

APPENDIX K - GEOLOGY AND HYDROGEOLOGY INFORMATION

LEGGETTE, BRASHEARS & GRAHAM, INC.

PROFESSIONAL GROUND-WATER AND ENVIRONMENTAL ENGINEERING SERVICES

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July 30, 2008

Mr. Dave McElroy
City of Sioux Falls – Sanitary Landfill
224 West 9th Street
Sioux Falls, SD 57104

RE: Expansion Area Hydrogeologic Assessment
Sioux Falls Regional Sanitary Landfill
Sioux Falls, SD

Dear Mr. McElroy:

Leggette, Brashears & Graham, Inc. (LBG) has completed the work relating to the performance of the Hydrogeologic Assessment at the above referenced site. The work was authorized by Mr. DJ Buthe's acceptance of the LBG proposal dated May 9, 2008.

The purpose of the assessment was to provide information regarding the nature of the geologic materials beneath a new proposed landfill liner depth (from approximately 50 to 95 feet below grade). Previous landfill design in this area had proposed shallower cell depths, and thus the existing data was not sufficient to characterize the deeper intervals.

1.0 SCOPE OF WORK

The scope of services performed on this portion of the project consisted of the following:

1. performing eleven rotosonic soil borings at the locations indicated on Figure 1 to depths of up to 125 feet below grade;
2. observing the performance of the borings and logging the soil samples recovered from the borings;
3. collecting representative soil samples from the proposed, approximate liner depth and submitting them to a geotechnical laboratory for Sieve and Hydrometer Analysis (ASTM:D422) and Permeability Test with Verification of Saturation (ASTM:D5084);
4. abandoning the soil borings in accordance with state law; and

5. submitting a report including the data generated during our activities with our conclusions and recommendations based on that data.

2.0 PROJECT RESULTS

2.1 Soil Borings

Between June 17 and 21, 2008, eleven soil borings were advanced utilizing a rotasonic drilling rig. The borings were advanced using the methods presented in Appendix A. The boring locations were placed in the field by JSA Associates, Sioux Falls, SD based on a conceptual site plan developed by R.W. Beck. The borings were located near the center line of each proposed cell and sampled continuously to the terminal depth of each boring. The terminal depths of the borings were determined based on the proposed depth of the liner plus 15 feet, rounded to the next deeper 5 foot depth interval. The locations of the borings are presented on Figure 1. A table summarizing the liner, sampling and completion depth for each location is shown on Table 1. The specific soil boring logs are presented in Appendix B.

Due to site configuration, two borings, ESB-3 and ESB-7, were moved slightly from their original locations prior to drilling. ESB-3 was moved approximately 80 feet north off of a steep side-slope to a more accommodating flat area. ESB-7 was moved approximately 43 feet north of the original location in a haul road. Each was moved in a direct northern direction to ensure that the boring remained in the centerline (and deepest lateral portion) of each proposed cell.

The sediments encountered generally consisted of oxidized and un-oxidized glacial clay till (clay, with some silt, sand and pebbles). The gradational oxidized/un-oxidized boundary (transition zone) was observed in each boring except ESB-1 and ESB-2. These borings were advanced in the base of nearly-completed Cell 2, which has already been excavated to the un-oxidized till beneath the transition zone. In the balance of the borings, the estimated elevation of the base of the transition zone (top of un-oxidized till) ranged between 1,501 and 1,541 feet NGVD (14 to 53 fbg). ESB-4 exhibits an apparent separate oxidized zone beneath an un-oxidized zone at 27 to 46 fbg. The lower oxidized clay in ESB-4 is not a new oxidized interval; rather, it is a continuation of the transition zone, with the boring re-intersecting tortuous oxidized fractures extending from the upper oxidized till. The elevation of the base of the transition zone in ESB-4 is 1,501 NGVD, which is consistent with neighboring boring ESB-3.

Silts and sands were erratically and intermittently encountered in various borings. Sands with a gross thickness of greater than 5 feet were rare, and limited only to borings ESB-2, ESB-7, and ESB-11. The sand in ESB-2 (74.5 to 84 fbg) was dry in the upper 0.5 foot of the interval and wet beneath, indicating that the sand body was not completely saturated, and thus very limited in extent and discontinuous in nature.

Except for the minimal water contained in the sands, ground water was not encountered in any of the soil borings during drilling operations.

2.2 Geotechnical Soil Testing and Analysis

Sediment samples were collected from each boring at depths below the proposed liner for geotechnical analysis. The samples were analyzed for Sieve and Hydrometer Analysis (ASTM:D422) and Permeability Test with Verification of Saturation (ASTM:D5084) at the request of the engineers to aid in estimating soil properties for liner construction purposes. The results of the hydraulic conductivity testing are presented on Table 2. The full laboratory report is included in Appendix C.

3.0 DISCUSSION AND CONCLUSIONS

Historical soil boring depths in the expansion area were governed by a previous, shallower cell design. The present-day conceptual plan for this area now envisions utilizing deeper cell depths for which the existing soil boring information is inadequate. The proposed deepening of the cells beyond the existing geologic data has necessitated this assessment, which advanced the deepest soil boring investigations in the expansion area to date.

In the shallower depth intervals, where the existing and new information overlap, the sediments encountered during this phase of assessment are consistent with the historical soil boring and cell excavation observational data: the sediments are clay-rich glacial clay till, with rare, intermittent, discontinuous sands. The information obtained from the new, deeper soil borings indicates the deeper sediments are, not surprisingly, a continuation of the shallower clay-rich glacial clay sediments and rare, intermittent sands. When integrated with the existing expansion area geologic data, the data indicates that the tight, dense glacial clay till is the predominant sediment and the sands encountered are limited in horizontal and vertical extent and are not laterally continuous. This new data fully supports and confirms similar conclusions from the earlier site studies.

July 30, 2008

The hydraulic conductivities (K) of the sediments beneath the proposed liner elevation indicate that K values are consistently very low in this interval across the expansion area, ranging from 1.1×10^{-8} to 9.7×10^{-9} cm/s with an arithmetic average of 3.33×10^{-9} cm/s.

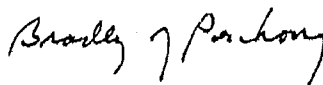
From a geologic perspective, the results of the Sieve and Hydrometer Analysis show that the grain size distribution is consistent with glacial till in that all grain sizes from clay to gravel are present. All the borings except ESB-5 are virtually identical in grain size distribution, indicating the widespread homogeneous nature of the till. ESB-5 contains slightly coarser grain sizes, but is still typical of glacial clay till.

This new geologic data is supportive of the predominance of glacial clay till across the expansion area and the limited and discontinuous nature of the sands in the sequence. The sub-liner glacial till hydraulic conductivity is significantly less than required by SD regulation. The data acquired to date confirms the suitability of the expansion area for landfill siting.

4.0 STANDARD OF CARE

The recommendations contained in this report represent our professional opinions. These opinions were arrived at in accordance with currently accepted hydrogeologic and engineering practices at this time and location. Other than this, no warranty is implied or intended.

LEGGETTE, BRASHEARS & GRAHAM, INC.



Bradley J. Peschong, CPG
Senior Hydrogeologist

Reviewed by:



Tim Kenyon
Vice President

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Enclosures

~~2 - RW Beck, Jr. Landfill File~~

TABLES

TABLE 1
SIOUX FALLS REGIONAL SANITARY LANDFILL
SIOUX FALLS, SOUTH DAKOTA

2008 Expansion Area Soil Boring Data

Location	Surface Elevation feet AMSL	Proposed Liner Elevation feet AMSL	Proposed Liner Depth fbg	Hydraulic Conductivity Sample Depth fbg	Total Depth fbg
ESB-1	1500.8	1455	46	49-50	60
ESB-2	1513.8	1455	59	61-64	85
ESB-3	1566.3	1457	109	112-113	125
ESB-4	1553.7	1465	89	92-93	105
ESB-5	1549.5	1465	85	86-87	100
ESB-6	1543.7	1461	83	83-83.5	100
ESB-7	1546.7	1472	75	80-81	90
ESB-8	1558.1	1481	77	79-80	90
ESB-9	1554.2	1473	81	82-83	95
ESB-10	1555.7	1475	81	82-83	95
ESB-11	1551.2	1475	76	93-95	95

fbg- feet below grade

AMSL - Above mean sea level

TABLE 2
SIOUX FALLS REGIONAL SANITARY LANDFILL
SIOUX FALLS, SOUTH DAKOTA

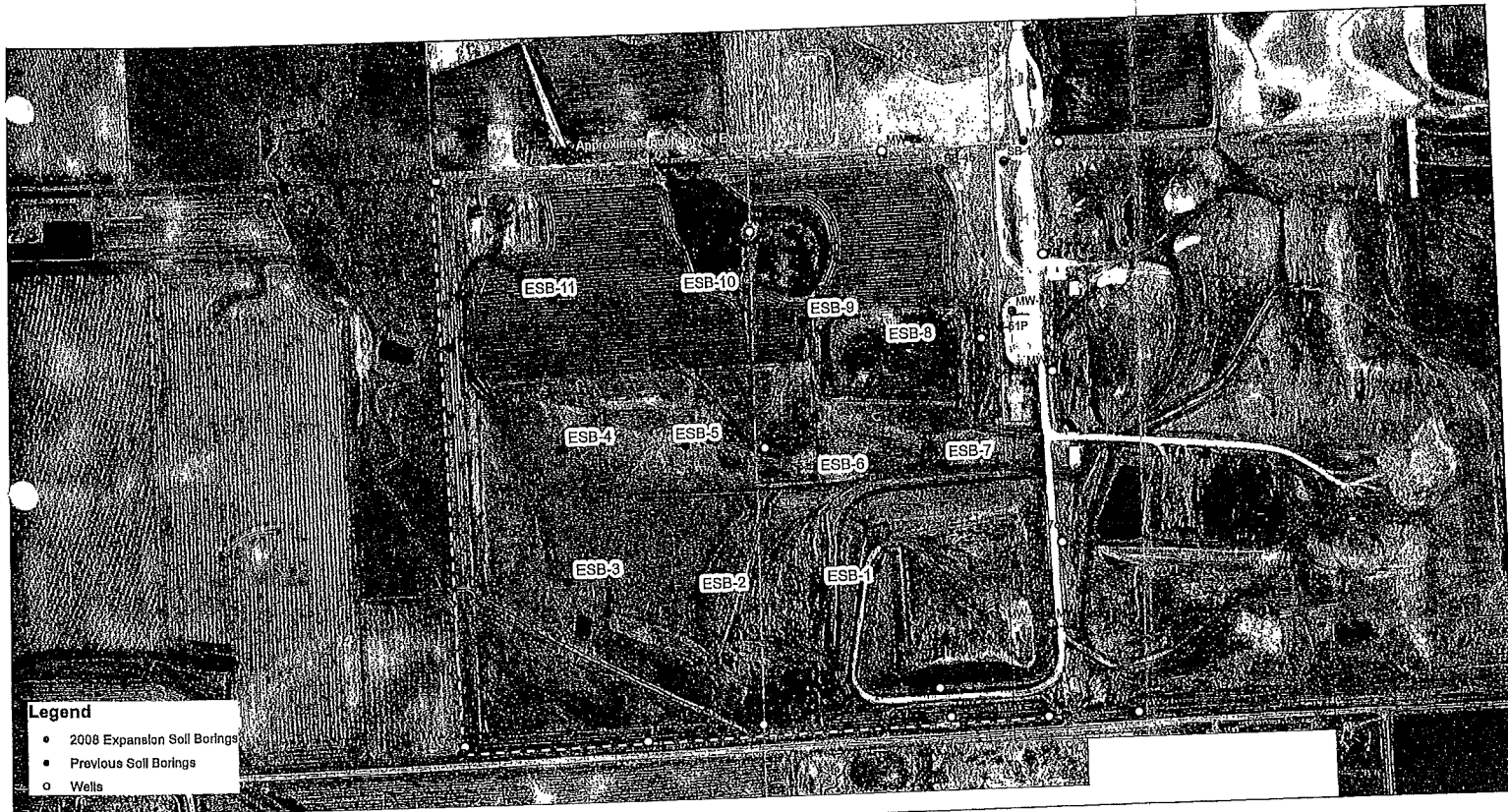
Coefficient of Permeability Testing Results

BORING LOCATION	Depth fbg	Permeability (K) (cm/sec) 10-Jul-08	Permeability (K) (ft/min) 10-Jul-08
ESB-1	49-50	9.0×10^{-9}	1.8×10^{-8}
ESB-2	61-64	2.7×10^{-8}	5.3×10^{-8}
ESB-3	112-113	1.3×10^{-8}	2.6×10^{-8}
ESB-4	92-93	7.4×10^{-9}	1.4×10^{-8}
ESB-5	86-87	1.9×10^{-8}	3.7×10^{-8}
ESB-6	83-83.5	1.4×10^{-8}	2.8×10^{-8}
ESB-7	80-81	1.3×10^{-8}	2.5×10^{-8}
ESB-8	79-80	9.4×10^{-9}	1.8×10^{-8}
ESB-9	82-83	9.7×10^{-9}	1.9×10^{-8}
ESB-10	82-83	1.1×10^{-8}	2.3×10^{-8}
ESB-11	93-95	1.3×10^{-8}	2.5×10^{-8}

fbg - feet below grade

K @ 20° C

FIGURE



0 200 400 600 800 Feet
1 inch = 400 feet

This is not a legal survey. Locations are approximate.



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CITY OF SIOUX FALLS SANITARY LANDFILL
SIOUX FALLS, SOUTH DAKOTA

EXPANSION AREA SOIL BORINGS
(SE 1/4 SW 1/4 Sec. 35, T101N, R51E)

FILE: SF_landfill_2004_e	DATE: July 2008	FIGURE: 1
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LEGGETT, BRASHEARS & GRAHAM, INC.
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GEOTECHNICAL LOG

TEST HOLE NO.: ESB-2

Page 1 of 1

OWNER: Sioux Falls Regional Landfill
LOCATION: Sioux Falls, South Dakota
BORING CO: Beart Longyear
SAMPLING METHOD: Rotasonic with 10' Continuous Core Sampling
DATE STARTED: 6-17-08
DATE COMPLETED: 6-17-08

TOTAL DEPTH OF HOLE: 85' bgs
GEOLOGISTS: Brad Peschong
REFERENCE POINT ELEV.: Grade
GROUND SURFACE ELEV.: 1513.78'
STATIC WATER LEVEL:

APPROX. ELEVATION (feet AMSL)	FROM	TO	SAMPLE TYPE	RECOVERY (in feet)	GRAPHIC	PROPOSED LENSER DEPTH (in feet)	COEFFICIENT OF PERMEABILITY K @ 2.5 ft/sq ft (percent)	DEPTH (in feet)	LITHOLOGIC DESCRIPTION
1510	0	5	CCS	5				0	UNOXIDIZED CLAY: with some sand and a little silt, few pebbles, gray with brown mottling
1505	5	14	CCS	9				-5	
1500	14	15	CCS	1				-10	
1495	15	25	CCS	10				-15	gray at 15 ft
1490	25	35	CCS	10				-20	
1485								-25	
1480	35	37	CCS	2				-30	
1475	37	40	CCS	3				-35	UNOXIDIZED CLAY: with abundant silt and a little sand, a few pebbles, gray
1470	40	45	CCS	5				-40	
1465	45	55	CCS	10				-45	
1460	55	65	CCS	10				-50	2 inch sand lens at 64.5 ft, gray, medium to very coarse grained, wet
1455								-55	
1450	65	69	CCS	4				-60	
1445	69	69.5	CCS	0.5				-65	SAND: medium to very coarse grained, with a little silt, gray, moist
1440	69.5	74.5	CCS	5				-70	UNOXIDIZED CLAY: with silt and sand, pebbles, gray
1435	74.5	75	CCS	0.5				-75	1 inch silt lens at 73.5 ft
1430	75	78	CCS	3				-80	SAND: fine to very coarse grained, some pebbles, gray, dry, poorly sorted
1425	78	80	CCS	2				-85	SAND: fine to very coarse grained, pebbles, gray, wet, poorly sorted
1420	80	81	CCS						4 inch lens of fine grained sand, wet, poorly sorted
1415	81	82.5	CCS						6 inch lens of sand, very fine to very coarse grained, with silt, wet
1410	82.5	84	CCS						6 inch lens of sand, medium to very coarse grained, wet
1405	84	85	CCS						SAND: very fine grained, with abundant silt, gray, wet
1400									SAND: fine to very coarse grained, well rounded, poorly sorted, pebbles, gray, wet
1395									SILT: with sand, very fine grained, gray and dark gray mottled, wet

NOTES:



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GEOTECHNICAL LOG

TEST HOLE NO.: ESB-3

Page 1 of 1

OWNER: Sioux Falls Regional Landfill
LOCATION: Sioux Falls, South Dakota
DRILLING CO.: Borehole Services
SAMPLING METHOD: Borehole with 10' Continuous Core Sampling
DATE STARTED: 6-19-08
DATE COMPLETED: 6-19-08

TOTAL DEPTH OF HOLE: 125' bgs
GEOLOGIST: Brad Pesching
REFERENCE POINT ELEV.:
Grade
GROUND SURFACE ELEV.: 1566.3'
STATIC WATER LEVEL:

APPROX. ELEVATION (feet AMSL)	FROM	TO	SAMPLE TYPE	RECOVERY (in feet)	GRAPHIC	PROPOSED LINER DEPTH (in feet)	COEFFICIENT OF PERMEABILITY K @ 20 degrees C (cm/sec)	DEPTH (in feet)	LITHOLOGIC DESCRIPTION
1545	0	5	CCS	5					UNOXIDIZED CLAY: with sand, silt and pebbles, brown to grey (FH)
1540	5	15	CCS	10					
1535	15	25	CCS	8					
1530									
1525	25	35	CCS	10					
1520									
1515	35	35.5	CCS	0.5					OXIDIZED CLAY: with silt, sand, black, with roots (Topsoil)
1510	35.5	45	CCS	9.5					OXIDIZED CLAY: with silt and sand, grey pebbles, brown with roots, medium to 1 inch sand from, medium to very coarse grained at 3 1/2 and 37 ft
1505	45	47	CCS	2					slight grey mottling at 44 ft
1500	47	49	CCS	2					grey with brown mottling
1495	55	65	CCS	10					UNOXIDIZED CLAY: with silt, sand and pebbles, grey
1490									
1485	65	67	CCS	10					
1480	67	71	CCS	4					SILT: with a little sand, very fine grained, grey, wet
1475	71	74	CCS	3					UNOXIDIZED CLAY: with abundant silt, some sand and pebbles
1470	74	75	CCS	1					SAND: medium to very fine grained, some coarse grained, and silt, grey, wet, wet mottled
1465	75	85	CCS	8					SILT: very fine to medium grained, grey, wet, subangular to subrounded
1460	85	90	CCS	5					UNOXIDIZED CLAY: with silt, sand and pebbles, grey
1455	90	95	CCS	5					
1450	95	105	CCS	10					SAND: very fine to very coarse grained, grey, poorly sorted, angular to rounded
1445	105	115	CCS	10					UNOXIDIZED CLAY: with silt, sand and pebbles, grey
1440									
1435	115	125	CCS	10					1/8 inch fracture of sand, very coarse to medium grained, wet, grey at 120 ft
1430									
1425									

NOTES:



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LOGIC LOG

TEST HOLE NO.: ESB-4

Page 1 of 1

OWNER: State Falls Regional Landfill
LOCATION: State Falls, South Dakota
DRILLING CO: Best Leasing
SAMPLING METHOD: Rotasonic with 10' Continuous Core Sampling
DATE STARTED:
DATE COMPLETED:

TOTAL DEPTH OF HOLE: 105' bgs
GEOLOGIST: Brad Peschong
REFERENCE POINT ELEV.: Grade
GROUND SURFACE ELEV.: 1553.71'
STATIC WATER LEVEL:

APPROX. ELEVATION (feet AMSL)	FROM	TO	SAMPLE TYPE	RECOVERY (in Feet)	GRAPHIC	PROPOSED LINER DEPTH (in feet)	COEFFICIENT OF PERMEABILITY K @ 20 degrees C (cm/sec)	DEPTH (in feet)	LITHOLOGIC DESCRIPTION
1550	0	4	CCS	4				0	OXIDIZED CLAY: with silt and sand, pebbles, brown with gray mottling (FH)
1545	4	5	CCS	1				-5	UNOXIDIZED CLAY: with silt and sand, pebbles, gray (FH)
	5	15	CCS	8				-10	OXIDIZED CLAY: with silt, sand and pebbles, brown with gray mottling (FH)
1540	13	15	CCS	2				-15	OXIDIZED CLAY: black, organic, roots at 14 ftg (Topsoil)
1535	15	25	CCS	10				-20	OXIDIZED CLAY: with silt, sand and pebbles, brown
1530	25	27	CCS	2				-25	
1525	27	35	CCS	8				-30	UNOXIDIZED CLAY: with silt, sand and pebbles, gray with brown mottling
1520	35	45	CCS					-35	UNOXIDIZED CLAY: with silt, sand and pebbles, gray
1515								-40	
1510	45	46	CCS	1				-45	OXIDIZED CLAY: with silt, sand and pebbles, brown mottling, vertical oxidized fissures at 46 to 49 ftg
1505	46	53	CCS	7				-50	
1500	53	55	CCS	2				-55	UNOXIDIZED CLAY: with silt, sand and pebbles, gray
1495	55	65	CCS	10				-60	3 inch line of silt with clay, a little sand at 57.5 ftg
1490	65	75	CCS	10				-65	
1485								-70	
1480	75	85	CCS	10				-75	
1475								-80	
1470	85	95	CCS	10				-85	
1465								-90	
1460	95	105	CCS	10				-95	
1455								-100	
1450								-105	

NOTES:



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GEOLOGIC LOG

TEST HOLE NO.: ESB-5

Page 1 of 1

OWNER: LEGGETT, BRASHEARS & GRAHAM, INC.	100' bgs Brnd Peshong Grade 1549.45'
LOCATION: Sioux Falls Regional Landfill Sioux Falls, South Dakota	
DRAWING NO.: None	
DATE STARTED: 6-18-08	
DATE COMPLETED: 6-18-08	
APPROX. ELEVATION (feet AMSL):	
DRILLING METHOD: Resonance with 10' Continuous Core Sampling	
GROUND SURFACE ELEV.: 1549.45'	
STATIC WATER LEVEL:	

APPROX. ELEVATION (feet AMSL)	FROM	TO	SAMPLE TYPE	RECOVERY (in ft)	GRAPHIC	PROPOSED LITHO DEPTH (in feet)	COEFFICIENT OF PERMEABILITY K @ 20 degrees C (cm/sec)	DEPTH (in feet)	LITHOLOGIC DESCRIPTION
1545	0	5	CCS	5				0	SILT: with clay, dark brown to black, roots
1540	5	10	CCS	3				-5	
1535	10	14	CCS					-10	SAND: fine to very coarse grained, and silt, reddish-brown, wet, subrounded to rounded, poorly sorted
1530	15	20	CCS					-15	OXIDIZED CLAY: with sand, silt and a few pebbles, brown with dark brown mottling
1525	20	22.5	CCS	1				-20	wet
1520	22.5	25	CCS	1.5				-25	OXIDIZED CLAY: with some sand, silt, a few pebbles, brown, dense
1515	25	30	CCS					-30	No sample recovered (rock encountered)
1510	30	32	CCS	5				-35	OXIDIZED CLAY: with silt, sand and pebbles, gray with brown mottling
1505	32	35	CCS	10				-40	UNOXIDIZED CLAY: with silt, sand and pebbles, gray
1500	35	45	CCS					-45	3 inch sand lens at 43 ft, with silt and clay
1495	45	55	CCS	10				-55	
1490	55	58	CCS	1.5				-60	SILT: with sand and clay, few pebbles, gray
1485	58	59	CCS	1.5				-65	UNOXIDIZED CLAY: with silt and sand, gray, dense; 6 inch sand lens at 60 ft
1480	60	65	CCS	3				-70	UNOXIDIZED CLAY: with silt, clay and a little sand
1475	65	70	CCS	3				-75	SILT: with clay, sand and pebbles, gray, dense
1470	70	71	CCS	1				-80	UNOXIDIZED CLAY: with silt, sand and pebbles, gray, dense
1465	71	75	CCS	4				-85	3 inch sand lens at 81 ft
1460	75	85	CCS	10				-90	
1455	85	95	CCS	10				-95	1/8 inch fragments of sand, fine grained, well sorted, gray, wet
1450	95	100	CCS					-100	
Total Depth: 100 ft									

NOTES:



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GEOTECHNICAL LOG

TEST HOLE NO.: ESB-6

Page 1 of 1

OWNER: Sioux Falls Regional Landfill
LOCATION: Sioux Falls, South Dakota
DRILLING CO: Boart Longyear
SAMPLING METHOD: Rotasonic with 10' Continuous Core Sampling
DATE STARTED: 6-17-08
DATE COMPLETED: 6-18-08

TOTAL DEPTH OF HOLE: 100' bgs
GEOLOGISTS: Brad Peschong
REFERENCE POINT ELEV.: 1541.74'
GROUND SURFACE ELEV.: 1541.74'
STATIC WATER LEVEL:

APPROX. ELEVATION (feet AMSL)	FROM	TO	SAMPLE TYPE	RECOVERY (in feet)	GRAPHIC	PROPOSED LINER DEPTH (in feet)	COEFFICIENT OF PERMEABILITY K @ 20 degrees C (cm/sec)	DEPTH (in feet)	LITHOLOGIC DESCRIPTION
1540	0	5	CCS	5				0	OXIDIZED CLAY: with sand and silt, dark brown, roots
1535	5	15	CCS	10				5	OXIDIZED CLAY: with silt, sand and pebbles, brown with reddish-brown and light brown mottling
1530	15	20	CCS	5				15	
1525	20	25	CCS	5				20	OXIDIZED CLAY: with silt, sand and pebbles, brown with gray mottling
1520	25	26	CCS	1				25	UNOXIDIZED CLAY: with silt, sand and pebbles, gray
1515	26	35	CCS	9				30	fracture at 27' bgs, sand, medium grained, well sorted, wet
1510	35	45	CCS	10				35	fracture at 35' bgs, sand, very coarse grained, pebbles, wet
1505								40	
1500	45	55	CCS	10				45	
1495								50	
1490	55	63.5	CCS	8.5				55	silty at 53 to 54' bgs
1485								60	
1480	63.5	64.5	CCS	1				65	SAND: very fine grained, angular to subangular, with a little silt, gray
1475	64.5	68	CCS	0.5				66	SILT: with a little sand, very fine to fine grained, gray, wet
1470	68	75	CCS	8				70	UNOXIDIZED CLAY: with silt, sand and pebbles, gray
1465	75	85	CCS	10				75	
1460	85	95	CCS	10				80	1/8 inch fracture at 79' bgs, sand, very fine grained, gray
1455								85	* Interval sample depth to 83 to 83.5' bgs
1450	95	100	CCS	5				90	1/2 inch lens of sand at 92 to 93' bgs, fine to medium grained, unconsolidated to remoulded, with a little silt and clay, gray, wet
1445								95	1/8 inch lens of sand, medium grained, well sorted at 96' bgs

NOTES:



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COLOGIC LOG

TEST HOLE NO.: ESB-7

OWNER: Sioux Falls Regional Landfill
LOCATION: Sioux Falls, South Dakota
INVESTIGATING CO: Boart Loring
SAMPLING METHOD: Resonance with 10' Continuous Core Sampling
DATE STARTED: 6-19-08
DATE COMPLETED: 6-19-08

TOTAL DEPTH OF HOLE: 90' bgs
GEOLGISTS: Brad Peschong
REFERENCE POINT ELEV.: Grade
GROUND SURFACE ELEV.: 1546.79'
STATIC WATER LEVEL:

APPROX. ELEVATION (feet AMSL)	FROM	TO	SAMPLE TYPE	RECOVERY (in feet)	GRAPHIC	COEFFICIENT OF PERMEABILITY K @ 20 degrees C (cm/sec)	DEPTH (in feet)	LITHOLOGIC DESCRIPTION
1545	0	5	CCS	4			0	OXIDIZED CLAY: with silt, sand and pebbles, brown with dark brown mottling
1540	5	12	CCS	7			-5	
1535	12	14	CCS	2			-10	gray with brown mottling
1530	14	15	CCS	1			-15	UNOXIDIZED CLAY: with silt, sand and pebbles, gray
1525	15	25	CCS	10			-20	some very minor brown mottling
1520	25	32	CCS	7			-25	1/2 inch sand lines at 23 ft; medium to coarse grained, subangular, rounded, gray
1515	32	33	CCS	1			-30	SAND: fine to coarse grained, with silt and clay, gray
1510	33	35	CCS	2			-35	SAND: fine to very coarse grained, poorly sorted, rounded, gray, sand
1505	35	35.5	CCS	0.5			-40	UNOXIDIZED CLAY: with silt, sand and pebbles, gray
1500	37	45	CCS	9.5			-45	
1495	45	55	CCS	10			-50	1/2 inch lines of silt, gray at 54.5 ft
1490	55	57	CCS	2			-55	SAND: very fine to very coarse grained, pebbles, gray, wet
1485	57	57.5	CCS	0.5			-60	UNOXIDIZED CLAY: with silt, sand and pebbles, gray
1480	58	61	CCS	3.5			-65	SAND: fine to coarse grained, with silt and a little clay, gray
1475	61	65	CCS	4			-70	very fine to very coarse grained, gray, wet
1470	65	71	CCS	6			-75	1/2 inch lines of silt at 63-65 ft
1465	71	73	CCS	2			-80	SAND: fine to medium grained, rounded, poorly sorted, with silt, gray
1460	73	75	CCS	2			-85	SAND: coarse to very coarse grained, rounded, gray
	75	80	CCS	5			-90	very fine to medium grained, same pebbles, with silt
	80	85	CCS	5			-95	increasing silt at 78 ft
	85	87	CCS	2			-100	UNOXIDIZED CLAY: with silt, sand and pebbles, gray
	87	90	CCS	3			-105	shale-like, fine sand and pebbles, wet, with few small lenses of sand, medium to very coarse grained
							-110	gray, silt

NOTES:



LEGGETT, BRASHEARS & GRAHAM, INC.
140 East Hinks Lane, Suite 126
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(605) 334-6000 or Fax (605) 334-1850

OWNER:
LOCATION:
DRILLING CO:
SAMPLING METHOD:
DATE: 6/24/08
DATE COMPLETED: 6/24/08

90' logs
Brad Pennington
Grade
1553.06'
Grade
1553.06'
Grade
1553.06'

APPROX. ELEVATION (feet AMSL)
1555
1550
1545
1540
1535
1530
1525
1520
1515
1510
1505
1500
1495
1490
1485
1480
1475
1470

FROM
0
3
5

13
15

25

33

33.5
34
35
36
40
45
55

65

75

85

90

TO
3
5
13

15
25

33

33.5
34
35
36
40
45
55

65

75

85

90

SAMPLE TYPE
CCS
CCS
CCS

CCS
CCS
CCS

CCS

CCS

CCS

CCS

CCS

CCS

RECOVERY (in feet)
3
2
8

2
10

8

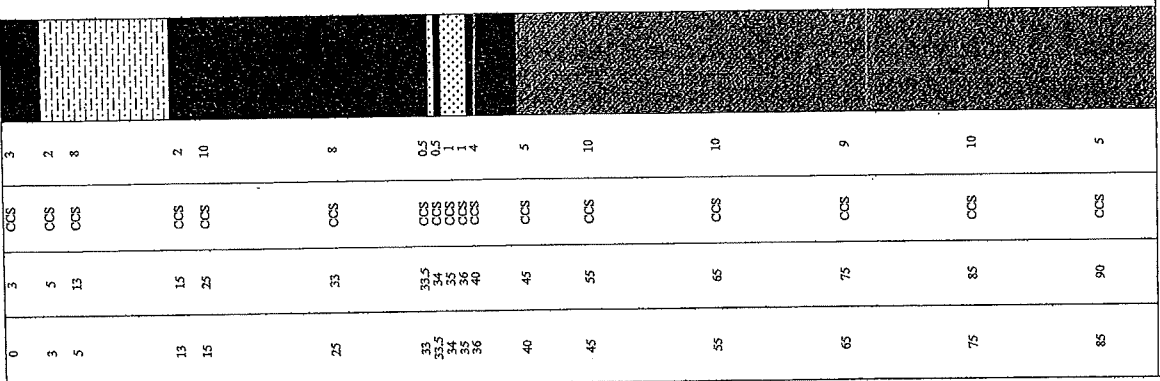
0.5
0.5
1
1
1
5
10

10

9

10

5

GRAPHIC


COEFFICIENT OF PERMEABILITY (cm/sec)
K @ 20 degrees C (cm/sec)

DEPTH (in feet)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90

LITHOLOGIC DESCRIPTION
OXIDIZED CLAY: with silt, sand and pebbles, brown
SILT, with clay, brown to dark brown
OXIDIZED CLAY: with silt, sand and pebbles, brown
brown with dark brown mottling
SAND: coarse to very coarse grained, brown
OXIDIZED CLAY: with silt, sand and pebbles, gray with brown mottling
SAND: medium to very coarse grained, pebbles, subangular, rounded, poorly sorted, brown
clay to >24.5 ft
OXIDIZED CLAY: with silt, sand and pebbles, gray with brown mottling
UNOXIDIZED CLAY: with silt, sand and pebbles, gray

NOTES:



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LOGIC LOG
TEST HOLE NO.: ESB-9

OWNER:
LEGGETT, BRASHEARS & GRAHAM, INC.
140 East Hinks Lane, Suite 126
Sioux Falls, SD 57104
(605) 334-6000 or Fax (605) 334-1850

LOCATION:
Sioux Falls Regional Landfill
Sioux Falls, South Dakota
East Langston
Adjacent to 10' Continuous Core Sampling
DATE COMPLETED: 6-19-08
DATE COMPLETED: 6-20-08

TOTAL DEPTH OF HOLE: 95 ft
GEOLOGIST: R. P. Seaborg
GROUND SURFACE ELEV.: 1554.18'
STATIC WATER LEVEL:

APPROX. ELEVATION (feet AMSL)	FROM	TO	SAMPLE TYPE	RECOVERY (in feet)	GRAPHIC	PROPOSED LINER DEPTH (in feet)	COEFFICIENT OF PERMEABILITY K @ 20 degrees C (cm/sec)	DEPTH (in feet)	LITHOLOGIC DESCRIPTION
1550	0	5	CCS	5				0	OXIDIZED CLAY: with silt, sand and a few pebbles, brown
1545	5	12	CCS	7				-5	some gray mottling
1540	12	15	CCS	3				-10	SILT: brown, a 4 inch lens of sand, very fine grained at 13 ft
1535	15	25	CCS	4				-15	OXIDIZED CLAY: with silt, sand and pebbles, brown with minor gray mottling
1530	25	27	CCS	2				-20	brown with gray mottling
1525	27	35	CCS	4				-25	UNOXIDIZED CLAY: with silt, sand and pebbles, gray
1520	35	45	CCS	10				-30	
1515								-35	
1510	45	47	CCS	2				-40	SAND: coarse to very coarse grained, some pebbles, gray
1505	47	48	CCS	1				-45	SILT: gray
1500	48	50.5	CCS	2.5				-50	SAND: medium grained, silty, well sorted
1495	50.5	55	CCS	4.5				-55	UNOXIDIZED CLAY: with silt, sand and pebbles, gray
1490	55	65	CCS	10				-60	
1485	65	75	CCS	10				-65	
1480	75	84	CCS	8				-70	with sand, coarse to very coarse grained, with abundant silt, gray
1475								-75	
1470	84	85	CCS	10				-80	
1465	85	95	CCS	10				-85	No samples recovered (rock encountered)
1460								-90	UNOXIDIZED CLAY: with silt, sand and pebbles, gray
								-95	

NOTES:



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LITHOLOGIC LOG

TEST HOLE NO.: ESB-10

Page 1 of 1

OWNER:
LOCATION:
SAMPLING CO.:
SAMPLING METHOD:
DATE STARTED:
DATE COMPLETED:

TOTAL DEPTH OF HOLE:
GEOLOGISTS:
REFERENCE POINT ELEV.:
GROUND SURFACE ELEV.:
STATIC WATER LEVEL:

APPROX. ELEVATION (feet AMSL)	FROM	TO	SAMPLE TYPE	RECOVERY (in feet)	GRAPHIC	PROPOSED LINER DEPTH (in feet)	COEFFICIENT OF PERMEABILITY K @ 100 cm H ₂ O (cm/sec)	DEPTH (in feet)	LITHOLOGIC DESCRIPTION
1555	0	1	CCS	1		1		0	OXIDIZED CLAY: with sand and silt, black (Tropell)
1550	3	5	CCS	1.5		1.5		-5	OXIDIZED CLAY: with silt, sand and pebbles, brown with some dark brown mottling
1545	5	6	CCS	1		1		-10	SAND: medium to coarse grained, with silt and clay, brown
1540	6	13	CCS	7		7		-15	OXIDIZED CLAY: with silt, sand and pebbles, brown with gray mottling
1535	13	15	CCS	2		2		-15	gray with minor brown mottling
1530	15	25	CCS	10		10		-20	UNOXIDIZED CLAY: with silt, sand and pebbles, gray
1525	25	35	CCS	10		10		-25	
1520	35	45	CCS	10		10		-30	
1515	45	55	CCS	10		10		-35	
1510	55	65	CCS	10		10		-40	
1505	65	75	CCS	10		10		-45	
1500	75	85	CCS	10		10		-50	
1495	85	95	CCS	10		10		-55	
1490	95	105	CCS	10		10		-60	
1485	105	115	CCS	10		10		-65	
1480	115	125	CCS	10		10		-70	
1475	125	135	CCS	10		10		-75	boulders at 75 to 78 ft
1470	135	145	CCS	10		10		-80	
1465	145	155	CCS	10		10		-85	
	155	165	CCS	10		10		-90	
	165	175	CCS	10		10		-95	

NOTES:



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C LOGIC LOG

TEST HOLE NO.: ESB-11

Page 1 of 1

OWNER: Sioux Falls Regional Landfill
LOCATION: Sioux Falls, South Dakota
DRILLING CO: Boat Longyear
SAMPLING METHOD: Rotasonic with 10' Continuous Core Sampling
DATE STARTED: 6-20-88
DATE COMPLETED: 6-20-88

TOTAL DEPTH OF HOLE: 95' bgs
GEOLOGISTS: Brad Peschong
REFERENCE POINT ELEV.: 1351.20'
GROUND SURFACE ELEV.: 1351.20'
STATIC WATER LEVEL:

APPROX. ELEVATION (feet AMSL)	FROM	TO	SAMPLE TYPE	RECOVERY (in feet)	GRAPHIC	PROPOSED LINER DEPTH (in feet)	COEFFICIENT PERMEABILITY K @ 20 degrees C (cm/sec)	DEPTH (in feet)	LITHOLOGIC DESCRIPTION
1550	0	1	CCS	1				0	OXIDIZED CLAY: with silt and sand, dark brown to black (topsoil)
1545	5	15	CCS	10				-5	brown with reddish-brown mottling
1540								-10	
1535	15	23	CCS	8				-15	brown with gray mottling
1530	23	25	CCS	2				-20	
1525	25	35	CCS	10				-25	UNOXIDIZED CLAY: with silt and sand, gray
1520								-30	gray, silty at 27 to 28 ftg
1515	35	44	CCS	8				-35	
1510								-40	
1505	44	45	CCS	2				-45	SAND: fine to very fine grained, angular to rounded, with silt, gray
1500	45	49	CCS	4				-49	fine to very coarse grained, subangular to rounded, poorly sorted, with pebbles
1495	49	53	CCS	4				-53	very fine grained, grading to silt at 52 ftg
1490	53	55	CCS	2				-55	UNOXIDIZED CLAY: with silt, sand and pebbles, gray
1485	55	65	CCS	10				-65	
1480	65	74.5	CCS	9.5				-74.5	
1475	74.5	75	CCS	0.5				-75	SAND: fine to very coarse grained, angular to subangular, poorly sorted, with pebbles, gray
1470	75	79	CCS	4				-79	very coarse grained, well rounded, wet
1465	79	83	CCS	4				-83	coarse to very coarse grained, rounded, well sorted, few pebbles, gray
1460	83	84	CCS	1				-84	very fine to medium grained, with silt, gray
	84	85	CCS	1				-85	UNOXIDIZED CLAY: with silt, sand and pebbles, gray
	85	86	CCS	1				-86	SILT: gray, with a finer sand and pebbles at 90 to 91 ftg
	86	95	CCS	2				-95	UNOXIDIZED CLAY: with silt, sand and pebbles, gray

NOTES:

