around the landfill to determine if the landfill is contributing to groundwater contamination, and collection and treatment of leachate which may be produced. These changes are based upon an evaluation of new and existing data which indicated the revised removal action would address the risks to human health and the environment in a more efficient and cost effective manner.

Background

The Remedial Investigation (RI) Report for the Northeast Corner Operable Unit (NECOU), dated March 1995, indicated that the Area 16 Abandoned Landfill (ABLF) was a source of Volatile Organic Compounds (VOCs), metals, and explosives based on sporadic detections in monitoring wells downgradient of the landfill and in groundwater seeps. Based on these results the Army prepared an Engineering Evaluation/Cost Analysis Report (EE/CA) for a Non-Time Critical Removal Action at the ABLF dated January 1997.

The selected removal action alternative presented in the EE/CA consisted of regrading and selective placement of additional soil cover over the landfill surface, construction of a groundwater/leachate collection trench, a groundwater/leachate storage and transfer system, treatment of the groundwater/leachate in the existing groundwater treatment plant (Bldg. 163), and installation of passive gas collection vents. The Action Memorandum for a Non-Time Critical Removal Action at the Area 16 Abandoned Landfill was signed by the Army on 26 June 2000, authorizing the Removal Action.

Following approval of the Action Memorandum, a Preplaced Remedial Action Contractor (TN & Associates) was selected to assist with the finalization of the Removal Action Management Plan (RAMP) and to implement the Removal Action. During the preparation of the RAMP, groundwater and leachate samples were collected and analyzed in April 2001 and April 2002. Additional soil sampling to evaluate the permeability and thickness of the existing landfill cover was also undertaken to determine whether the landfill cover complied with the closure standards set forth in Missouri Department of Natural Resources (MDNR) Div 80 Chapter 3, 10 CSR 80-3.010 as written at the time the landfill was closed. The soil samples from the landfill indicated that the cover material is a minimum of 2.5 feet thick and meets regulatory requirements for permeability no greater than 1×10^{-5} cm/sec. However, the low levels and non-detects of contaminants in the groundwater and seeps brought into question the necessity of the groundwater/leachate collection trench component of the Removal Action.

Groundwater/Leachate System Review

A sampling event was undertaken in April 2001 to obtain recent water quality data to determine if water generated by the groundwater/leachate collection trench could be disposed through the existing Building 163 Groundwater Treatment Plant. In April 2001 three temporary piezometers were installed along the alignment of the proposed groundwater/leachate collection trench at the ABLF. Only one of the temporary piezometers had sufficient water to collect samples. Surface water samples were collected from 2 seeps located at the toe of the ABLF. Additionally, one influent water sample was collected from Building 163. All groundwater and surface water samples were submitted for laboratory analyses of VOCs using EPA Method 8260B, Semi-Volatile Organic Compounds (SVOCs) using EPA Method 8270, explosives using EPA Method 8330, Polychlorinated Biphenyls (PCBs) using EPA Method 8082, and priority pollutant metals using EPA Method 6010B. The samples were also analyzed for cations, alkalinity, total suspended solids, and total dissolved solids. The results of the sample analyses are shown in Table 1. The results indicated that contaminants in the groundwater and water from the seeps were at low levels (below regulatory standards), in many cases they were not detected, and that they could be disposed at Bldg. 163. Only one compound slightly exceeded the Federal Maximum Contaminant Levels (MCLs) for drinking water. The compound 1,1-Dichloroethene was detected at 12.1 parts per billion (ppb), compared to the Federal MCL of 7 ppb for 1,1-Dichloroethene.

In April 2002 another sampling event was undertaken to verify the results of the April 2001 sampling event and to help determine the necessity of constructing the groundwater/leachate collection trench. Groundwater samples were collected on April 23-25, 2002 from 3 existing monitoring wells near the ABLF, MW16-1, MW16-3, and MW16-4. Additionally, 3 temporary piezometers were installed along the alignment of the proposed groundwater collection trench at the same location as temporary piezometers installed in April 2001. Surface water samples were collected from 2 seeps located at the toe of the ABLF. All groundwater and surface water samples were submitted for laboratory analysis of VOCs using EPA Method 8260B, SVOCs using EPA Method 8270, explosives using EPA Method 8330, perchlorates using EPA Method SW-846 9058, PCBs using EPA Method 8082, and priority pollutant metals using EPA Method 6010B. The results of the sample analyses are shown in Table 2. Once again, the results indicated that contaminants in the groundwater and water from the seeps were at low levels (below regulatory standards), and in many cases were not detected. No compounds exceeded the MCLs for drinking water.

ABLF Cover Review

Cover material on landfills performs several functions, including elimination of direct contact with the waste materials and reduction of water infiltrating the landfill and producing leachate. By improving the thickness, compaction, and grading and by eliminating any cracks in the cover, water available to produce leachate will be greatly reduced. The Sanitary Landfill standards in place at the time of the ABLF closure required 24 inches of soil with permeability no greater than 1 X 10^{-5} cm/sec overlain by

12 inches of soil capable of sustaining vegetative growth. (DNR Div 80 Chapter 3, Title 10 CSR 80-3.010). The EE/CA presented results from soil sampling into the landfill cover on 100'x 100' centers that indicated a minimum of 2.5 feet of cover existed across the entire landfill, however, no permeability testing of the cover material was conducted.

In December 2002 a sampling event was undertaken to verify the thickness and determine the permeability of the existing ABLF cover. Existing cover thickness was measured and undisturbed soil samples were collected at 8 locations. The soil samples were tested using ASTM D5084 to determine permeability. The results of the permeability testing are included in the Attachment. The results indicate that the existing cover material substantially meets the regulatory requirements. All samples except one have a hydraulic conductivity less than 1×10^{-5} cm/s in the bottom 24 inches of the cover, and the permeability of that one sample is 1.3×10^{-5} cm/s. The borings show there is a minimum of 24 inches of clay covering the site. The soil is capable of supporting vegetation, as evidenced by the growth of vegetation on the site; however, three locations have less than 12 inches of soil capable of sustaining vegetative growth overlying the clay.

Soil vapor data collected in 1994 for the preparation of the EE/CA was reanalyzed to verify the need for passive gas collection vents in the ABLF. Of the 16 samples of soil vapor that could be collected from 46 locations in the 1994 sampling effort, only 2 exceeded the Lower Explosive Limit (LEL) for methane, which is approximately 5% by volume, or 50,000 parts per million (ppm). These 2 samples were duplicates of samples, one of which was well below the LEL (1300 ppm) and the other was not quantifiable. Current Missouri Sanitary Landfill Regulations (DNR Div 80 Chapter 3, Title 10 CSR 80-3.010) require gas venting if the concentration of gas exceeds 25% of the LEL in buildings on the landfill site, or if the concentration of gas in the soil exceeds 50% at the landfill boundary. Currently there are no buildings associated with, or near, the ABLF and the samples exceeding the LEL for methane were obtained from near the center of the landfill. Soil gas samples near the landfill boundary either could not be collected due to saturated soil conditions or were well below the LEL for methane.

Proposed Changes

The results of two rounds of sampling of the groundwater and seeps at the ABLF showed contaminants at lower levels (or non-detects) than reported in the EE/CA. The Army has determined that the groundwater/leachate collection trench, groundwater/leachate storage and transfer system, and treatment of the groundwater/leachate in Bldg. 163 are not warranted at this time, however, continued monitoring will be required.

Currently groundwater seepage emanating from the landfill toe discharges onto the ground surface, accumulates in low lying areas, and infiltrates into the shallow water-bearing zone or is channeled to intermittent surface water drainage swales. An engineered wetland is proposed at the toe of the ABLF to collect, contain, and treat the water from these seeps.

Based on the results of the existing ABLF cover soil sampling, the Army has determined that the regrading and selective placement of additional soil cover over the landfill surface as presented in the EE/CA will be constructed as planned. This action is necessary for maintenance to repair erosion and cracks, fill in low spots, and prevent ponding of water on top of the landfill.

The Army will install groundwater monitoring wells down gradient of the ABLF and sample them on a regular basis to determine if the landfill is contributing to groundwater contamination above MCLs.

Further analysis of soil gas data presented in the EE/CA, as described above, indicates that methane is not emanating from the ABLF above regulatory limits. The Army has determined that installation of the passive gas collection vents is not warranted at this time, however, gas monitoring will be performed during construction.

Design of Engineered Wetland

An engineered wetland will be designed and constructed at the toe of the ABLF to collect, contain, and treat water from the ABLF seeps. Prior to initiating the design the average yearly combined flow rate of the seeps will be determined and samples of the water from the seeps will be collected for analysis. The wetland will be designed to treat low levels of VOCs and explosives in the water from the seeps, while metals are expected to accumulate in the wetland vegetation. Surface water will be diverted around the wetland. The size of the wetland (presently assumed to be in the range of 1/2 to 1 acre) will accommodate water from the seeps without discharge to the ground surface. Native plants will be planted in the wetland. The plants will treat the contamination through uptake of the water. The selected plants will also be suited to the predicted hydrologic regime of alternating wet and dry periods. Prior to construction of the wetland any seepage leaving the landfill toe will be collected in a tank, sampled, and properly treated prior to disposal.

In the event there is insufficient flow from the seeps to construct and sustain a wetland the tank will remain in place until sufficient flow is available. If analysis of the water from the seeps detects contaminants that would not be adequately treated by a wetland the collection of the water from the seeps will continue pending determination of remedies the entire Northeast Corner Operable Unit in 2007. Collected water will be sampled prior to treatment at a permitted treatment facility. The wetland sediment and the inflow of water to the wetland will be sampled quarterly for the first year after construction and annually thereafter. The wetland vegetation and sediments with accumulated metals contamination may require removal and proper disposal after several years. Performance criteria for determining the appropriate time to remove sediment based on sampling results will be developed during the design of the wetland. The capital costs for construction of the wetland are shown in Table 5.

Ability to Achieve Removal Action Objectives

The following specific Removal Action Objectives were identified in the EE/CA for the ABLF:

- Prevent ecological and human receptor contact with ABLF leachate
- Reduce the potential for leachate flows associated with the ABLF to infiltrate into shallow groundwater and migrate outside Area 16 boundaries at unacceptable levels.
- Reduce the potential for leachate contamination of shallow groundwater at the ABLF to migrate into the alluvial aquifer west of Buckner Road.
- Treat leachate and contaminated shallow groundwater collected at the ABLF to levels consistent with the selected discharge option.

The selective placement of additional soil and regrading the landfill cover as presented in the EE/CA, combined with the establishment of improved erosion and sediment controls around the landfill to control storm water run-on and run-off, will achieve the first Removal Action Objective of preventing ecological and human receptor contact with the ABLF groundwater seeps through minimizing site run-off of storm water from the landfill and reducing seepage by limiting storm water infiltration. Long term monitoring of the engineered wetland and the wells around the landfill will help to determine if the second and third Remedial Action Objectives are being met. The selected discharge option has been changed from discharge to Bldg. 163 to discharge to an engineered wetland or collection and treatment. The wetland will be designed to treat low levels of explosives and VOCs in the groundwater seepage to below MCLs, and to accumulate metals contamination. Therefore, the fourth Remedial Action Objective will be met by the construction of the engineered wetland.

The Removal Action for the ABLF will be evaluated in the Feasibility Study as a part of the overall remedy for the Northeast Corner Operable Unit (NECOU). Data collected from the groundwater monitoring wells to be installed down gradient of the ABLF will be analyzed to determine if the performance of the ABLF Removal Action is consistent with the Remedial Action Objectives to be presented in the Feasibility Study (FS).

Cost Analysis

The estimated capital cost for the ABLF Removal Action as presented in the EE/CA was $2,168,910 and is summarized in Table 3. The proposed changes reduce the estimated capital cost by $1,279,571. The estimated capital cost for the ABLF Removal Action with the proposed changes is $889,339 and is summarized in Table 4.

References

EA Engineering, Science and Technology. 1997. *Engineering Evaluation/Cost Analysis Report, Non-Time Critical Removal Action for the Area 16 Abandoned Landfill at the Northeast Corner Operable Unit, Lake City Army Ammunition Plant, Independence, Missouri.* Final. January.

IT Corporation. 2001. *Action Memorandum, Non-Time Critical Removal Action for the Area 16 Abandoned Landfill at the Northeast Corner Operable Unit, Lake City Army Ammunition Plant, Independence, Missouri.* Final. February.

TABLES

Table 1
Summary of April 2001 Data from Area 16 ABLF and Area 18 Extracted Groundwater

Chemicals Monitored in Leachate	LBVSD Historical Discharge limits (ug/L)	Concentration in Samples From Area 16 ABLF			Concentration in Area 18 Extracted Groundwater	Projected Concentration in Building 163 Effluent[a]			
		Seep 1	Seep 2	16GW2		Seep 1	Seep 2	16GW2	Maximum
1,1-Dichloroethane	26	11.1	ND	46.6	ND	0.64	ND	1.57	1.57
1,1-Dichloroethene	35	ND	ND	12.1	ND	ND	ND	0.67	0.67
1,2-Dichloroethene	400	ND	ND	ND	251	ND	ND	ND	ND
1,1,1-Trichloroethane	900	ND	ND	3.2	ND	ND	ND	0.43	0.43
Benzene	43	4.0	ND	ND	1.4	0.35	ND	ND	0.35
Carbon Tetrachloride	44	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	9	ND	ND	ND	ND	ND	ND	ND	ND
Ethyl Benzene	7	60.3	ND	ND	1.1	1.78	ND	ND	1.78
Methylene Chloride	30	ND	ND	ND	ND	ND	ND	ND	ND
Methylisobutyl Ketone	2	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	110	4.8	ND	ND	1.4	0.37	ND	ND	0.37
Trichloroethene	680	ND	ND	ND	22.3	ND	ND	ND	ND
Vinyl Chloride	250	ND	ND	1.6	134	ND	ND	23.32	23.32
Other VOCs, total		173.9	ND	2.0		4.58	ND	0.05	4.58
Semivolatile Organic Compounds									
Bis(2-Ethylhexyl)Phthalate	360	8.2	8.3	109	5.9	1.08	1.09	14.34	14.34
Chrysene	66	ND	ND	ND	ND	ND	ND	ND	ND
Di-N-Octyl Phthalate	13	2	ND	1	ND	0.26	ND	0.13	0.26
Explosive Compounds									
2,4-Dinitrotoluene	6	NA	0.5661	0.4322	ND	ND	0.07	0.06	0.07
HMX	2	NA	ND	ND	ND	ND	ND	ND	ND
Nitrobenzene	13	NA	ND	0.3856	ND	ND	ND	0.05	0.05
RDX	5	NA	ND	1.6268	ND	ND	ND	0.21	0.21
Metals and Other Inorganic Compounds									ND
Antimony	78	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	30	ND	ND	ND	9.2	ND	ND	ND	ND
Barium	856	1120	390	198	603	148.05	51.99	26.73	148.05
Beryllium	10	0.96	0.75	1.2	0.78	0.13	0.10	0.16	0.16
Cadmium	200	314	ND	0.73	ND	41.32	ND	0.10	41.32
Chromium	1000	6	ND	11	ND	0.79	ND	1.45	1.45
Copper	3000	4.1	40.7	3.9	ND	0.54	5.36	0.51	5.36
Lead	1500	16	9.6	5.1	ND	2.11	1.26	0.67	2.11
Nickel	1000	22	ND	14	ND	2.89	ND	1.84	2.89
Selenium	34	4.7	ND	ND	ND	0.62	ND	ND	0.62
Silver	100	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	5000	48.8	137	29	77.1	6.42	18.03	3.82	18.03

[a] Calculated for Minimum Area 18 Extracted Groundwater Flow and 50 gallons per minute Area 16 Leachate flow, the maximum possible.
LBVSD = Little Blue Valley Sewer District
ND = Not detected

Table 2
Summary of April 2002 Data from Area 16 ABLF

Location	Analyte	VOCs (Method 8260)																				SVOCs (Method 8270)
		1,1-Dichloroethane	1,1-Dichloroethene	1,2,4-Trimethylbenzene	1,3,5-Trimethylbenzene	2-Butanone	4-Isopropyltoluene	Acetone	Benzene	Chloroethane	Chloromethane	Ethylbenzene	Isopropylbenzene	Methylene chloride	m-Xylene and p-Xylene	Naphthalene	n-Propylbenzene	o-Xylene	sec-Butylbenzene	Toluene	Vinyl Chloride	Naphthalene
	DATE COLLECTED	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
Seep 16-1	04/23/02																					
Seep 16-2	04/23/02	6.4		42	13 3		4.48		4.13	44 2		80	5 22	0.61J	79	45 1	4 16	14 4	1 33J	4 43		17 3J
16GW4	04/23/02	9 02						3.79		29 4						9J						–
	04/24/02	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
	04/25/02	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
16GW5	04/23/02	5 53						1 58J		89 4				56J								–
	04/25/02	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
16GW6	04/23/02	15.8	3.12							0 52J	0.56J										0 5J	–
	04/24/02	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
MW16-1	04/23/02																					
MW16-3	04/25/02																					
MW16-4**	04/25/02																					
MW16-504***	04/25/02																					
TB042302	04/23/02					3.32								8.27						1.53J		–
TB042502	04/25/02							5.44						9 25								–

Notes:

Only compounds detected or "J" flagged are reported on this table.

Blank cell indicates compound was not detected

– Indicates that sample was not collected on indicated date

Sample MW16-4 was reported on some reports as MW16-4(MS/MSD) to show that an MS/MSD analysis is to be run.

****Sample MW16-504 is a duplicate of MW16-4. A Split was sent to the USACE lab in Omaha, NE.**

Table 2
Summary of April 2002 Data from Area 16 ABLF

Location	Analyte	ICP-MS Metals (Method 6020)								TAL Metals (Method 6010B)														
		Chromium	Arsenic	Selenium	Cadmium	Antimony	Mercury	Thallium	Lead	Aluminum	Barium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Nickel	Potassium	Sodium	Vanadium	Zinc
	DATE COLLECTED	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Seep 16-1	04/23/02				0 797J	7 95			10.05		0.323	121			0 0421	0.772		21 2	0.0712		3.2J	9 14		0 131
Seep 16-2	04/23/02		4 95	2.17	0.552J	5.09		1 85	13	0.891	1.25	170		0 0105J		98	0.0588J	61.5	1.42	0 0297J	6 9J	133	0 0179J	0 0605
16GW4	04/23/02	8.64	3.25	3 97				1 34	3 36	6.06	0.288	192	0 0182J		0109J	8.15		46.4	2.06	0242J	2.7J	143	.0079J	0461J
	04/24/02	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	04/25/02	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
16GW5	04/23/02	12.02	2 28	2 93					3.48	6 01	0.407	221	0 0238	.0102J	.0117J	8 97		56.3	1 61	.0212J	2 78J	150	0 0095J	0 037J
	04/25/02	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
16GW6	04/23/02	9.4	2.08	1 53J					3.91	6 97	0.202	79 3	.0156J			9 75		17.2	0.645	018J		39	0102J	0342J
	04/24/02	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
MW16-1	04/23/02			2					1.29	0.761	0.0791	81 5				0.715		17 7	0 0114			24 3		
MW16-3	04/25/02	3.23	2.87	1 02J	2 54				4.86	5.7	0 238	40.8				5.61		8	0 831			14.4	0 0128J	0 0426J
MW16-4**	04/25/02		2 62	1 24J	1.64				1.77	.376J	0.364	121				2 09		14 3	0 0831			33 7		
MW16-504***	04/25/02		2 3	1 13J					1.68	0.425	0.364	97.9				1.93		14.7	0.0606			35.9		
TB042302	04/23/02	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
TB042502	04/25/02	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Notes:

Only compounds detected or "J" flagged are reported on this table.

Blank cell indicates compound was not detected

– indicates that sample was not collected on indicated date

**Sample MW16-4 was reported on some reports as MW16-4(MS/MSD) to show that an MS/MSD analysis is to be run.

***Sample MW16-504 is a duplicate of MW16-4. A Split was sent to the USACE lab in Omaha, NE.

Table 2
Summary of April 2002 Data from Area 16 ABLF

Location	Analyte	Explosives (Method 8330)	PCBs (Method 8082)	Perchlorates (Method 9058)
		1,3,5-TNB	All	
	DATE COLLECTED	(µg/L)	(mg/L)	(µg/L)
Seep 16-1	04/23/02			
Seep 16-2	04/23/02			
16GW4	04/23/02	–	–	
	04/24/02		–	–
	04/25/02	–		–
16GW5	04/23/02		–	
	04/25/02	–	–	–
16GW6	04/23/02	–	–	
	04/24/02			–
MW16-1	04/23/02			
MW16-3	04/25/02			
MW16-4**	04/25/02			
MW16-504***	04/25/02			
TB042302	04/23/02	–	–	–
TB042502	04/25/02	–	–	–

Notes:
Only compounds detected or "J" flagged are reported on this table.
Blank cell indicates compound was not detected
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****Sample MW16-4 was reported on some reports as MW16-4(MS/MSD) to show that an MS/MSD analysis is to be run.**
******Sample MW16-504 is a duplicate of MW16-4. A Split was sent to the USACE lab in Omaha, NE.***

TABLE 3 ESTIMATE OF CAPITAL COSTS FOR REMOVAL ACTION ALTERNATIVE NO. 4: LEACHATE RECOVERY, STORAGE, AND TRANSFER SYSTEM WITH TREATMENT THROUGH THE AREA 18 GROUNDWATER TREATMENT SYSTEM[1][2][3]

Item	Description	Quantity	Unit Cost	Total
1	Grading and Site Preparation[4] To establish grades for final cover material under landfill post-closure maintenance actions.	68,000 sy	1.63/sy	$110,900
2	Vegetative Support Layer[4] Selective placement of additional soil layers with a permeability $\leq 1 \times 10^{-5}$ cm/sec. Includes loading from onsite stockpile, 4-mile round-trip haul, placement, and grading	6,000 cy	$6.50/cy	$39,000
3	Topsoil Layer[4] Placement of average 6-in.-deep soil layer containing sufficient organic material for vegetative growth. Includes loading from offsite sources, 20-mile round-trip haul, placement, and grading	10,500 cy	$20/cy	$210,000
4	Landfill Post-Closure Maintenance Seeding[4] Includes hydroseeding and fertilizing over landfill and disturbed site areas.	68,000 sy	$0 67/sy	$45,600
5	Landfill Gas (Passive) Collection and Venting System Includes passive shallow gas vents (20 total) and horizontal pipe collectors with passive vents in areas of elevated methane concentrations.	1	$15,000/ea.	$15,000
6	Erosion and Sediment Control Includes temporary and permanent sediment and erosion control structures (earth dikes, silt fencing, and stabilized construction entrance), and temporary and permanent seeding of disturbed areas.	1	$40,000/ea.	$40,000
7	Landfill Leachate Seep Drains Trench System and Collection Piping[5] Includes excavation, stone, geotextile, clay liner, piping, one manhole, and geomembrane	1	LS	$34,000
8	Landfill Leachate Recovery Trench [6] Includes excavation, stone, geotextile, HDPE liner, and 4 manholes placed within the waste.	1	LS	$513,500
9	Placement of Excavated Waste From Recovery Trench Into Landfill	4,700 cy	$10/cy	$47,000
10	Gravity Line From Leachate Recovery Trench to Pump Station[7] Includes excavation, bedding, 6-in. HDPE pipe, and backfill	510 lf	$39/lf	$20,100
11	Leachate Pump Station Includes duplex pumping station, valves, electrical equipment (explosion proof), and controls	1	$55,000/ea.	$55,000

TABLE 3 ESTIMATE OF CAPITAL COSTS FOR REMOVAL ACTION ALTERNATIVE NO. 4: LEACHATE RECOVERY, STORAGE, AND TRANSFER SYSTEM WITH TREATMENT THROUGH THE AREA 18 GROUNDWATER TREATMENT SYSTEM[1][2][3]

Item	Description	Quantity	Unit Cost	Total
12	Forcemain From Pump Station to Leachate Storage Facility Includes excavation, stone bedding, piping, backfill and compaction.	430 lf	$14/lf	$6,000
13	Two (2) 20,000-Gal Steel Aboveground Storage Tanks	2	$20,000/ea	$40,000
14	Transfer Pumps Includes 2 pumps rated to pump from pump station to Area 18 Groundwater Treatment System	2	8,500/ea.	$17,000
15	Leachate Forcemain From Pump Station to Area 18 Groundwater Treatment System [5]	2,900 lf	$15/lf	$43,500
16	46.5 ft x 52 ft Concrete Containment Pad for Tank and 25 ft x 60 ft Truck Loading Area Includes concrete slab, containment curb, drains, loading rack, and loading arm.	1	LS	$69,000
17	Programmable Logic Control (PLC) Includes computerized PLC unit with related instruments and wiring for leachate conveyance system to Area 18 Groundwater Treatment System	1	LS	$25,000
18	Electrical Supply System and Site Lighting Includes primary service extension from Buckner Road to storage facility, lightning protection, transformers, secondary service feeder, heat tracing, tank immersion heaters, site lighting, PLC interface, and panel board	1	LS	$80,000
19	Access Road and Site Paving, Leachate Storage and Transfer Facility	2,200 sy	$21/sy	$46,200
20	Sampling During Startup and for First Year of Operation	1	LS	$39,000
21	SUBTOTAL			$1,522,800
22	MOBILIZATION/DEMOBILIZATION, CONSTRUCTION MANAGEMENT, SITE SERVICES	10% of capital cost items 1 through 21		$152,300
23	IMPLEMENTATION, DESIGN	10% of capital cost items 1 through 21		$152,300
24	CONTINGENCY	10% of capital cost items 1 through 21		$380,700
25	TOTAL			$2,181,100

TABLE 3 ESTIMATE OF CAPITAL COSTS FOR REMOVAL ACTION ALTERNATIVE NO. 4: LEACHATE RECOVERY, STORAGE, AND TRANSFER SYSTEM WITH TREATMENT THROUGH THE AREA 18 GROUNDWATER TREATMENT SYSTEM[1][2][3]

Item	Description	Quantity	Unit Cost	Total

(1) Costs are developed per the Innovative and Alternative Technology Assessment Manual, EPA 700/200

(2) Equipment supplier-prepared current quote was received for each major treatment process used in the removal action alternative

(3) Excavation within the Area 16 Abandoned Landfill and downgradient of the Abandoned Landfill site for the passive gas venting system, leachate seep drains, leachate collection trench, manholes, leachate collection piping system (to the leachate pumping stations), and the leachate pumping station includes Level C personal protective equipment

(4) Area of landfill is approximately 17 3 acres Total area of disturbance due to regrading is estimated as 18 2 acres.

(5) Landfill Leachate Seep Drains Trench System and Collection Piping includes:
- 305 lf of recovery trench backfill with stone and wrapped in geotextile.
- Excavation and backfill of three leachate seeps.
- 385 lf of 8-in. HDPE piping and associated pipe beveling.
- Clay barrier construction.
- One 48-in -diameter HDPE manhole

(6) Landfill Leachate Recovery Trench includes:
- 1,664 lf of 6-in. HDPE piping in the collection trench.
- 1,700 lf of trench excavation lined with 60-mil HDPE geomembrane on the downgradient portion of the trench, with trench wrapped in geotextile and backfilled with stone.
- Four 48-in -diameter, HDPE manholes, averaging 15 ft deep with associated concrete slab at grade for antiflotation.

(7) Utility line construction includes excavation with 3.5-ft cover (backfill/compaction).

(8) Forcemain construction includes excavation with 4-ft cover (backfill/compaction)

TABLE 4 ESTIMATE OF CAPITAL COSTS FOR REMOVAL ACTION WITH PROPOSED CHANGES [1]

Costs in 2003 dollars

Item	Description	Quantity	Unit Cost	Total
1	Grading and Site Preparation To establish grades for final cover material, repair cracks, clearing and grubbing, drainage ditch exc., and general site work	42,700 sy	$1.30/sy	$55,500
2	Compacted Clay Layer Selective placement of additional soil layers with a permeability $\leq 1 \times 10^{-5}$ cm/sec. Includes loading from offsite source, 20-mile round-trip haul, placement, and grading	6,500 cy	$15.70/cy	$102,000
3	Topsoil Layer Placement of average 12-in.-deep soil layer containing sufficient organic material for vegetative growth. Includes loading from offsite sources, 20-mile round-trip haul, placement, and grading.	14,400 cy	$23/cy	$331,200
4	Landfill Post-Closure Maintenance Seeding Includes hydroseeding and fertilizing over landfill and disturbed site areas.	42,700 sy	$0.67/sy	$28,600
5	Erosion and Sediment Control Includes temporary and permanent sediment and erosion control structures (earth dikes, silt fencing, and stabilized construction entrance), and temporary and permanent seeding of disturbed areas.	1	$10,000/ea.	$10,000
6	Leachate Seep Drains and Collection Piping Includes excavation, geotextile, piping, and backfill	1	LS	$21,700
7	Engineered Wetland Includes construction of engineered wetland (See Table 5 for break down of costs)	1	LS	$32,337
8	Groundwater Monitoring Wells[2] Includes installation and development of groundwater monitoring wells.	8	$4,000/ea.	$32,000
9	SUBTOTAL			$613,337
10	MOBILIZATION/DEMOBILIZATION, CONSTRUCTION MANAGEMENT, SITE SERVICES	10% of capital cost items 1 through 7		$61,334
11	IMPLEMENTATION, DESIGN	10% of capital cost items 1 through 7		$61,334
12	CONTINGENCY	25% of capital cost items 1 through 7		$153,334
13	TOTAL			$889,339

Note:

(1) Costs are developed from contractor quotes.

(2) Sampling and analysis costs will be bourne by the NECOU FS Workplan

TABLE 5 ESTIMATE OF CAPITAL COSTS FOR ENGINEERED WETLAND (0.5 Acre)

Item	Description	Quantity	Unit Cost	Total
1	Grading and Site Preparation To establish grades of engineered wetland	3500 cy	$4.00	$14,000
2	Topsoil Placement of one foot of topsoil. On-site topsoil can be used if acceptable to the engineer	2420 sy	$2.60	$6,292
3	Silt Fence Includes installation, maintenance and removal of silt fence (Delivered and Installed)	400 lf	$3.00	$1,200
4	Seeding Includes discing or rototilling the topsoil to provide a suitable planting substrate, supplying and sowing native seed and cover crop and raking and mulching seeded areas.	2420 sy	$1.25	$3,025
5	Wetland Rootstock Includes supplying and planting native wetland rootstock	2000 ea	$1.75	$3,500
6	Wetland Trees Includes supplying and planting wetland trees	120 ea	$20.00	$2,400
7	Wetland Shrubs Includes supplying and planting wetland shrubs	160 ea	$12.00	$1,920
	SUBTOTAL			$32,337
	MOBILIZATION/DEMOBILIZATION, CONSTRUCTION MANAGEMENT AND SITE SERVICES	10 % Capital cost items 1-7		$3,233
	IMPLEMENTATION, DESIGN	25% Capital cost items 1-7		$8,084
	CONTINGENCY	25% Capital cost items 1-7		$8,084
	TOTAL			$51,738

ATTACHMENT

T N & Associates, Inc.
Engineering and Science

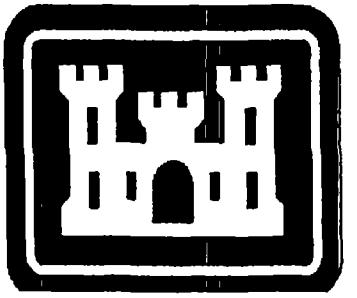
TECHNICAL MEMORANDUM

DATE: February 13, 2003

TO: Tom Semotuk
U.S. Army Corps of Engineers
Kansas City District
Kansas City, Missouri

FROM: Roger Strohm
T N & Associates, Inc.
1033 N. Mayfair Rd. Suite 200
Milwaukee, WI 53226-3442

REGARDING: Area 16 Maintenance Investigation
Lake City Army Ammunition Plant
Independence, Missouri



Background

On December 16, 2002, TN& Associates conducted a maintenance investigation of the Area 16 Landfill cover. The investigation consisted of determining the cover material thickness, material classification, and hydraulic conductivity.

TN&A used a geoprobe rig with an auger (ASM D1452) to determine the thickness of the cover. In the same location, TN&A also used the geoprobe to collect two Shelby tube samples (ASTM D1587) of the cover material. These samples were analyzed in the laboratory for soil classification (ASTM D2487) and hydraulic conductivity (ASTM D5084). This procedure was followed at eight locations on the landfill as shown on Figure 1.

Regulatory Requirements

The regulatory requirements for the final cover of this site consist of two items:

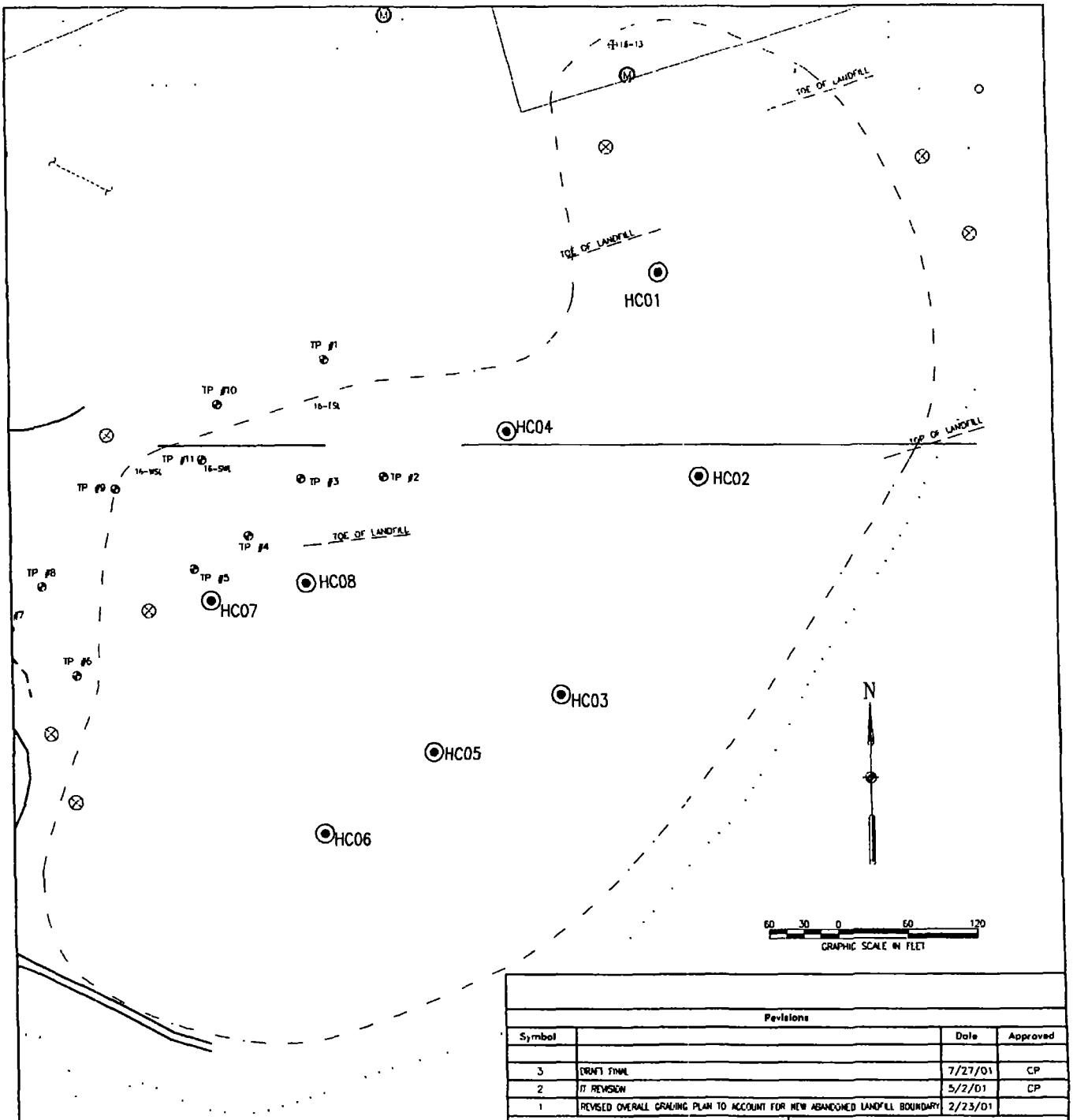
- A minimum of 24 inches of compacted clay with a coefficient of permeability less than 1 $x10^{-5}$ cm/s
- A minimum of 12 inches of soil capable of sustaining vegetation overlying the clay

Findings

Based on the laboratory results which are included in Appendix A and the field investigation, the cover material generally meets the regulatory requirements. There is a minimum of 24 inches of clay covering the site. The soil is capable of supporting vegetation. The evidence of this is the growth of vegetation on the site. However, three samples (HC01, HC06, and HC08) have less than 12 inches of soil capable of sustaining vegetation overlying the clay. All samples except HC08 have a hydraulic conductivity less than 1 $x10^{-5}$ cm/s at depths in the bottom 24 inches of the cover. These results are shown in the following table. Sample locations are shown in Figure 1.

Summary of Field Investigation Results

Sample ID	Cover Thickness (ft)	Hydraulic Conductivity of Clay Layer (cm/s)	Typical Name/Description of the clay layer	UCS Classification
HC01	2.3	8.6×10^{-8}	Inorganic Clays of low to medium plasticity, lean clay	CL
HC02	4.5	8.0×10^{-7}	Inorganic Clays of high plasticity, fat clay	CH
HC03	5.5	6.05×10^{-6}	Inorganic Clays of low to medium plasticity, lean clay	CL
HC04	3.5	8.4×10^{-6}	Inorganic Clays of low to medium plasticity, lean clay	CL
HC05	4.0	1.1×10^{-6}	Inorganic Clays of low to medium plasticity, lean clay	CL
HC06	2.5	3.6×10^{-6}	Inorganic Clays of low to medium plasticity, lean clay	CL
HC07	3.0	1.2×10^{-8}	Inorganic Clays of high plasticity, fat clay	CH
HC08	2.5	1.3×10^{-5}	Inorganic Clays of low to medium plasticity, lean clay	CL



LEGEND

HC03 SAMPLE ID

Revisions			
Symbol		Date	Approved
3	DRAFT FINAL	7/27/01	CP
2	IT REVISION	5/2/01	CP
1	REVISED OVERALL GRADING PLAN TO ACCOUNT FOR NEW ABANDONED LANDFILL BOUNDARY	2/23/01	

TN & A T N & Associates, Inc. Engineering and Science

DEPARTMENT OF THE ARMY

LAKE CITY ARMY AMMUNITION PLANT INDEPENDENCE, MISSOURI

REMOVAL ACTION
NORTHEAST CORNER OPERABLE UNIT
AREA 16 ABANDONED LANDFILL
POST-CLOSURE MAINTENANCE ACTION

MAINTENANCE INVESTIGATION

Designed by: RS	Scale 1" = 120'		Date: FEBRUARY 2003
Drawn by: MW	Spec No LCP-M-		Figure: FIGURE 1
Checked by RS	Drawing Name Figure_01a.dwg		
Reviewed by: RS			
Submitted by RS			

1

APPENDIX A

Geotechnical Laboratory Results

MAXIM
Technologies Inc.

February 6, 2003

Roger Strohm
TN & Associates
1033 N Mayfair Road
Milwaukee, Wisconsin 53226

RE: Geotechnical Lab Testing
Lake City Ammunition
Maxim #3390098

Dear Mr. Strohm

On Behalf of Maxim Technologies, Inc., we are pleased to present this laboratory testing report. The laboratory results have been completed for Lake City Ammunition, Independence, MO. Submitted are the Summary of results and Permeability results.

The following report is organized as depicted in the table below:

- Lab Summary Sheet
- Permeability Results

We thank you for the opportunity to be of service. We can be reached at (913) 321-8100 if you have any questions or require additional information.

Sincerely,

Eric Walston

Eric Walston
Staff Geologist

Maxim Technologies Inc.

Soil Classification Record Sheet

Lake City Ammunition
Independence, MO

Sample ID	Depth (in)	Moisture (%)	Dry Density (pcf)	Atterberg Limits		Grading (cumulative Percents Finer) U.S. Standard Sieve Size							Hydraulic Conductivity (cm/sec)	Classification	
				LL	PI	200	100	60	40	20	10	4			
A16 HC 1A	6-11	22.6	104.3										1.9×10^{-06}	Clay, grayish brown, rust & black concretions, moist	
A16 HC 1B	12-17	21.2	104.4	43	25								8.6×10^{-06}	Clay, grayish brown, rust, moist	CL
A16 HC 2A	7-13	21.5	100.1	53	38								8.0×10^{-07}	Clay, some silt, brown, trace roots, moist	CH
A16 HC 2B	5-9	21.5	102.3										1.3×10^{-06}	Clay, mottled reddish & yellowish brown & black, some roots, moist	
A16 HC 3A	0-27	16.0	109.8	41	24									Clay, some silt, brown, some roots, moist	CL
A16 HC 3B	12-15	18.8	104.7										1.0×10^{-06}	Clay, some silt, mottled yellowish & grayish brown, rust & black concretions, trace roots, moist	
A16 HC 3B	16-22	14.5	97.3										2.1×10^{-06}	Clay, some silt, yellowish brown, moist	
A16 HC 4A	9-16	22.1	96.6	45	28									Clay, some silt, brown, some roots, moist	CL
A16 HC 4A	16-22	17.8	106.7											Clay, some silt, brown, some roots, moist	
A16 HC 4B	14-17	20.1	95.4										1.0×10^{-06}	Clay, brown, some silt, some roots, moist	
A16 HC 4B	22-26	7.8	111.5										6.8×10^{-06}	Clay, brown, some silt, some roots, damp	
A16 HC 5A	2-8	18.0	100.6	41	24								1.2×10^{-06}	Clay, some silt, yellowish brown, some roots, moist	CL
A16 HC 5A	12-19	16.2	106.4										1.1×10^{-06}	Clay, some silt, mottled yellowish & grayish brown, some roots, moist	
A16 HC 5B-1	0-26	14.5	112.0										1.3×10^{-07}	Clay, some silt, yellowish brown, trace roots, moist	
A16 HC 5B-2	0-23	14.9		40	24									Clay, mottled grayish & yellowish brown, moist	CL
A16 HC 6A	6-12	19.3	101.7	40	20								1.6×10^{-06}	Clay, some silt, yellowish brown, trace roots, moist	CL
A16 HC 6A	18-20	19.4	101.2										3.6×10^{-09}	Clay, some silt, mottled grayish & yellowish brown, some roots, rust & black concretions, moist	
A16 HC 6B	0-22	18.2	99.6											Clay, some silt, yellowish brown, moist	
A16 HC 7A	6-10	23.9	97.0										2.6×10^{-05}	Clay, mottled reddish & yellowish brown, some roots, moist	
A16 HC 7B	18-21	21.2	104.4	51	32								1.2×10^{-06}	Clay, mottled gray & brown, rust & black concretions, moist	CH
A16 HC 8A	1-5	20.1	101.1										7.4×10^{-05}	Clay, dark brown, trace roots, moist	
A16 HC 8A	15-18	19.7	108.8										1.3×10^{-05}	Clay, grayish brown, some roots, moist	
A16 HC 8B	0-23	15.1	104.7	40	20									Shale, highly weathered, some silt, brown, moist	CL

Maxim Technologies INC.

Project Name;	**Lake City Ammunition Independence, MO**
Laboratory Number:	**NA**
Project Number:	**3390098**

REPORT OF PERMEABILITY TEST RESULTS

TYPE OF TEST	Flexible Wall Test - ASTM D5084 (method A)
TYPE OF SAMPLE	Undisturbed
PERMANENT	Deaired Tap Water
SAMPLE DATE	01/15/03
SAMPLE ID	A16 HC 1A 6"-11"
DESCRIPTION	Clay, grayish brown, rust & black concretions, moist

	INITIAL	FINAL	
SAMPLE HEIGHT, in.	2.87	2.87	
SAMPLE DIAMETER, in.	2.82	2.83	
DENSITY, pcf	104.3	103.1	
% MOISTURE	22.6	23.5	
VOID RATIO	0.615	0.635	
% SATURATION	99.2	99.8	
% Compaction (Not Applicable if Undisturbed Sample is Used)	100.0	98.8	
SPECIFIC GRAVITY		2.70	Assumed
TOTAL BACK PRESSURE, psi		100.0	
EFFECTIVE CONSOLIDATION STRESSES			
MAX EFFECTIVE STRESS, psi		15.0	
MIN EFFECTIVE STRESS, psi		5.0	
HYDRAULIC GRADIENT, i		98.8	

HYDRAULIC CONDUCTIVITY

K_{20C}	X 10 -POWER	1.9E-08	cm/sec
K_{20C}	X 10 -POWER	5.0E-05	ft/day

Maxim Technologies INC.

Project Name;	**Lake City Ammunition Independence, MO**
Laboratory Number:	**NA**
Project Number:	**3390098**

REPORT OF PERMEABILITY TEST RESULTS

TYPE OF TEST	Flexible Wall Test - ASTM D5084 (method A)
TYPE OF SAMPLE	Undisturbed
PERMANENT	Deaired Tap Water
SAMPLE DATE	01/15/03
SAMPLE ID	A16 HC 2B 5"-9"
DESCRIPTION	Clay, mottled reddish & yellowish brown & black, some roots, damp

	INITIAL	FINAL	
SAMPLE HEIGHT, in.	2.81	2.83	
SAMPLE DIAMETER, in.	2.81	2.88	
DENSITY, pcf	102.3	99.3	
% MOISTURE	21.5	25.3	
VOID RATIO	0.647	0.696	
% SATURATION	89.7	98.0	
% Compaction (Not Applicable If Undisturbed Sample is Used)	100.0	97.1	
SPECIFIC GRAVITY		2.70	Assumed
TOTAL BACK PRESSURE, psi		82.0	
EFFECTIVE CONSOLIDATION STRESSES			
MAX EFFECTIVE STRESS, psi		5.0	
MIN EFFECTIVE STRESS, psi		3.0	
HYDRAULIC GRADIENT, I		20.8	

HYDRAULIC CONDUCTIVITY

K_{20C}	X 10 -POWER	1.3E-06	cm/sec
K_{20C}	X 10 -POWER	3.6E-03	ft/day

Maxim Technologies INC.

Project Name;	**Lake City Ammunition Independence, MO**
Laboratory Number:	**NA**
Project Number:	**3390098**

REPORT OF PERMEABILITY TEST RESULTS

TYPE OF TEST	Flexible Wall Test - ASTM D5084 (method A)
TYPE OF SAMPLE	Undisturbed
PERMANENT	Deaired Tap Water
SAMPLE DATE	01/15/03
SAMPLE ID	A16 HC 3B 12"-15"
DESCRIPTION	CL, Clay, some silt, mottled yellowish & grayish brown, rust & black concretions, trace roots, damp

	INITIAL	FINAL	
SAMPLE HEIGHT, in.	2.83	2.83	
SAMPLE DIAMETER, in.	2.83	2.84	
DENSITY, pcf	104.7	102.3	
% MOISTURE	18.8	24.0	
VOID RATIO	0.608	0.646	
% SATURATION	83.6	100.2	
% Compaction (Not Applicable if Undisturbed Sample is Used)	100.0	97.7	
SPECIFIC GRAVITY		2.70	Assumed
TOTAL BACK PRESSURE, psi		83.0	
EFFECTIVE CONSOLIDATION STRESSES			
MAX EFFECTIVE STRESS, psi		5.0	
MIN EFFECTIVE STRESS, psi		2.0	
HYDRAULIC GRADIENT, I		31.8	

HYDRAULIC CONDUCTIVITY

K_{20C}	X 10 -POWER	1.0E-05	cm/sec
K_{20C}	X 10 -POWER	2.7E-02	ft/day

Maxim Technologies INC.

Project Name;	**Lake City Ammunition Independence, MO**
Laboratory Number:	**NA**
Project Number:	**3390098**

REPORT OF PERMEABILITY TEST RESULTS

TYPE OF TEST	Flexible Wall Test - ASTM D5084 (method A)
TYPE OF SAMPLE	Undisturbed
PERMANENT	Deaired Tap Water
SAMPLE DATE	01/15/03
SAMPLE ID	A16 HC 3B 16"-22"
DESCRIPTION	Clay, some silt, yellowish brown, damp

	INITIAL	FINAL	
SAMPLE HEIGHT, in.	2.99	2.90	
SAMPLE DIAMETER, in.	2.83	2.85	
DENSITY, pcf	97.3	96.7	
% MOISTURE	14.5	26.0	
VOID RATIO	0.732	0.742	
% SATURATION	53.3	94.6	
% Compaction (Not Applicable if Undisturbed Sample is Used)	100.0	99.4	
SPECIFIC GRAVITY		2.70	Assumed
TOTAL BACK PRESSURE, psi		82.0	
EFFECTIVE CONSOLIDATION STRESSES			
MAX EFFECTIVE STRESS, psi		5.0	
MIN EFFECTIVE STRESS, psi		3.0	
HYDRAULIC GRADIENT, i		21.2	

HYDRAULIC CONDUCTIVITY

K_{20C}	$X\ 10^{-POWER}$	2.1E-06	cm/sec
K_{20C}	$X\ 10^{-POWER}$	5.7E-03	ft/day

Maxim Technologies INC.

Project Name;	**Lake City Ammunition Independence, MO**
Laboratory Number:	**NA**
Project Number:	**3390098**

REPORT OF PERMEABILITY TEST RESULTS

TYPE OF TEST	Flexible Wall Test - ASTM D5084 (method A)
TYPE OF SAMPLE	Undisturbed
PERMANENT	Deaired Tap Water
SAMPLE DATE	01/15/03
SAMPLE ID	A16 HC 4B 14"-17"
DESCRIPTION	Clay, brown, some silt, some roots, damp

	INITIAL	FINAL	
SAMPLE HEIGHT, in.	2.87	2.88	
SAMPLE DIAMETER, in.	2.83	2.84	
DENSITY, pcf	95.4	99.5	
% MOISTURE	20.1	24.5	
VOID RATIO	0.766	0.693	
% SATURATION	70.9	95.3	
% Compaction (Not Applicable if Undisturbed Sample is Used)	100.0	104.3	
SPECIFIC GRAVITY		2.70	Assumed
TOTAL BACK PRESSURE, psi		100.0	
EFFECTIVE CONSOLIDATION STRESSES			
MAX EFFECTIVE STRESS, psi		15.0	
MIN EFFECTIVE STRESS, psi		5.0	
HYDRAULIC GRADIENT, I		97.0	

HYDRAULIC CONDUCTIVITY

K_{20C}	X 10 -POWER	1.0E-05	cm/sec
K_{20C}	X 10 -POWER	2.7E-02	ft/day

Maxim Technologies INC.

Project Name;	**Lake City Ammunition Independence, MO**
Laboratory Number:	**NA**
Project Number:	**3390098**

REPORT OF PERMEABILITY TEST RESULTS

TYPE OF TEST	Flexible Wall Test - ASTM D5084 (method A)
TYPE OF SAMPLE	Undisturbed
PERMANENT	Dealred Tap Water
SAMPLE DATE	01/15/03
SAMPLE ID	A16 HC 4B 22"-26"
DESCRIPTION	Clay, brown, some silt, some roots, damp

	INITIAL	FINAL	
SAMPLE HEIGHT, in.	3.01	3.07	
SAMPLE DIAMETER, in.	2.82	2.85	
DENSITY, pcf	111.5	99.6	
% MOISTURE	7.8	24.3	
VOID RATIO	0.511	0.692	
% SATURATION	41.1	94.8	
% Compaction (Not Applicable if Undisturbed Sample is Used)	100.0	89.3	
SPECIFIC GRAVITY		2.70	Assumed
TOTAL BACK PRESSURE, psi		88.0	
EFFECTIVE CONSOLIDATION STRESSES			
MAX EFFECTIVE STRESS, psi		5.0	
MIN EFFECTIVE STRESS, psi		2.0	
HYDRAULIC GRADIENT, i		30.0	

HYDRAULIC CONDUCTIVITY

K_{20C}	X 10 -POWER	6.8E-06	cm/sec
K_{20C}	X 10 -POWER	1.9E-02	ft/day

Maxim Technologies INC.

Project Name: Lake City Ammunition
Independence, MO
Laboratory Number: NA
Project Number: 3390098

REPORT OF PERMEABILITY TEST RESULTS

TYPE OF TEST	Flexible Wall Test - ASTM D5084 (method A)
TYPE OF SAMPLE	Undisturbed
PERMANENT	Deaired Tap Water
SAMPLE DATE	01/15/03
SAMPLE ID	A16 HC 5A 2"-8"
DESCRIPTION	CL, Clay, some silt, yellowish brown, some roots, damp

	INITIAL	FINAL	
SAMPLE HEIGHT, in.	3.15	3.17	
SAMPLE DIAMETER, in.	2.84	2.83	
DENSITY, pcf	100.6	100.0	
% MOISTURE	18.0	24.1	
VOID RATIO	0.675	0.685	
% SATURATION	72.1	94.9	
% Compaction (Not Applicable if Undisturbed Sample is Used)	100.0	99.4	
SPECIFIC GRAVITY		2.70	Assumed
TOTAL BACK PRESSURE, psi		72.0	
EFFECTIVE CONSOLIDATION STRESSES			
MAX EFFECTIVE STRESS, psi		5.0	
MIN EFFECTIVE STRESS, psi		3.0	
HYDRAULIC GRADIENT, i		18.9	

HYDRAULIC CONDUCTIVITY

K_{20C}	$X\ 10^{-POWER}$	1.2E-06	cm/sec
K_{20C}	$X\ 10^{-POWER}$	3.2E-03	ft/day

Maxim Technologies INC.

Project Name;	**Lake City Ammunition Independence, MO**
Laboratory Number:	**NA**
Project Number:	**3390098**

REPORT OF PERMEABILITY TEST RESULTS

TYPE OF TEST	Flexible Wall Test - ASTM D5084 (method A)
TYPE OF SAMPLE	Undisturbed
PERMANENT	Deaired Tap Water
SAMPLE DATE	01/15/03
SAMPLE ID	A16 HC 5A 12"-19"
DESCRIPTION	Clay, some silt, mottled yellowish & grayish brown, some roots, damp

	INITIAL	FINAL	
SAMPLE HEIGHT, in.	2.98	2.98	
SAMPLE DIAMETER, in.	2.86	2.86	
DENSITY, pcf	106.4	105.3	
% MOISTURE	16.2	22.0	
VOID RATIO	0.584	0.601	
% SATURATION	75.0	98.9	
% Compaction (Not Applicable if Undisturbed Sample is Used)	100.0	98.9	
SPECIFIC GRAVITY		2.70	Assumed
TOTAL BACK PRESSURE, psi		72.0	
EFFECTIVE CONSOLIDATION STRESSES			
MAX EFFECTIVE STRESS, psi		5.0	
MIN EFFECTIVE STRESS, psi		3.0	
HYDRAULIC GRADIENT, i		20.0	

HYDRAULIC CONDUCTIVITY

K_{20C}	X 10 -POWER	1.1E-06	cm/sec
K_{20C}	X 10 -POWER	3.0E-03	ft/day

Maxim Technologies INC.

Project Name;	**Lake City Ammunition Independence, MO**
Laboratory Number:	**NA**
Project Number:	**3390098**

REPORT OF PERMEABILITY TEST RESULTS

TYPE OF TEST	Flexible Wall Test - ASTM D5084 (method A)
TYPE OF SAMPLE	Undisturbed
PERMANENT	Dealred Tap Water
SAMPLE DATE	01/15/03
SAMPLE ID	A16 HC 5B-1 21"-24"
DESCRIPTION	Clay, some silt, yellowish brown, trace roots, damp

	INITIAL	FINAL	
SAMPLE HEIGHT, in.	3.06	3.17	
SAMPLE DIAMETER, in.	2.88	2.91	
DENSITY, pcf	112.0	104.2	
% MOISTURE	14.5	22.4	
VOID RATIO	0.504	0.617	
% SATURATION	77.7	98.0	
% Compaction (Not Applicable if Undisturbed Sample is Used)	100.0	93.0	
SPECIFIC GRAVITY		2.70	Assumed
TOTAL BACK PRESSURE, psi		83.0	
EFFECTIVE CONSOLIDATION STRESSES			
MAX EFFECTIVE STRESS, psi		5.0	
MIN EFFECTIVE STRESS, psi		2.0	
HYDRAULIC GRADIENT, I		29.6	

HYDRAULIC CONDUCTIVITY

K_{20C}	X 10 -POWER	1.3E-07	cm/sec
K_{20C}	X 10 -POWER	3.5E-04	ft/day

Maxim Technologies INC.

Project Name;	**Lake City Ammunition Independence, MO**
Laboratory Number:	**NA**
Project Number:	**3390098**

REPORT OF PERMEABILITY TEST RESULTS

TYPE OF TEST	Flexible Wall Test - ASTM D5084 (method A)
TYPE OF SAMPLE	Undisturbed
PERMANENT	Deaired Tap Water
SAMPLE DATE	01/15/03
SAMPLE ID	A16 HC 6A 6"-12"
DESCRIPTION	Clay, some silt, yellowish brown, trace roots, moist

	INITIAL	FINAL	
SAMPLE HEIGHT, in.	3.02	3.04	
SAMPLE DIAMETER, in.	2.83	2.87	
DENSITY, pcf	101.7	97.0	
% MOISTURE	19.3	25.3	
VOID RATIO	0.657	0.737	
% SATURATION	79.4	92.7	
% Compaction (Not Applicable if Undisturbed Sample is Used)	100.0	95.4	
SPECIFIC GRAVITY		2.70	Assumed
TOTAL BACK PRESSURE, psi		42.0	
EFFECTIVE CONSOLIDATION STRESSES			
MAX EFFECTIVE STRESS, psi		5.0	
MIN EFFECTIVE STRESS, psi		3.0	
HYDRAULIC GRADIENT, I		20.4	

HYDRAULIC CONDUCTIVITY

K_{20C}	X 10 -POWER	1.6E-06	cm/sec
K_{20C}	X 10 -POWER	4.3E-03	ft/day

Maxim Technologies INC.

Project Name;	**Lake City Ammunition Independence, MO**
Laboratory Number:	**NA**
Project Number:	**3390098**

REPORT OF PERMEABILITY TEST RESULTS

TYPE OF TEST	Flexible Wall Test - ASTM D5084 (method A)
TYPE OF SAMPLE	Undisturbed
PERMANENT	Deaired Tap Water
SAMPLE DATE	01/15/03
SAMPLE ID	A16 HC 6A 18"-20"
DESCRIPTION	CL, Clay, some silt, mottled grayish & yellowish brown, some roots, rust & black concretions, damp

	INITIAL	FINAL	
SAMPLE HEIGHT, in.	2.94	2.98	
SAMPLE DIAMETER, in.	2.85	2.87	
DENSITY, pcf	101.2	96.9	
% MOISTURE	19.4	27.2	
VOID RATIO	0.665	0.739	
% SATURATION	78.9	99.2	
% Compaction (Not Applicable if Undisturbed Sample is Used)	100.0	95.7	
SPECIFIC GRAVITY		2.70	Assumed
TOTAL BACK PRESSURE, psi		82.0	
EFFECTIVE CONSOLIDATION STRESSES			
MAX EFFECTIVE STRESS, psi		5.0	
MIN EFFECTIVE STRESS, psi		3.0	
HYDRAULIC GRADIENT, i		20.7	

HYDRAULIC CONDUCTIVITY

K_{20C}	X 10 -POWER	3.6E-06	cm/sec
K_{20C}	X 10 -POWER	9.7E-03	ft/day

Maxim Technologies INC.

Project Name;	**Lake City Ammunition Independence, MO**
Laboratory Number:	**NA**
Project Number:	**3390098**

REPORT OF PERMEABILITY TEST RESULTS

TYPE OF TEST	Flexible Wall Test - ASTM D5084 (method A)
TYPE OF SAMPLE	Undisturbed
PERMANENT	Deaired Tap Water
SAMPLE DATE	01/15/03
SAMPLE ID	A16 HC 7A 6"-10"
DESCRIPTION	Clay, mottled reddish & yellowish brown, some roots, damp

	INITIAL	FINAL	
SAMPLE HEIGHT, in.	3.32	3.33	
SAMPLE DIAMETER, in.	2.85	2.86	
DENSITY, pcf	97.0	98.9	
% MOISTURE	23.9	25.7	
VOID RATIO	0.736	0.704	
% SATURATION	87.6	98.6	
% Compaction (Not Applicable if Undisturbed Sample is Used)	100.0	101.9	
SPECIFIC GRAVITY		2.70	Assumed
TOTAL BACK PRESSURE, psi		81.0	
EFFECTIVE CONSOLIDATION STRESSES			
MAX EFFECTIVE STRESS, psi		5.0	
MIN EFFECTIVE STRESS, psi		4.0	
HYDRAULIC GRADIENT, i		9.6	

HYDRAULIC CONDUCTIVITY

K_{20C}	X 10 -POWER	2.6E-05	cm/sec
K_{20C}	X 10 -POWER	7.3E-02	ft/day

Maxim Technologies INC.

Project Name; Lake City Ammunition
Independence, MO
Laboratory Number: NA
Project Number: 3390098

REPORT OF PERMEABILITY TEST RESULTS

TYPE OF TEST	Flexible Wall Test - ASTM D5084 (method A)
TYPE OF SAMPLE	Undisturbed
PERMANENT	Dealred Tap Water
SAMPLE DATE	01/15/03
SAMPLE ID	A16 HC 7B 18"-21"
DESCRIPTION	Clay, mottled gray & brown, rust & black concretions, moist

	INITIAL	FINAL	
SAMPLE HEIGHT, In.	3.00	3.08	
SAMPLE DIAMETER, In.	2.83	2.83	
DENSITY, pcf	104.4	104.3	
% MOISTURE	21.2	22.8	
VOID RATIO	0.614	0.615	
% SATURATION	93.0	100.1	
% Compaction (Not Applicable if Undisturbed Sample is Used)	100.0	99.9	
SPECIFIC GRAVITY		2.70	Assumed
TOTAL BACK PRESSURE, psi		100.0	
EFFECTIVE CONSOLIDATION STRESSES			
MAX EFFECTIVE STRESS, psi		15.0	
MIN EFFECTIVE STRESS, psi		5.0	
HYDRAULIC GRADIENT, i		94.4	

HYDRAULIC CONDUCTIVITY

K_{20C}	X 10 -POWER	1.2E-08	cm/sec
K_{20C}	X 10 -POWER	3.1E-05	ft/day

Maxim Technologies INC.

Project Name;	**Lake City Ammunition Independence, MO**
Laboratory Number:	**NA**
Project Number:	**3390098**

REPORT OF PERMEABILITY TEST RESULTS

TYPE OF TEST	Flexible Wall Test - ASTM D5084 (method A)
TYPE OF SAMPLE	Undisturbed
PERMANENT	Deaired Tap Water
SAMPLE DATE	01/15/03
SAMPLE ID	A16 HC 8A
DESCRIPTION	Clay, dark brown, trace roots, damp

	INITIAL	FINAL	
SAMPLE HEIGHT, in.	3.55	3.56	
SAMPLE DIAMETER, in.	2.82	2.83	
DENSITY, pcf	101.1	99.9	
% MOISTURE	20.1	25.4	
VOID RATIO	0.668	0.686	
% SATURATION	81.4	99.9	
% Compaction (Not Applicable if Undisturbed Sample is Used)	100.0	98.9	
SPECIFIC GRAVITY		2.70	Assumed
TOTAL BACK PRESSURE, psi		82.0	
EFFECTIVE CONSOLIDATION STRESSES			
MAX EFFECTIVE STRESS, psi		5.0	
MIN EFFECTIVE STRESS, psi		3.0	
HYDRAULIC GRADIENT, I		15.6	

HYDRAULIC CONDUCTIVITY

K_{20C}	X 10 -POWER	7.4E-05	cm/sec
K_{20C}	X 10 -POWER	2.0E-01	ft/day

Maxim Technologies INC.

Project Name;	**Lake City Ammunition Independence, MO**
Laboratory Number:	**NA**
Project Number:	**3390098**

REPORT OF PERMEABILITY TEST RESULTS

TYPE OF TEST	Flexible Wall Test - ASTM D5084 (method A)
TYPE OF SAMPLE	Undisturbed
PERMANENT	Deaired Tap Water
SAMPLE DATE	01/15/03
SAMPLE ID	A16 HC 8A 15"-18"
DESCRIPTION	Clay, grayish brown, some roots, damp

	INITIAL	FINAL	
SAMPLE HEIGHT, in.	2.95	2.95	
SAMPLE DIAMETER, in.	2.84	2.86	
DENSITY, pcf	108.8	106.1	
% MOISTURE	19.7	21.7	
VOID RATIO	0.549	0.588	
% SATURATION	97.1	99.5	
% Compaction (Not Applicable if Undisturbed Sample is Used)	100.0	97.5	
SPECIFIC GRAVITY		2.70	Assumed
TOTAL BACK PRESSURE, psi		70.3	
EFFECTIVE CONSOLIDATION STRESSES			
MAX EFFECTIVE STRESS, psi		5.0	
MIN EFFECTIVE STRESS, psi		4.7	
HYDRAULIC GRADIENT, i		5.4	

HYDRAULIC CONDUCTIVITY

K_{20C}	X 10 -POWER	1.3E-05	cm/sec
K_{20C}	X 10 -POWER	3.4E-02	ft/day