APPENDIX III-3C-1

EXCAVATION STABILITY

EXCAVATION STABILITY

Made By: VK
Checked by: JBF
Reviewed by: CGD

1.0 OBJECTIVE

Evaluate the factor of safety against failure of the excavated slopes.

2.0 GIVEN

Based on a review of the design grades, the deepest proposed excavation occurs within Tract 5, Cell 16 and Cell 17. The cross-section in this area consists of a 3H:1V slope from approximate elevation of 593 ft to the toe at an approximate elevation of 541 ft (Section A-A', shown in Figure III 3-4).

STATE OF TEXAS
12/5/16
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SOIL CONDITIONS

For the purposes of this analysis, a conservatively generalized subsurface stratigraphy has been developed based on available laboratory test data and field data from boring logs. The subsurface stratigraphy has been developed using three layers from top to bottom: a residual clay layer, a weathered claystone layer, and an unweathered claystone layer. The analysis is conducted for both total stress and effective stress conditions. The soil strength parameters are obtained from the available laboratory data from testing performed by Jones and Neuse Inc., 1993, except the undrained shear strength of the residual clay for which the Golder 2015 testing data was used, conservatively. Table 1 summarizes the soil parameters used in the analysis.

Table 1 Soil parameters used in the stability analysis

Material	Unit Weight (pcf)		Strength Parameters		Analysis Stress State	Reference
	Moist	Saturated	ϕ (degrees)	c (psf)		
Residual Clay	115	120	0	1700	Total	Golder 2015
			21.6	460	Effective	Jones & Neuse 1993
Weathered Claystone	120	125	16.7	5040	Total	Jones & Neuse 1993
			11	6840	Effective	
Unweathered Claystone	130	130	40.4	5800	Total	Jones & Neuse 1993
			45	7200	Effective	

Note: Jones & Neuse 1993 refers to the previous geotechnical investigation data performed during the MSW-692A permit application, which were based on consolidated undrained triaxial shear testing. Testing results are included in Part III, Attachment 4, Appendix III-4D.

Groundwater level is conservatively assumed to be approximately 10 ft below ground surface, based on the available piezometer data. Within the excavation, the phreatic surface is conservatively assumed to correspond to the excavation grade.

3.0 METHOD

Use SLIDE v.6.0 to analyze excavation stability, based on limit equilibrium methods following Spencer's and GLE/Morgenstern-Price methods of analysis. The results from the method providing the least factor of safety is presented.

4.0 RESULTS

SLIDE output files attached to this appendix.

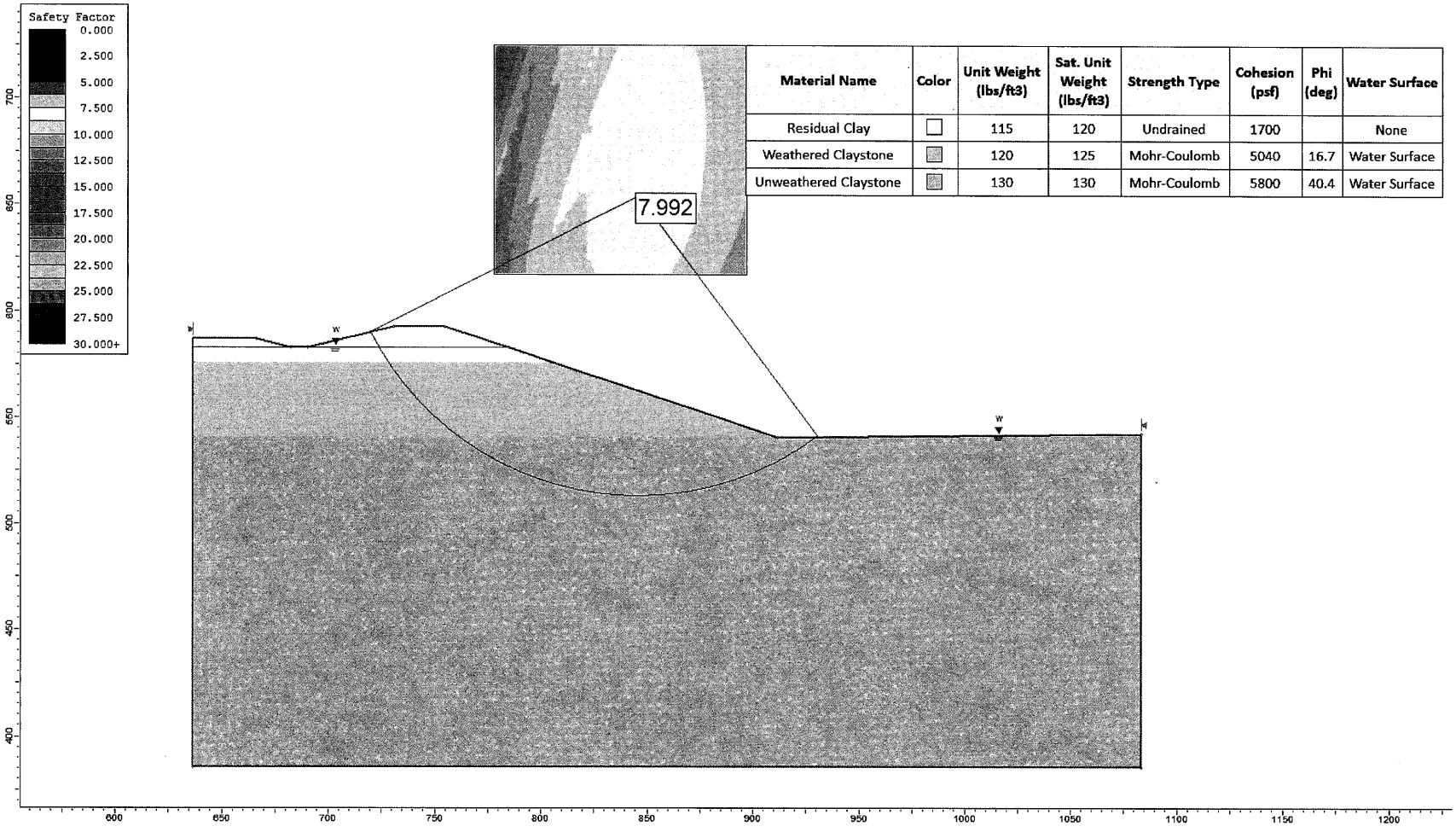
The factor of safety against instability for the slope analyzed is 8.0 for the total stress condition and 4.5 for the effective stress condition. These values are acceptable.
Based on generally accepted industry practice, the minimum allowable factor of safety is 1.5.

5.0 CONCLUSION

Using a generalized cross-section and shear strength parameters from laboratory tests, the analysis indicates that the excavated slopes will be stable.

6.0 REFERENCES

Rocscience 2015, SLIDE - 2D Limit Equilibrium Slope Stability for Soil and Rock Slopes



Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Residual Clay		115	120	Undrained	1700		None
Weathered Claystone		120	125	Mohr-Coulomb	5040	16.7	Water Surface
Unweathered Claystone		130	130	Mohr-Coulomb	5800	40.4	Water Surface

FIGURE **3CA.1**

Excavation Stability Analysis - Total Stress Analysis

Permit Amendment Application MSW 692B Temple Recycling and Disposal Facility, Bell County, Texas

Slide Analysis Information

SLIDE - An Interactive Slope Stability Program

Project Summary

File Name: Exc Stab_A-A'_Total.slim
Slide Modeler Version: 6.03
Project Title: SLIDE - An Interactive Slope Stability Program
Date Created: 6/2/2015, 9:53:21 AM

General Settings

Units of Measurement: Imperial Units
Time Units: days
Permeability Units: feet/second
Failure Direction: Left to Right
Data Output: Standard
Maximum Material Properties: 20
Maximum Support Properties: 20

Analysis Options

Analysis Methods Used

GLE/Morgenstern-Price with interslice force function: Half Sine
Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50
Check malpha < 0.2: Yes
Initial trial value of FS: 1
Steffensen Iteration: Yes

Groundwater Analysis

Groundwater Method: Water Surfaces
Pore Fluid Unit Weight: 62.4 lbs/ft3
Advanced Groundwater Method: None

Random Numbers

Pseudo-random Seed: 10116
Random Number Generation Method: Park and Miller v.3

Surface Options

Surface Type: Circular
Search Method: Grid Search
Radius Increment: 10
Composite Surfaces: Disabled
Reverse Curvature: Create Tension Crack
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Material Properties

Property	Residual Clay	Weathered Claystone	Unweathered Claystone
Color			
Strength Type	Undrained	Mohr-Coulomb	Mohr-Coulomb
Unsaturated Unit Weight [lbs/ft3]	115	120	130
Saturated Unit Weight [lbs/ft3]	120	125	130
Cohesion [psf]		5040	5800
Friction Angle [deg]		16.7	40.4
Cohesion Type	1700		
Water Surface	None	Water Table	Water Table
Hu Value		1	1
Ru Value	0		

Global Minimums

Method: spencer

FS: 7.991580
Center: 845.775, 654.122
Radius: 141.389
Left Slip Surface Endpoint: 719.642, 590.236
Right Slip Surface Endpoint: 930.567, 540.980
Resisting Moment=2.50398e+008 lb-ft
Driving Moment=3.13327e+007 lb-ft
Resisting Horizontal Force=1.57951e+006 lb
Driving Horizontal Force=197647 lb
Total Slice Area=8256.94 ft2

Method: gle/morgenstern-price

FS: 7.978790
Center: 845.775, 654.122
Radius: 141.389
Left Slip Surface Endpoint: 719.642, 590.236
Right Slip Surface Endpoint: 930.567, 540.980
Resisting Moment=2.49997e+008 lb-ft
Driving Moment=3.13327e+007 lb-ft
Resisting Horizontal Force=1.57789e+006 lb
Driving Horizontal Force=197761 lb
Total Slice Area=8256.94 ft2

Slice Data

oal Minimum Query (spencer) - Safety Factor: 7.99158

Slice Number	Width [ft]	Weight [lbs]	Base Material	Base Cohesion [psf]	Base Friction Angle [degrees]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]
1	8.28433	7833.58	Residual Clay	1700	0	212.724	1700	478.682	0	478.682
2	8.32291	22279.4	Weathered Claystone	5040	16.7	659.196	5268.02	1543.03	783.011	760.022
3	8.32291	33099.8	Weathered Claystone	5040	16.7	682.362	5453.15	2803.38	1426.27	1377.11
4	8.32291	42043.6	Weathered Claystone	5040	16.7	703.077	5618.69	3891.44	1962.54	1928.9
5	8.32291	48786.2	Weathered Claystone	5040	16.7	718.663	5743.25	4761.56	2417.49	2344.07
6	8.46745	53749.7	Unweathered Claystone	5800	40.4	983.523	7859.9	5229.92	2809.55	2420.37
7	8.46745	56987.1	Unweathered Claystone	5800	40.4	1001.84	8006.28	5740.49	3148.12	2592.37
8	8.46745	59340.6	Unweathered Claystone	5800	40.4	1015.05	8111.85	6153.16	3436.74	2716.42
9	8.46745	60828.4	Unweathered Claystone	5800	40.4	1035.55	8275.67	6465.14	3556.24	2908.9
10	8.46745	61562.1	Unweathered Claystone	5800	40.4	1056.57	8443.7	6690.68	3584.35	3106.33
11	8.46745	61596.7	Unweathered Claystone	5800	40.4	1073.07	8575.53	6835.98	3574.74	3261.24
12	8.46745	60923.2	Unweathered Claystone	5800	40.4	1084.54	8667.15	6898.5	3529.62	3368.88
13	8.46745	59647.5	Unweathered Claystone	5800	40.4	1091.92	8726.19	6888.82	3450.56	3438.26
14	8.46745	57793.1	Unweathered Claystone	5800	40.4	1095.27	8752.97	6808.43	3338.7	3469.73
15	8.46745	55372.4	Unweathered Claystone	5800	40.4	1094.53	8747.06	6657.51	3194.73	3462.78
16	8.46745	52391.6	Unweathered Claystone	5800	40.4	1089.6	8707.62	6435.46	3019.02	3416.44
17	8.46745	48850.5	Unweathered Claystone	5800	40.4	1080.3	8633.33	6140.7	2811.54	3329.16
18	8.46745	44742.9	Unweathered Claystone	5800	40.4	1066.41	8522.31	5770.65	2571.95	3198.7
19	8.46745	40056.1	Unweathered Claystone	5800	40.4	1047.6	8372	5321.61	2299.52	3022.09
20	8.46745	34770.1	Unweathered Claystone	5800	40.4	1023.45	8178.95	4788.39	1993.13	2795.26
21	8.46745	28856.6	Unweathered Claystone	5800	40.4	993.358	7938.5	4163.9	1651.16	2512.74
22	8.46745	22276.5	Unweathered Claystone	5800	40.4	956.548	7644.33	3438.5	1271.42	2167.08
23	8.46745	15053.7	Unweathered Claystone	5800	40.4	913.042	7296.65	2609.48	850.927	1758.55
24	8.46745	9101.95	Unweathered Claystone	5800	40.4	876.539	7004.93	1931.76	515.968	1415.79

25	8.46745	3190.56	Unweathered Claystone	5800	40.4	838.939	6704.45	1243.59	180.866	1062.72

bal Minimum Query (gle/morgenstern-price) - Safety Factor: 7.97879

Slice Number	Width [ft]	Weight [lbs]	Base Material	Base Cohesion [psf]	Base Friction Angle [degrees]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]
1	8.28433	7833.58	Residual Clay	1700	0	213.065	1700	559.483	0	559.483
2	8.32291	22279.4	Weathered Claystone	5040	16.7	665.014	5306.01	1669.65	783.011	886.643
3	8.32291	33099.8	Weathered Claystone	5040	16.7	688.63	5494.44	2940.99	1426.27	1514.72
4	8.32291	42043.6	Weathered Claystone	5040	16.7	706.462	5636.71	3951.48	1962.54	1988.94
5	8.32291	48786.2	Weathered Claystone	5040	16.7	717.981	5728.62	4712.77	2417.49	2295.28
6	8.46745	53749.7	Unweathered Claystone	5800	40.4	968.589	7728.17	5075.14	2809.55	2265.59
7	8.46745	56987.1	Unweathered Claystone	5800	40.4	979.976	7819.02	5520.46	3148.12	2372.34
8	8.46745	59340.6	Unweathered Claystone	5800	40.4	989.487	7894.91	5898.25	3436.74	2461.51
9	8.46745	60828.4	Unweathered Claystone	5800	40.4	1009.81	8057.04	6208.26	3556.24	2652.02
10	8.46745	61562.1	Unweathered Claystone	5800	40.4	1034.05	8250.5	6463.67	3584.35	2879.32
11	8.46745	61596.7	Unweathered Claystone	5800	40.4	1056.7	8431.16	6666.35	3574.74	3091.61
12	8.46745	60923.2	Unweathered Claystone	5800	40.4	1076.54	8589.46	6807.22	3529.62	3277.6
13	8.46745	59647.5	Unweathered Claystone	5800	40.4	1093.63	8725.81	6888.37	3450.56	3437.81
14	8.46745	57793.1	Unweathered Claystone	5800	40.4	1106.97	8832.25	6901.58	3338.7	3562.88
15	8.46745	55372.4	Unweathered Claystone	5800	40.4	1115.39	8899.49	6836.62	3194.73	3641.89
16	8.46745	52391.6	Unweathered Claystone	5800	40.4	1117.69	8917.84	6682.47	3019.02	3663.45
17	8.46745	48850.5	Unweathered Claystone	5800	40.4	1112.71	8878.08	6428.27	2811.54	3616.73
18	8.46745	44742.9	Unweathered Claystone	5800	40.4	1099.46	8772.36	6064.46	2571.95	3492.51
19	8.46745	40056.1	Unweathered Claystone	5800	40.4	1077.25	8595.18	5583.85	2299.52	3284.33
20	8.46745	34770.1	Unweathered Claystone	5800	40.4	1045.81	8344.3	4982.67	1993.13	2989.54
21	8.46745	28856.6	Unweathered Claystone	5800	40.4	1005.35	8021.47	4261.38	1651.16	2610.22
22	8.46745	22276.5	Unweathered Claystone	5800	40.4	956.646	7632.88	3425.05	1271.42	2153.63
23	8.46745	15053.7	Unweathered Claystone	5800	40.4	902.082	7197.52	2493.01	850.927	1642.08
24	8.46745	9101.95	Unweathered Claystone	5800	40.4	855.815	6828.37	1724.3	515.968	1208.33
			Unweathered							

terslice Data

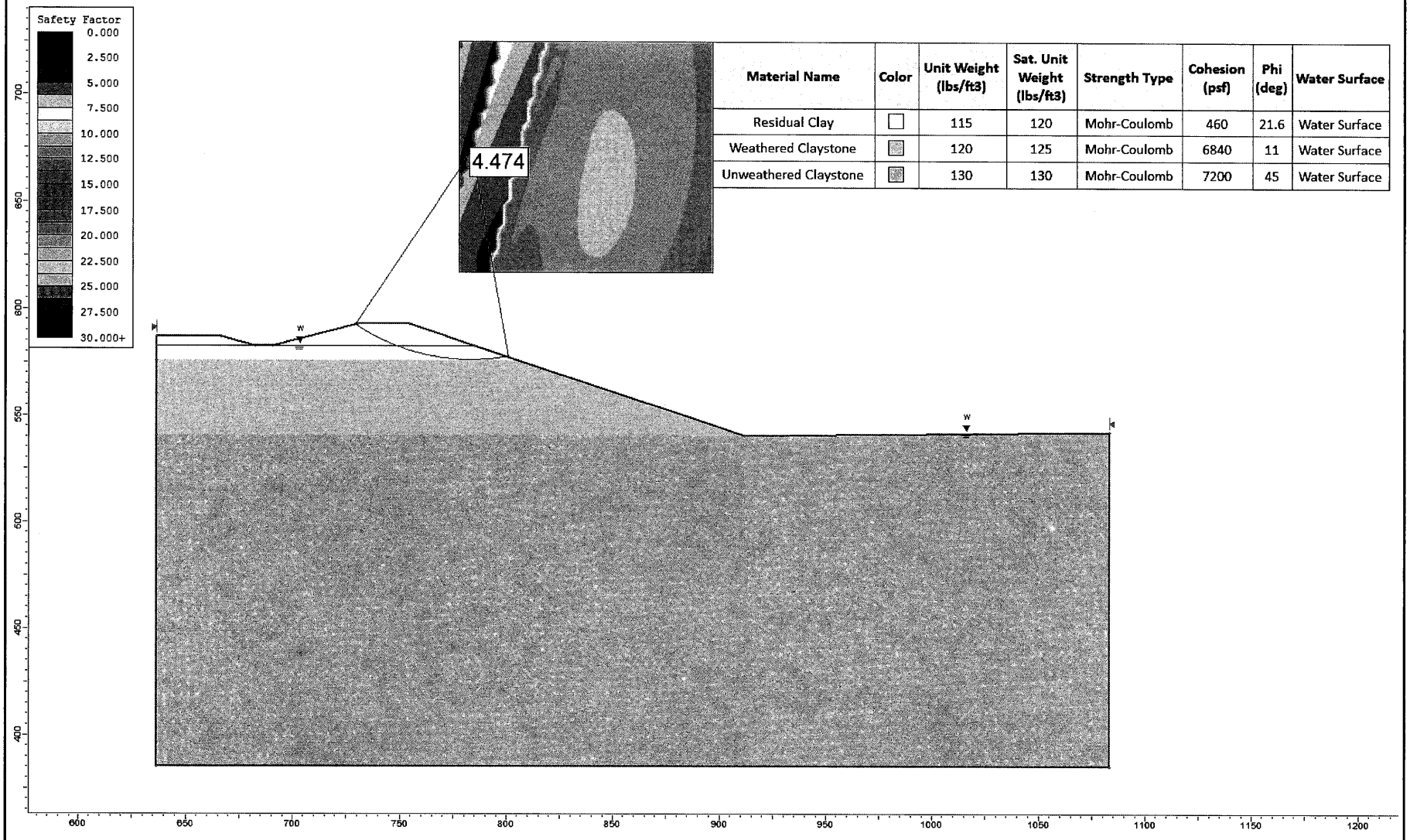
Global Minimum Query (spencer) - Safety Factor: 7.99158

Slice Number	X coordinate [ft]	Y coordinate - Bottom [ft]	Interslice Normal Force [lbs]	Interslice Shear Force [lbs]	Interslice Force Angle [degrees]
1	719.642	590.236	0	0	0
2	727.926	576.003	5050.96	841.401	9.45762
3	736.249	564.707	16993.9	2830.89	9.45764
4	744.572	555.385	37446.5	6237.92	9.45761
5	752.895	547.519	62207	10362.6	9.45763
6	761.218	540.804	88199.6	14692.5	9.45762
7	769.686	534.953	110471	18402.5	9.45761
8	778.153	529.952	130694	21771.4	9.45766
9	786.62	525.702	148249	24695.7	9.45763
10	795.088	522.131	162571	27081.4	9.4576
11	803.555	519.184	173342	28875.8	9.45765
12	812.023	516.821	180409	30052.9	9.4576
13	820.49	515.012	183701	30601.3	9.45761
14	828.958	513.737	183241	30524.8	9.45765
15	837.425	512.98	179120	29838.3	9.45764
16	845.893	512.733	171494	28567.9	9.45763
17	854.36	512.994	160589	26751.3	9.45762
18	862.827	513.765	146705	24438.5	9.45764
19	871.295	515.055	130230	21694.1	9.45766
20	879.762	516.879	111655	18599.7	9.4576
21	888.23	519.258	91597.8	15258.6	9.45764
22	896.697	522.222	70844.7	11801.5	9.45764
23	905.165	525.811	50401.7	8396.04	9.45763
24	913.632	530.081	31528.5	5252.1	9.45764
25	922.1	535.104	14403.1	2399.3	9.45761
26	930.567	540.98	0	0	0

Global Minimum Query (gle/morgenstern-price) - Safety Factor: 7.97879

Slice Number	X coordinate [ft]	Y coordinate - Bottom [ft]	Interslice Normal Force [lbs]	Interslice Shear Force [lbs]	Interslice Force Angle [degrees]
1	719.642	590.236	0	0	0
2	727.926	576.003	6197.78	165.151	1.52639
3	736.249	564.707	19521.2	1034.8	3.03435
4	744.572	555.385	41202.9	3236.79	4.49178
5	752.895	547.519	66406.1	6833.22	5.87509
6	761.218	540.804	92075.3	11570.6	7.1625
7	769.686	534.953	113566	16676.2	8.3537
8	778.153	529.952	132872	22015.2	9.40772
9	786.62	525.702	149557	27204.6	10.3095

10	795.088	522.131	163178	31856.4	11.0466
11	803.555	519.184	173469	35638.8	11.6097
12	812.023	516.821	180271	38290.9	11.9918
13	820.49	515.012	183463	39626.9	12.1883
14	828.958	513.737	182986	39552.2	12.1968
15	837.425	512.98	178834	38068.4	12.0172
16	845.893	512.733	171074	35277	11.6516
17	854.36	512.994	159864	31377.1	11.1045
18	862.827	513.765	145481	26655.2	10.3826
19	871.295	515.055	128345	21466.6	9.49523
20	879.762	516.879	109038	16207.1	8.45438
21	888.23	519.258	88327.6	11275.5	7.27477
22	896.697	522.222	67181.8	7030.31	5.97403
23	905.165	525.811	46784.3	3741.56	4.57248
24	913.632	530.081	28499.4	1539.9	3.09284
25	922.1	535.104	12589.7	342.851	1.55993
26	930.567	540.98	0	0	0



Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Residual Clay		115	120	Mohr-Coulomb	460	21.6	Water Surface
Weathered Claystone		120	125	Mohr-Coulomb	6840	11	Water Surface
Unweathered Claystone		130	130	Mohr-Coulomb	7200	45	Water Surface

FIGURE **3CA.2**

Excavation Stability Analysis - Effective Stress Analysis

Permit Amendment Application MSW 692B Temple Recycling and Disposal Facility, Bell County, Texas

Slide Analysis Information

SLIDE - An Interactive Slope Stability Program

Project Summary

File Name: Exc Stab_A-A'_Effective.slim
Slide Modeler Version: 6.03
Project Title: SLIDE - An Interactive Slope Stability Program
Date Created: 6/2/2015, 9:53:21 AM

General Settings

Units of Measurement: Imperial Units
Time Units: days
Permeability Units: feet/second
Failure Direction: Left to Right
Data Output: Standard
Maximum Material Properties: 20
Maximum Support Properties: 20

Analysis Options

Analysis Methods Used

GLE/Morgenstern-Price with interslice force function: Half Sine
Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50
Check malpha < 0.2: Yes
Initial trial value of FS: 1
Steffensen Iteration: Yes

Groundwater Analysis

Groundwater Method: Water Surfaces
Pore Fluid Unit Weight: 62.4 lbs/ft3
Advanced Groundwater Method: None

Random Numbers

Pseudo-random Seed: 10116
Random Number Generation Method: Park and Miller v.3

Surface Options

Surface Type: Circular
Search Method: Grid Search
ius Increment: 10
nposite Surfaces: Disabled
Reverse Curvature: Create Tension Crack
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Material Properties

Property	Residual Clay	Weathered Claystone	Unweathered Claystone
Color			
Strength Type	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb
Unsaturated Unit Weight [lbs/ft3]	115	120	130
Saturated Unit Weight [lbs/ft3]	120	125	130
Cohesion [psf]	460	6840	7200
Friction Angle [deg]	21.6	11	45
Water Surface	Water Table	Water Table	Water Table
Hu Value	0	1	1

Global Minimums

Method: spencer

FS: 4.473560
Center: 783.514, 673.910
Radius: 97.862
Left Slip Surface Endpoint: 729.074, 592.589
Right Slip Surface Endpoint: 800.842, 577.594
Resisting Moment=5.89859e+006 lb-ft
Driving Moment=1.31854e+006 lb-ft
Resisting Horizontal Force=57837.3 lb
Driving Horizontal Force=12928.7 lb
Total Slice Area=558.445 ft2

Method: gle/morgenstern-price

FS: 4.473550
Center: 783.514, 673.910
Radius: 97.862
Left Slip Surface Endpoint: 729.074, 592.589
Right Slip Surface Endpoint: 800.842, 577.594
Resisting Moment=5.89858e+006 lb-ft
Driving Moment=1.31854e+006 lb-ft
Resisting Horizontal Force=57837.5 lb
Driving Horizontal Force=12928.8 lb
Total Slice Area=558.445 ft2

Slice Data

Global Minimum Query (spencer) - Safety Factor: 4.47356

Slice mber	Width [ft]	Weight [lbs]	Base Material	Base Cohesion [psf]	Base Friction Angle [degrees]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]
1	2.87071	392.556	Residual Clay	460	21.6	109.542	490.044	75.8823	0	75.8823
2	2.87071	1009.03	Residual Clay	460	21.6	126.745	567.001	270.254	0	270.254
3	2.87071	1553.49	Residual Clay	460	21.6	142.286	636.526	445.856	0	445.856
4	2.87071	2056.46	Residual Clay	460	21.6	156.942	702.088	611.445	0	611.445
5	2.87071	2520.1	Residual Clay	460	21.6	170.73	763.771	767.237	0	767.237
6	2.87071	2946.24	Residual Clay	460	21.6	183.668	821.648	913.419	0	913.419
7	2.87071	3339.01	Residual Clay	460	21.6	195.84	876.104	1050.96	0	1050.96
8	2.87071	3708.62	Residual Clay	460	21.6	207.515	928.331	1182.87	0	1182.87
9	2.87071	4042.76	Residual Clay	460	21.6	218.319	976.662	1304.94	0	1304.94
10	2.87071	4152.53	Residual Clay	460	21.6	222.724	996.368	1354.71	0	1354.71
11	2.87071	4107.81	Residual Clay	460	21.6	222.629	995.946	1353.65	0	1353.65
12	2.87071	4031.14	Residual Clay	460	21.6	221.561	991.166	1341.57	0	1341.57
13	2.87071	3923.23	Residual Clay	460	21.6	219.52	982.038	1318.52	0	1318.52
14	2.87071	3784.65	Residual Clay	460	21.6	216.508	968.561	1284.48	0	1284.48
15	2.87071	3615.88	Residual Clay	460	21.6	212.52	950.723	1239.42	0	1239.42
16	2.87071	3417.33	Residual Clay	460	21.6	207.553	928.499	1183.29	0	1183.29
17	2.87071	3189.29	Residual Clay	460	21.6	201.595	901.849	1115.98	0	1115.98
18	2.87071	2932	Residual Clay	460	21.6	194.638	870.724	1037.37	0	1037.37
19	2.87071	2645.6	Residual Clay	460	21.6	186.665	835.058	947.287	0	947.287
20	2.87071	2327.92	Residual Clay	460	21.6	177.589	794.454	844.735	0	844.735
21	2.87071	1971.02	Residual Clay	460	21.6	167.135	747.69	726.621	0	726.621
22	2.87071	1583.77	Residual Clay	460	21.6	155.557	695.895	595.802	0	595.802
23	2.87071	1167.26	Residual Clay	460	21.6	142.864	639.111	452.381	0	452.381
24	2.87071	721.244	Residual Clay	460	21.6	129.021	577.184	295.973	0	295.973
25	2.87071	245.413	Residual Clay	460	21.6	113.99	509.939	126.131	0	126.131

Global Minimum Query (gle/morgenstern-price) - Safety Factor: 4.47355

Slice Number	Width [ft]	Weight [lbs]	Base Material	Base Cohesion [psf]	Base Friction Angle [degrees]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]
1	2.87071	392.556	Residual Clay	460	21.6	108.862	486.999	68.1914	0	68.1914
2	2.87071	1009.03	Residual Clay	460	21.6	127.198	569.027	275.371	0	275.371
3	2.87071	1553.49	Residual Clay	460	21.6	143.105	640.187	455.101	0	455.101
4	2.87071	2056.46	Residual Clay	460	21.6	157.654	705.275	619.495	0	619.495
5	2.87071	2520.1	Residual Clay	460	21.6	171.061	765.25	770.972	0	770.972
6	2.87071	2946.24	Residual Clay	460	21.6	183.5	820.896	911.521	0	911.521
7	2.87071	3339.01	Residual Clay	460	21.6	195.183	873.161	1043.53	0	1043.53
8	2.87071	3708.62	Residual Clay	460	21.6	206.47	923.652	1171.05	0	1171.05
9	2.87071	4042.76	Residual Clay	460	21.6	217.048	970.977	1290.58	0	1290.58
10	2.87071	4152.53	Residual Clay	460	21.6	221.454	990.685	1340.36	0	1340.36
11	2.87071	4107.81	Residual Clay	460	21.6	221.596	991.322	1341.97	0	1341.97
12	2.87071	4031.14	Residual Clay	460	21.6	220.942	988.393	1334.57	0	1334.57
13	2.87071	3923.23	Residual Clay	460	21.6	219.424	981.602	1317.42	0	1317.42
14	2.87071	3784.65	Residual Clay	460	21.6	216.968	970.615	1289.66	0	1289.66

15	2.87071	3615.88	Residual Clay	460	21.6	213.495	955.079	1250.43	0	1250.43
16	2.87071	3417.33	Residual Clay	460	21.6	208.929	934.656	1198.85	0	1198.85
17	2.87071	3189.29	Residual Clay	460	21.6	203.204	909.045	1134.16	0	1134.16
18	2.87071	2932	Residual Clay	460	21.6	196.268	878.015	1055.79	0	1055.79
19	2.87071	2645.6	Residual Clay	460	21.6	188.089	841.427	963.376	0	963.376
20	2.87071	2327.92	Residual Clay	460	21.6	178.592	798.939	856.062	0	856.062
21	2.87071	1971.02	Residual Clay	460	21.6	167.548	749.534	731.281	0	731.281
22	2.87071	1583.77	Residual Clay	460	21.6	155.288	694.688	592.756	0	592.756
23	2.87071	1167.26	Residual Clay	460	21.6	141.927	634.919	441.797	0	441.797
24	2.87071	721.244	Residual Clay	460	21.6	127.564	570.665	279.509	0	279.509
25	2.87071	245.413	Residual Clay	460	21.6	112.31	502.423	107.149	0	107.149

Interslice Data

Global Minimum Query (spencer) - Safety Factor: 4.47356

Slice Number	X coordinate [ft]	Y coordinate - Bottom [ft]	Interslice Normal Force [lbs]	Interslice Shear Force [lbs]	Interslice Force Angle [degrees]
1	729.074	592.589	0	0	0
2	731.944	590.738	-174.045	-28.288	9.23171
3	734.815	589.026	-74.9711	-12.1853	9.23174
4	737.686	587.442	222.68	36.1928	9.23172
5	740.557	585.981	665.805	108.215	9.2317
6	743.427	584.635	1207.92	196.326	9.23169
7	746.298	583.401	1808.18	293.889	9.23173
8	749.169	582.273	2431.35	395.174	9.23171
9	752.039	581.248	3048.42	495.468	9.23171
10	754.91	580.322	3630.13	590.015	9.23171
11	757.781	579.492	4114.8	668.79	9.23172
12	760.652	578.756	4471.9	726.83	9.23171
13	763.522	578.112	4700.24	763.944	9.23173
14	766.393	577.558	4801.2	780.352	9.23171
15	769.264	577.091	4778.56	776.673	9.23172
16	772.134	576.712	4638.56	753.918	9.23172
17	775.005	576.419	4389.81	713.488	9.23172
18	777.876	576.211	4043.34	657.176	9.23173
19	780.747	576.087	3612.68	587.179	9.23172
20	783.617	576.048	3113.9	506.11	9.2317
21	786.488	576.093	2566.01	417.06	9.2317
22	789.359	576.223	1992.17	323.793	9.23172
23	792.229	576.437	1418.05	230.479	9.23169
24	795.1	576.736	872.521	141.813	9.2317
25	797.971	577.122	388.095	63.0781	9.23171
26	800.842	577.594	0	0	0

Global Minimum Query (gle/morgenstern-price) - Safety Factor: 4.47355

X	Y	Interslice	Interslice	Interslice

Number	coordinate [ft]	coordinate - Bottom [ft]	Normal Force [lbs]	Shear Force [lbs]	Force Angle [degrees]
1	729.074	592.589	0	0	0
2	731.944	590.738	-186.273	-4.55736	1.40152
3	734.815	589.026	-79.6817	-3.86825	2.77931
4	737.686	587.442	230.322	16.5511	4.11025
5	740.557	585.981	683.234	64.2528	5.37242
6	743.427	584.635	1229.5	141.073	6.5455
7	746.298	583.401	1827.98	244.271	7.61128
8	749.169	582.273	2444.74	367.714	8.55375
9	752.039	581.248	3052.78	503.157	9.3593
10	754.91	580.322	3624.93	640.269	10.0168
11	757.781	579.492	4101.44	761.447	10.5174
12	760.652	578.756	4453	853.864	10.8547
13	763.522	578.112	4678.71	911.518	11.0244
14	766.393	577.558	4779.42	931.14	11.0244
15	769.264	577.091	4757.98	912.344	10.8547
16	772.134	576.712	4619.45	857.618	10.5174
17	775.005	576.419	4371.4	772.117	10.0168
18	777.876	576.211	4024.18	663.263	9.35931
19	780.747	576.087	3591.19	540.152	8.55376
20	783.617	576.048	3089.03	412.784	7.61129
21	786.488	576.093	2537.83	291.191	6.5455
22	789.359	576.223	1962.28	184.537	5.37242
23	792.229	576.437	1389.65	99.8614	4.11026
24	795.1	576.736	850.042	41.2663	2.77931
25	797.971	577.122	376.198	9.20408	1.40152
26	800.842	577.594	0	0	0

JONES AND NEUSE, INC.
Environmental and Engineering Services

DATE: 3-1-93

REPORT NUMBER: 007819-11-1

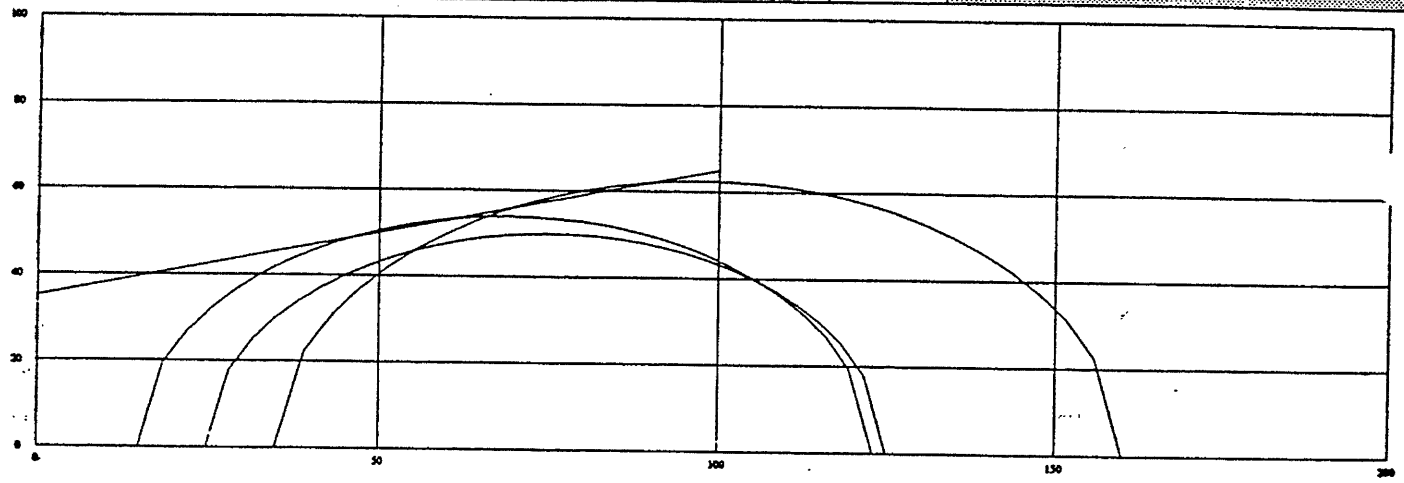
TO: CITY OF TEMPLE
ROMING-PARKER, ASSOCIATES

PROJECT: TEMPLE MUNICIPAL LANDFILL EXPANSION
TEMPLE, TEXAS

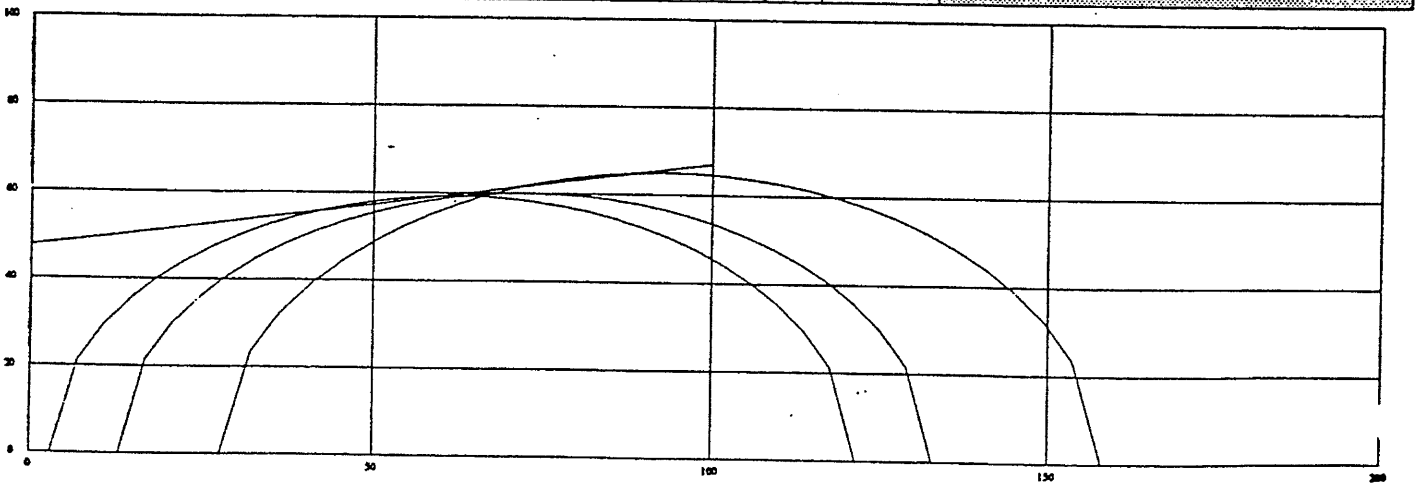
PROJECT NUMBER: 007819.4

TEST STANDARD	ASTM D-4767 CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST		
TEST METHOD	MULTI-STAGE SINGLE SPECIMEN		
SAMPLE TYPE	UNDISTURBED	REMOLDED PARAMETERS	
SAMPLE NUMBER	B1D23	DRY DENSITY(PCF)	-
BORING NUMBER	B-1	MOISTURE CONTENT(%)	-
DEPTH(FT)	23-25	PERCENT COMPACTION	-
		RELATIVE MOISTURE	-

TOTAL STRESS		
TOTAL COHESION(PSI)	35.0	
TOTAL COHESION(PSF)	5040.0	
FRICTION ANGLE(DEG)	16.7	



EFFECTIVE STRESS		
EFFECTIVE COHESION(PSI)	47.5	
EFFECTIVE COHESION(PSF)	6840.0	
FRICTION ANGLE(DEG)	11.0	



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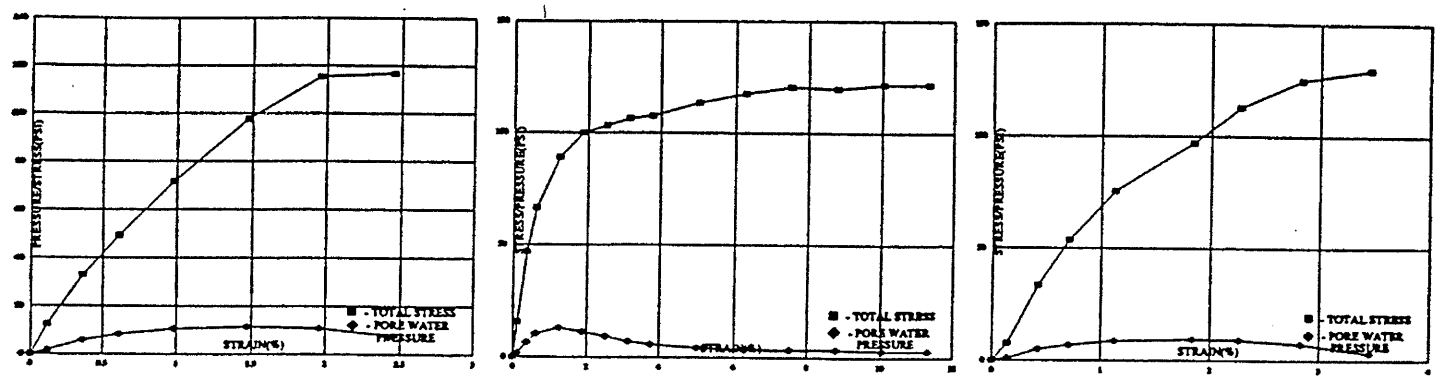
TRIAXIAL COMPRESSIVE STRENGTH TEST RESULTS

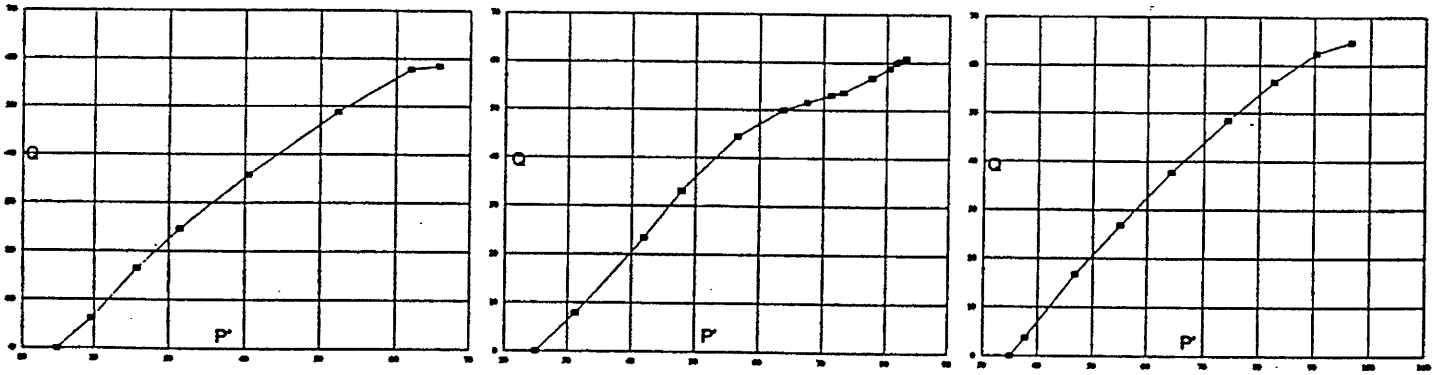
SAMPLE TYPE	UNDISTURBED
SAMPLE NUMBER	B1D23
BORING NUMBER	B-1
SAMPLE DEPTH	23-25

CONDITIONS	INITIAL			FINAL
EFFECTIVE CONFINING PRESSURE(PSI)		15	25	35
HEIGHT(IN)	4.08	4.08	3.98	3.53
DIAMETER(IN)	2.00	2.05	2.11	2.16
VOID RATIO	0.46	0.49	0.51	0.49
SATURATION(%)	100.7			100.1
MOISTURE CONTENT(%)	18.0			18.8
DRY DENSITY(PCF)	110.4			108.6
SPECIFIC GRAVITY	2.59			
CONFINING PRESSURE(PSI)		65	75	85
BACK PRESSURE(PSI)		50	50	50
MAX. DEVIATOR STRESS(PSI)		108	100	125
INDUCED PORE WATER PRESSURE(PSI)		12	12	7

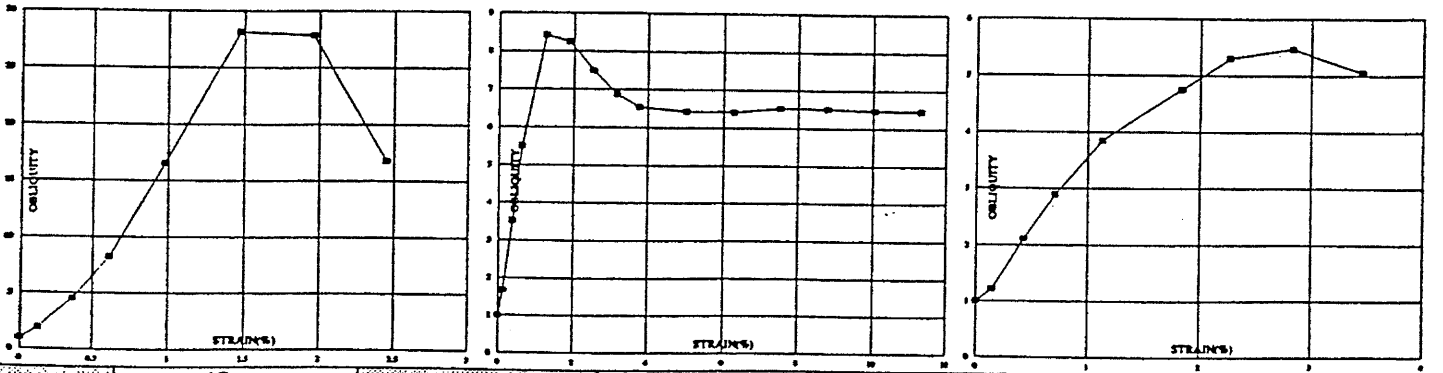
STRESS & INDUCED PORE WATER PRESSURE Vs. STRAIN



P'-Q DIAGRAMS



OBLIQUITY Vs. STRAIN



15 | 25 | 35

CONFINING STRESS(PSI)

JONES AND NEUSE, INC.
Environmental and Engineering Services

DATE: 3-1-93

REPORT NUMBER: 007819-11-1

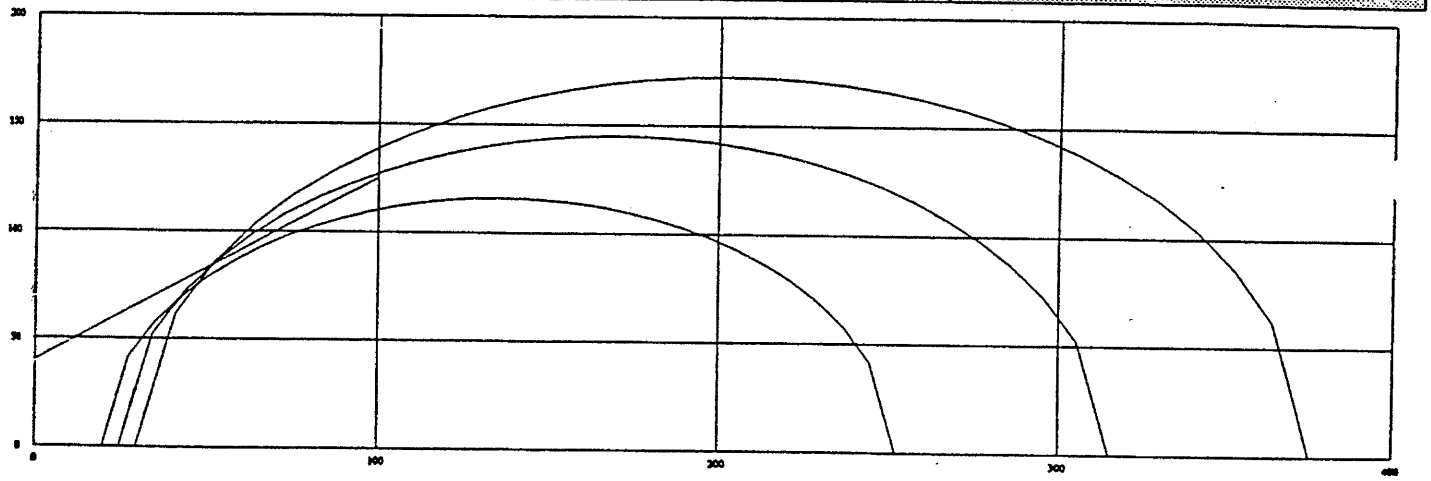
TO: CITY OF TEMPLE
ROMING-PARKER, ASSOCIATES

PROJECT: TEMPLE MUNICIPAL LANDFILL EXPANSION
TEMPLE, TEXAS

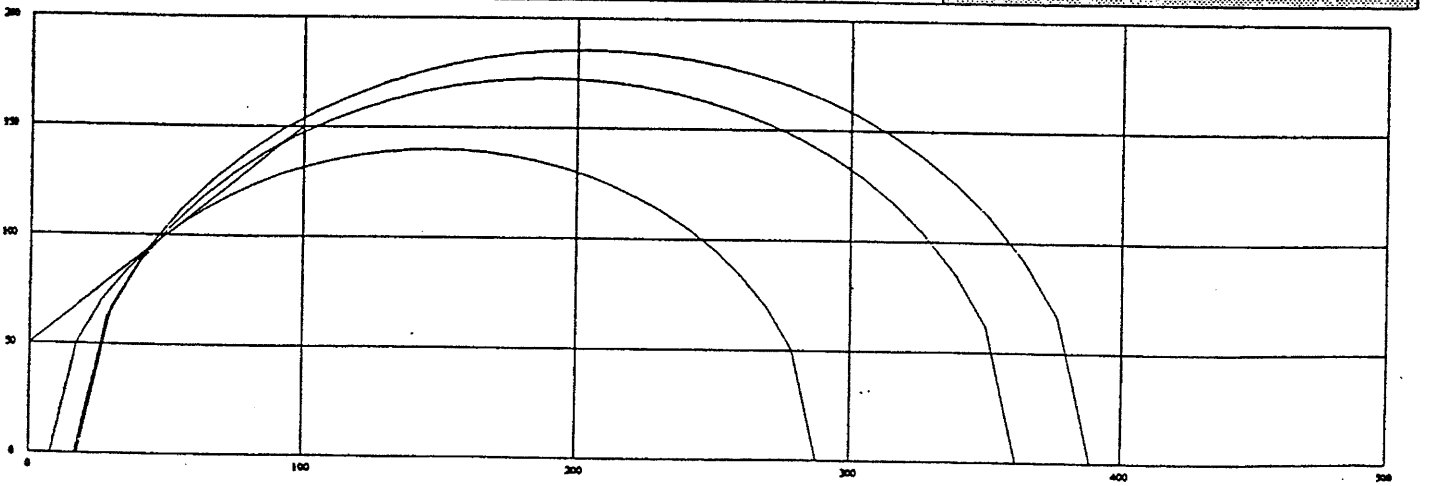
PROJECT NUMBER: 007819.4

TEST STANDARD	ASTM D-4767 CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST		
TEST METHOD	MULTI-STAGE SINGLE SPECIMEN		
SAMPLE TYPE	UNDISTURBED	REMOLDED PARAMETERS	
SAMPLE NUMBER	B20B5860	DRY DENSITY(PCF)	-
BORING NUMBER	B-20	MOISTURE CONTENT(%)	-
DEPTH(FT)	58.5-60	PERCENT COMPACTION	-
		RELATIVE MOISTURE	-

TOTAL STRESS		
TOTAL COHESION(PSI)	40.0	
TOTAL COHESION(PSF)	5760.0	
FRICTION ANGLE(DEG)	40.4	



EFFECTIVE STRESS		
EFFECTIVE COHESION(PSI)	50.0	
EFFECTIVE COHESION(PSF)	7200.0	
FRICTION ANGLE(DEG)	45.0	



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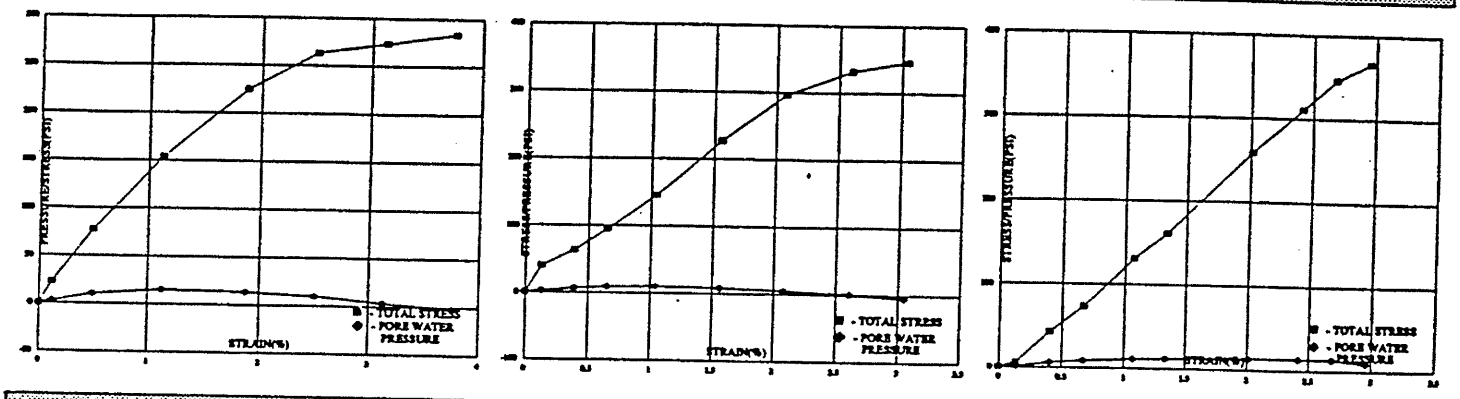
TRIAXIAL COMPRESSIVE STRENGTH TEST RESULTS

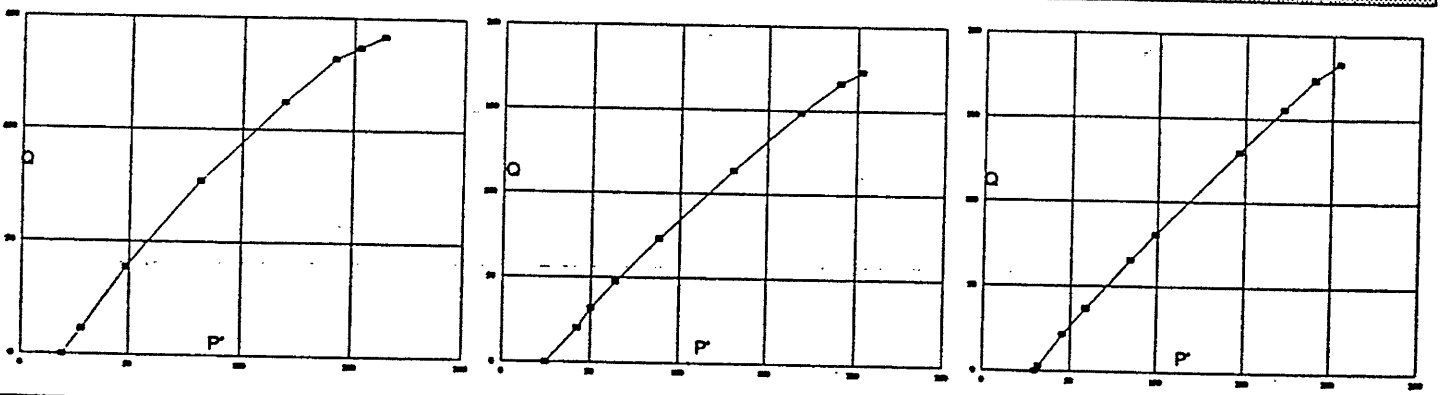
SAMPLE TYPE	UNDISTURBED
SAMPLE NUMBER	B20B5860
BORING NUMBER	B-20
SAMPLE DEPTH	58.5-60

CONDITIONS	INITIAL			FINAL
EFFECTIVE CONFINING PRESSURE(PSI)		20	25	30
HEIGHT(IN)	3.99	3.99	3.84	3.72
DIAMETER(IN)	2.04	2.06	2.09	2.12
VOID RATIO	0.33	0.34	0.33	0.34
SATURATION(%)	97.4			100.2
MOISTURE CONTENT(%)	12.3			13.1
DRY DENSITY(PCF)	121.8			120.8
SPECIFIC GRAVITY	2.59			
CONFINING PRESSURE(PSI)		75	80	85
BACK PRESSURE(PSI)		55	55	55
MAX. DEVIATOR STRESS(PSI)		232	290	345
INDUCED PORE WATER PRESSURE(PSI)		12	8	12

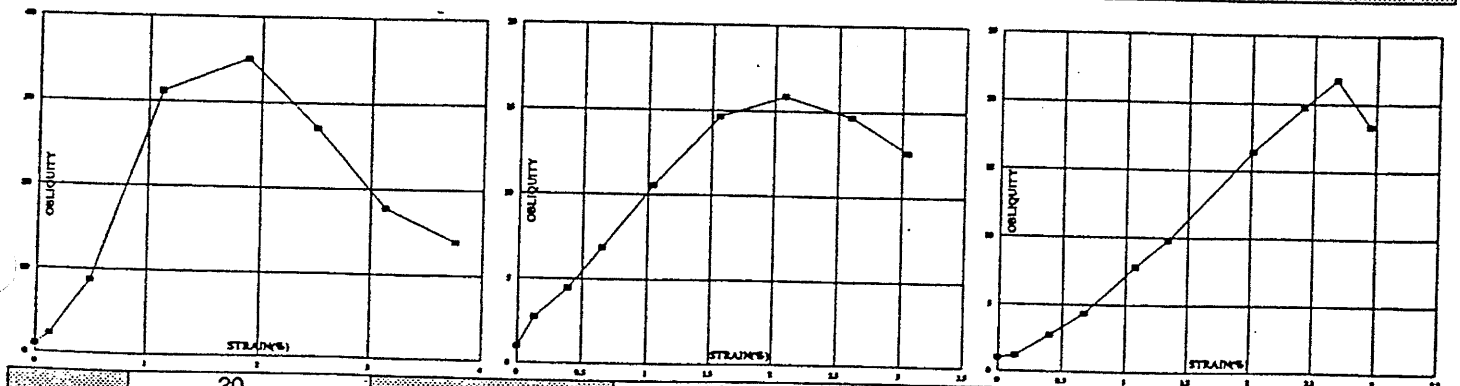
STRESS & INDUCED PORE WATER PRESSURE Vs. STRAIN



P'-Q DIAGRAMS



OBLIQUITY Vs. STRAIN

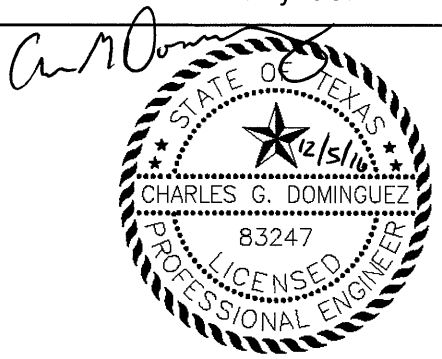


APPENDIX III-3C-2

SIDESLOPE STABILITY

SIDESLOPE STABILITY

Made By: VK
Checked by: JBF / MX
Reviewed by: CGD



Professional Engineering Firm
Registration Number F-2578

INTENDED FOR PERMITTING PURPOSES ONLY

1.0 OBJECTIVE

Investigate the stability of the lining system along the sideslope.

2.0 SIDESLOPE

Sideslopes are at 3H:1V.
Length of maximum slope is approximately 200 ft.

3.0 ASSUMPTIONS

The maximum head over the geomembrane is less than the thickness of the geocomposite drainage layer (See attached calculations in Appendix III-3D-2).

The failure mechanism will be sliding along one of the liner interfaces.

Proposed slope liner system consists of (from top to bottom):

24 inches of protective cover
Double-sided geocomposite
60-mil textured HDPE geomembrane
24-inch compacted clay liner
Subgrade

Based on a review of available data at low normal stresses, the following parameters were assigned to the materials.

Material	Strength Parameters		Unit Weight (pcf)		Reference
	ϕ (°)	c (psf)	Moist	Saturated	
Protective Cover	28	0	115	132	Ref. [1] (1)
Protective Cover/Geocomposite	28	0	N/A	N/A	Golder(2)
Geocomposite/Textured Geomembrane	24	0	N/A	N/A	Golder(2)
Textured Geomembrane/Clay Liner	35	0	N/A	N/A	Golder(2)
Clay Liner	28	0	N/A	N/A	Ref. [1] (1)
Clay Liner/Subgrade	28	0	N/A	N/A	Ref. [1] (1)

(1) The shear strength of the protective cover soils, clay liner and the clay liner/subgrade interface is estimated based on the on-site soil shear strength. This is estimated using the average plasticity index (PI = 40) of the Stratum I and Stratum II soils described in Attachment 4, and Ref. [1].

(2) Based on unpublished data from tests performed in Golder's laboratory, on similar geosynthetic materials. Strength parameters were conservatively assigned to be close to the lower bound of data to account for testing material variability. This data is presented in this appendix.

The shear strength parameters indicate that the critical interface above the geomembrane occurs at the geocomposite/geomembrane interface, with a friction angle of 24 degrees.

The critical interface below the geomembrane occurs between the clay liner and the subgrade with a friction angle of 28 degrees.

4.0 METHOD

Create a model representing the sideslope situation and use it in conjunction with limit equilibrium concepts to determine the minimum factor of safety against a sliding block failure along the critical interface.

Infinite Slope Analysis

$$FS = \frac{c + (\gamma b \cos\beta - \gamma_w d \cos\beta)\tan\phi}{\gamma b \sin\beta}$$

Sliding at Interface

ϕ =	24	interface friction angle
β =	18.4	slope angle (degrees)
c =	0	cohesion of soil (psf)
γ =	132	unit weight of soil (pcf)
b =	2.0	soil thickness (ft)
d =	0	water depth in cover (ft)
γ_w =	62.4	unit weight of water (pcf)
FS =	**1.34**	

5.0 RESULTS

By using limit equilibrium analysis for an infinite slope condition, the factor of safety is found to be at least 1.34, and likely to be higher due to the use of conservative parameters in the analysis.

Based on generally accepted industry practice, the minimum allowable factor of safety is 1.3 for a temporary slope.

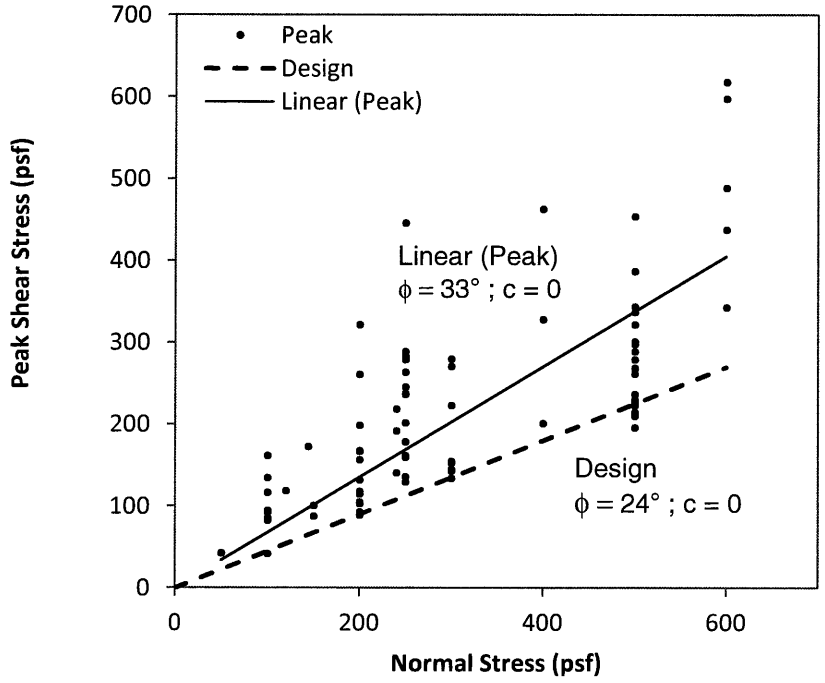
6.0 CONCLUSION

Through analysis of the composite lining system, this temporary condition is found to be stable.

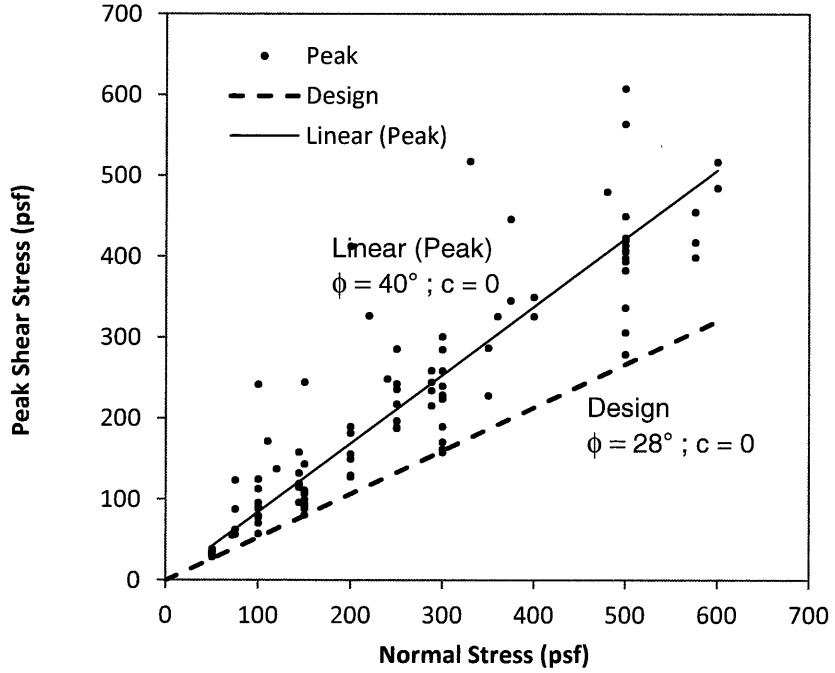
7.0 REFERENCES

[1] Bjerrum, L. and Simons, N. E. (1960). "Comparison of shear strength characteristics of normally consolidated clays." Proceedings of the Research Conference on Shear Strength of Cohesive Soils, ASCE, Boulder, Colorado, 1960, pp. 711–726.

Direct Shear - HDPE TGM vs GC
Low Normal Loads



Direct Shear - Geocomposite vs Protective Cover
Low Normal Loads



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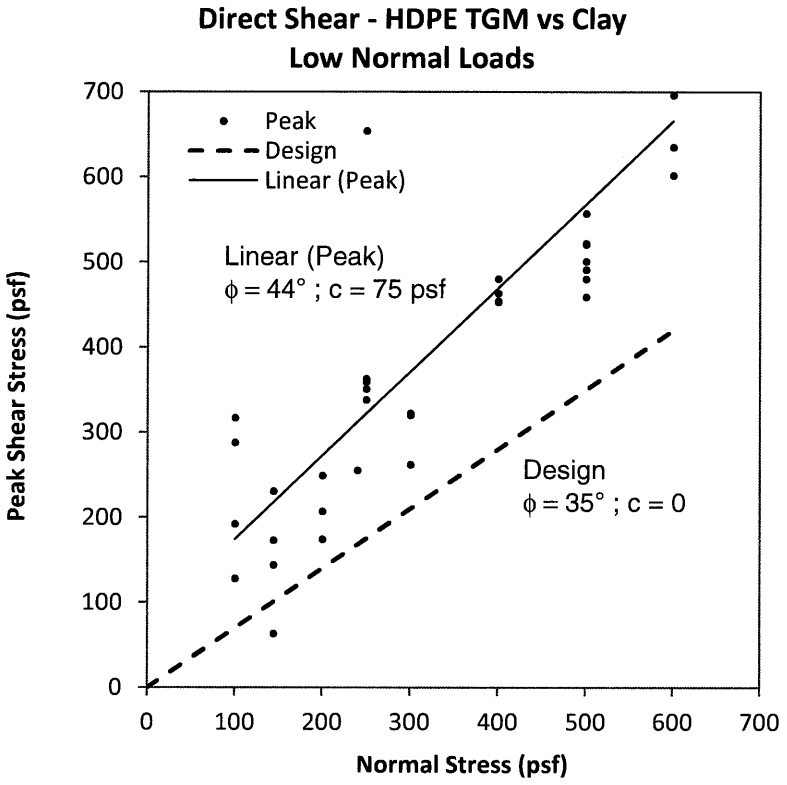
Submitted: June 2016
Revised: December 2016



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Submitted: June 2016
Revised: December 2016

APPENDIX III-3C-3

INTERIOR WASTE SLOPE STABILITY

INTERIOR WASTE SLOPE STABILITY

Made By: VK
Checked by: JBF / MX
Reviewed by: CGD

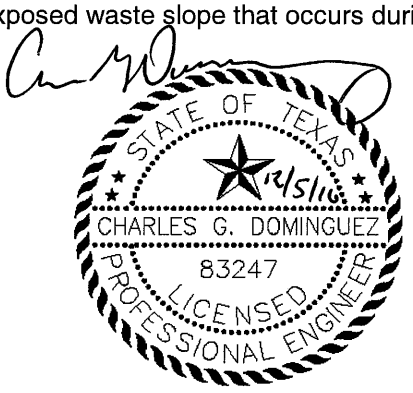
1.0 OBJECTIVE

Investigate the stability of the interior waste slopes against sliding along the interfaces of the proposed liner system.

2.0 GIVEN

Based on a review of the floor grades and filling sequence, it was identified that sliding along the liner of Tract 5 Cell 9 is the most critical case, where the filling and slope occur in the same direction with no buttress effect from existing waste or the floor slope. Along this section, the analysis evaluates temporary interior waste slopes of 3H:1V and 4H:1V.

In addition, the highest exposed waste slope, as part of the operational fill sequence is also analyzed. Section A on detail 4 of Figure III-3-4 shows the analyzed section with the highest exposed waste slope that occurs during operation fill sequence, phase 5 (Fig II-7.5).



GOLDER ASSOCIATES INC.
Professional Engineering Firm
Registration Number F-2578

INTENDED FOR PERMITTING PURPOSES ONLY

The cell liner system consists of:

FLOOR: 24 inches of protective cover (clay)
Nonwoven geotextile over geonet (floor)
60-mil HDPE smooth geomembrane (floor)
24-inch compacted clay liner
Subgrade

SIDEWALLS: 24 inches of protective cover (clay)
Double-sided geocomposite
60-mil HDPE textured geomembrane
24-inch compacted clay liner
Subgrade

OVERLINER: 24 inches of protective cover (clay)
Double-sided geocomposite
60-mil LLDPE textured Geomembrane
Geosynthetic Clay Liner (GCL)

The following parameters were assigned to the materials based on available data:

Material	Strength Parameters		Unit Weight (pcf)		Reference
	ϕ (deg)	c (psf)	Moist	Saturated	
Waste	Bi-Linear		65	75	Ref. [2]
Protective cover (soil)	28	0	115	132	Ref. [1] (1)
Prot. cover (soil)/Geotextile layer of Geocomposite (F)	28	0	N/A	N/A	Golder(2)
Geonet/Smooth Geomembrane (F)	9	0	N/A	N/A	Golder(2)
Smooth Geomembrane/Clay Liner (F)	15	0	N/A	N/A	Golder(2)
Textured Geomembrane/Clay Liner (S)	35	0	N/A	N/A	Golder(2)
Geocomposite/Text. Geomembrane (S/O)	15	0	N/A	N/A	Golder(2)
Textured Geomembrane/GCL (O)	18	0	N/A	N/A	Golder(2)
Clay Liner	28	0	N/A	N/A	Ref. [1] (1)
Clay Liner/Subgrade	28	0	N/A	N/A	Ref. [1] (1)

(F) = Floor; (S) Slope; (O) Overliner

(1) The shear strength of the protective cover soils, clay liner and the clay liner/subgrade interface is estimated based on the on-site soil shear strength. This is estimated using the average plasticity index (PI = 40) of the Stratum I and Stratum II soils described in Attachment 4, and Ref. [1].

(2) Based on unpublished data from tests performed in Golder's laboratory, on similar geosynthetic materials. Strength parameters were conservatively assigned to be equal to or a percentage of the peak strength (lower bound) to account for testing data variability and to avoid strains that result in residual interface shear strengths. This data is presented in this appendix.

Based on the data listed in the previous table, the weakest interface in the liner system along the floor of the cell is between the geonet and the smooth geomembrane. The weakest interface in the liner system along the sideslopes of the cell is between the textured geomembrane and the geocomposite. The weakest interface in the overliner system is between the textured geomembrane and GCL. These interfaces were used in the analysis. Subsurface profiles are determined based on available adjacent borehole information, and the same soil properties as the excavation stability analysis are used. These are shown in the below table and in Appendix III-3C-1.

Material	Unit Weight (pcf)		Strength Parameters		Analysis Stress State	Reference
	Moist	Saturated	ϕ (degrees)	c (psf)		
Residual Clay	115	120	21.6	460	Effective	Jones & Neuse 1993
Weathered Claystone	120	125	11	6840	Effective	Jones & Neuse 1993
Unweathered Claystone	130	130	45	7200	Effective	Jones & Neuse 1993

Note: Jones & Neuse 1993 refers to the previous geotechnical investigation data performed during the MSW-692A permit application, which were based on consolidated undrained triaxial shear testing. Testing results are included in Part III, Attachment 4, Appendix III-4D.

Based on generally accepted industry practice, the minimum allowable factor of safety for temporary waste slopes is 1.3.

3.0 METHOD

Use limit equilibrium slope stability methods to determine the maximum waste height (limited to 300 ft, corresponding to the design elevation of waste) at which the minimum factor of safety against sliding along the liner is equal to or greater than 1.3. Consider temporary waste slopes of 3H:1V and 4H:1V. In addition, analyze the highest exposed waste slope that occurs during the operational fill sequence. Use SLIDE v.6 (Ref. [3]) to aid analysis, following Spencer's method.

4.0 ASSUMPTIONS

- Use the lowest strength along the floor and sideslope interfaces simultaneously.
- One foot of leachate above the geomembrane

5.0 SCENARIOS

Two possible waste filling slopes are considered for sliding along the liner of Tract 5, Cell 9: (1) continuous 3H:1V temporary waste slopes with no benches; and (2) continuous 4H:1V temporary waste slope with no benches. Section A (detail 4 of Figure III-3-4), containing the highest exposed waste slope that occurs during the operation fill sequence, is also analyzed.

6.0 RESULTS

Minimum factors of safety and maximum waste heights calculated by SLIDE are summarized below:

Case Considered	Minimum Factor of Safety	Total Waste Height (ft)
Scenario 1 (3H:1V)	1.3	160
Scenario 2 (4H:1V)	1.4	300*
Section A**	1.3	275***

* Exceeds maximum elevation of final cover

**Shown on detail 4, Fig. III-3-4

***Contains one bench (~100 ft wide) at ~120 feet height

7.0 CONCLUSIONS

Using the strength parameters that are conservativey chosen from published studies or based on test results for similar conditions, the following conclusions are made:

(i) Considering a minimum factor of safety of 1.3, temporary waste slopes at 3H:1V can be raised to a maximum height of 160 ft. Slopes exceeding this height should be independently evaluated for stability.

(ii) Temporary waste slopes at 4H:1V can be raised to over 300 ft of slope height without reaching the minimum factor of safety of 1.3.

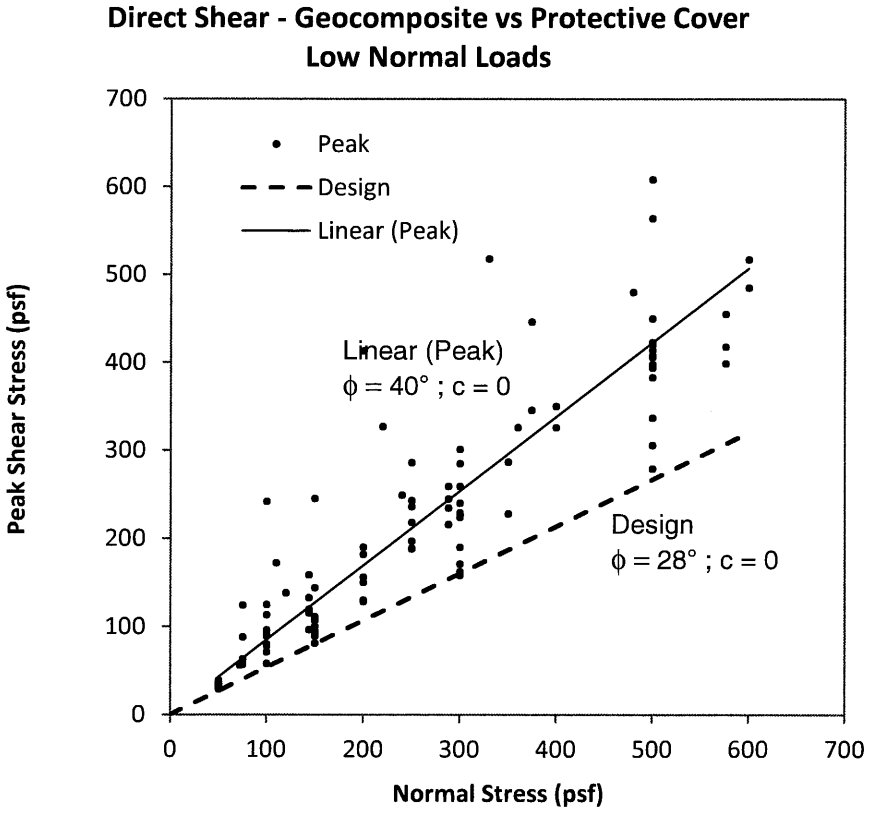
(iii) The most critical slope from the operational fill sequence has a factor of safety of 1.3.

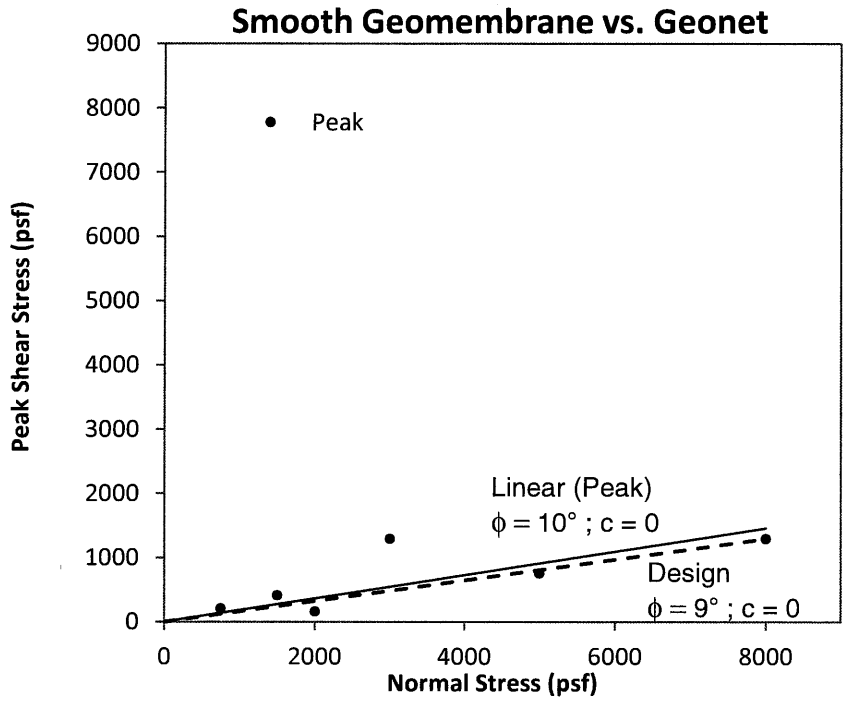
8.0 REFERENCES

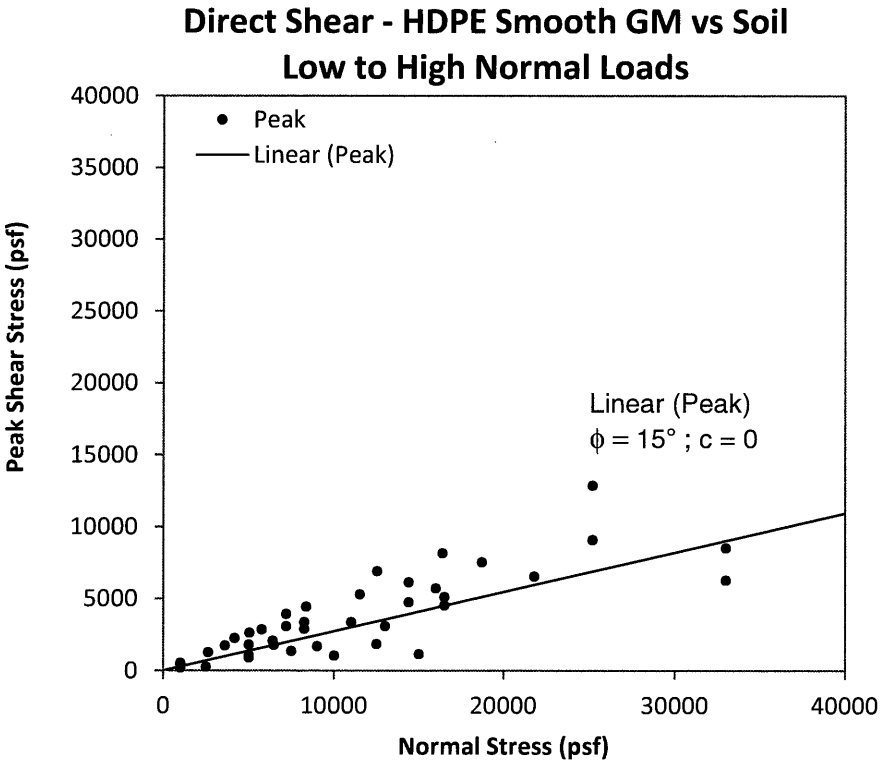
[1] Bjerrum, L. and Simons, N. E. (1960). "Comparison of shear strength characteristics of normally consolidated clays." Proceedings of the Research Conference on Shear Strength of Cohesive Soils, ASCE, Boulder, Colorado, 1960, pp. 711–726.

[2] Bray, J.D., D. Zekkos, E. Kavazanjian, Jr., G.A. Athanasopoulos, and F. Riemer. 2009. Shear strength of

[3] Rocscience 2015, SLIDE - 2D Limit Equilibrium Slope Stability for Soil and Rock Slopes.







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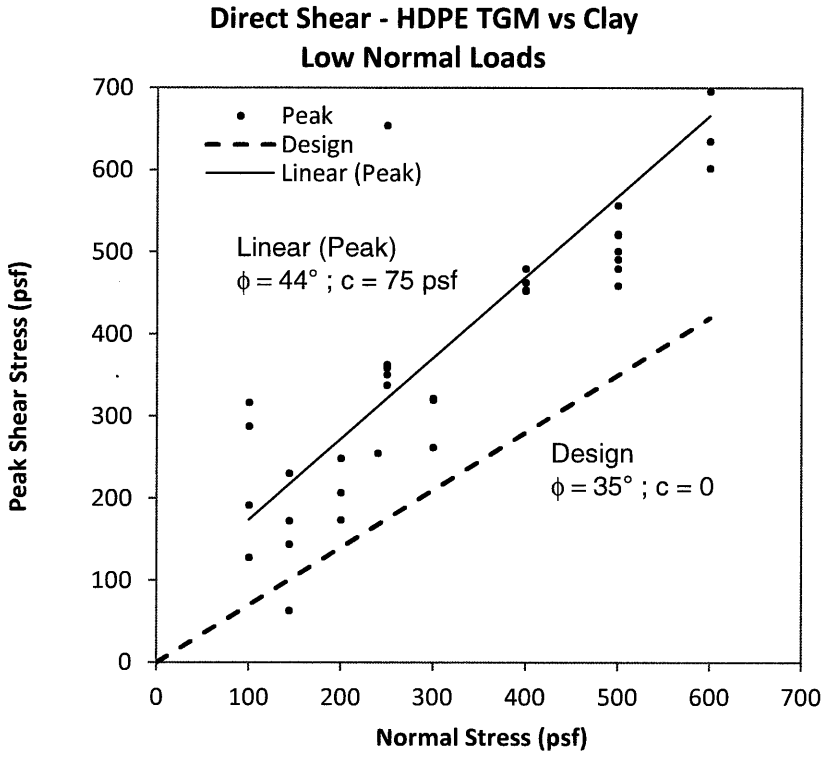
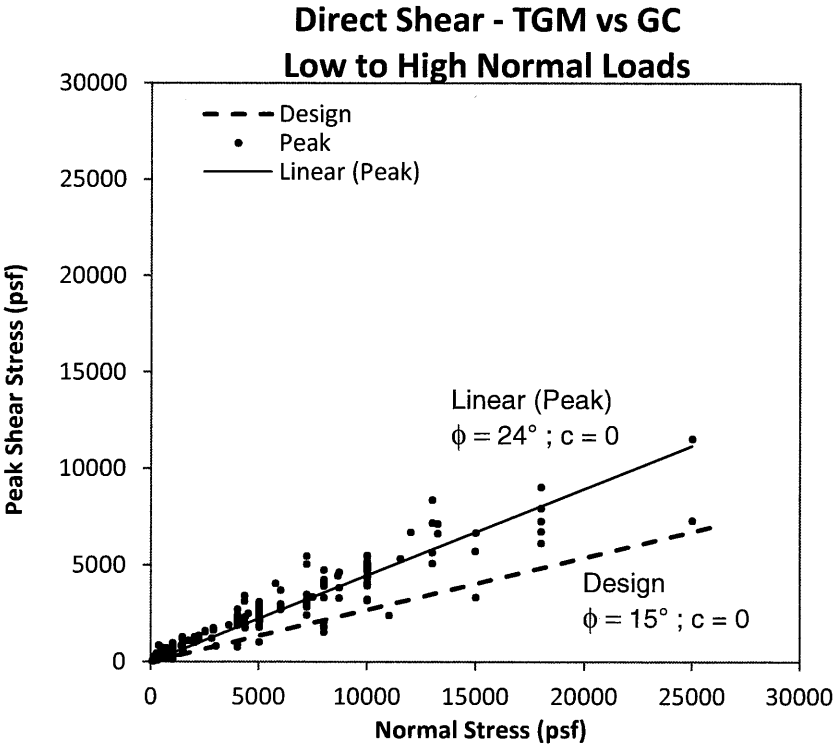
Submitted: June 2016
Revised: December 2016





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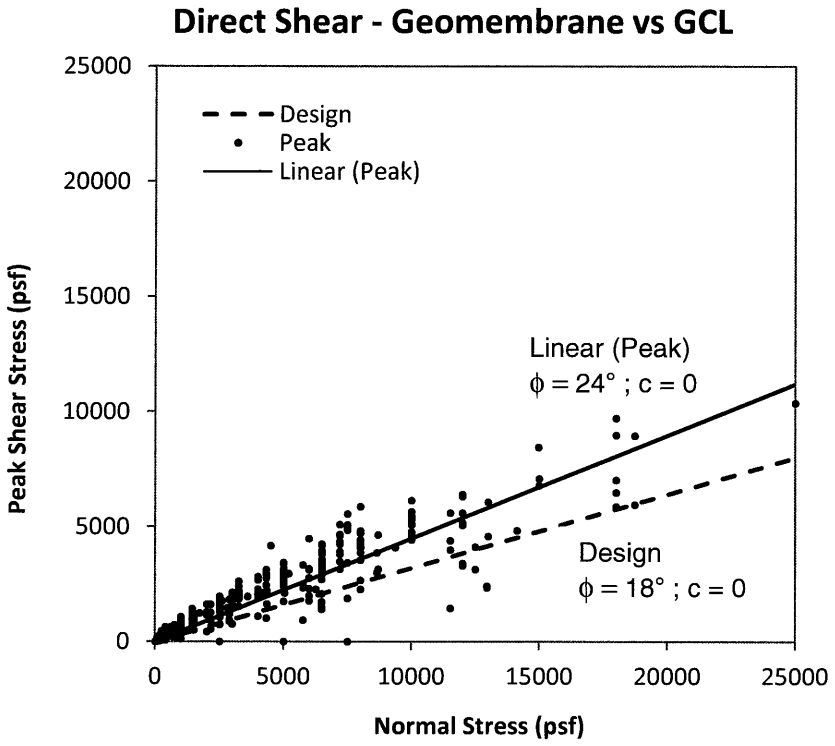
Submitted: June 2016
Revised: December 2016



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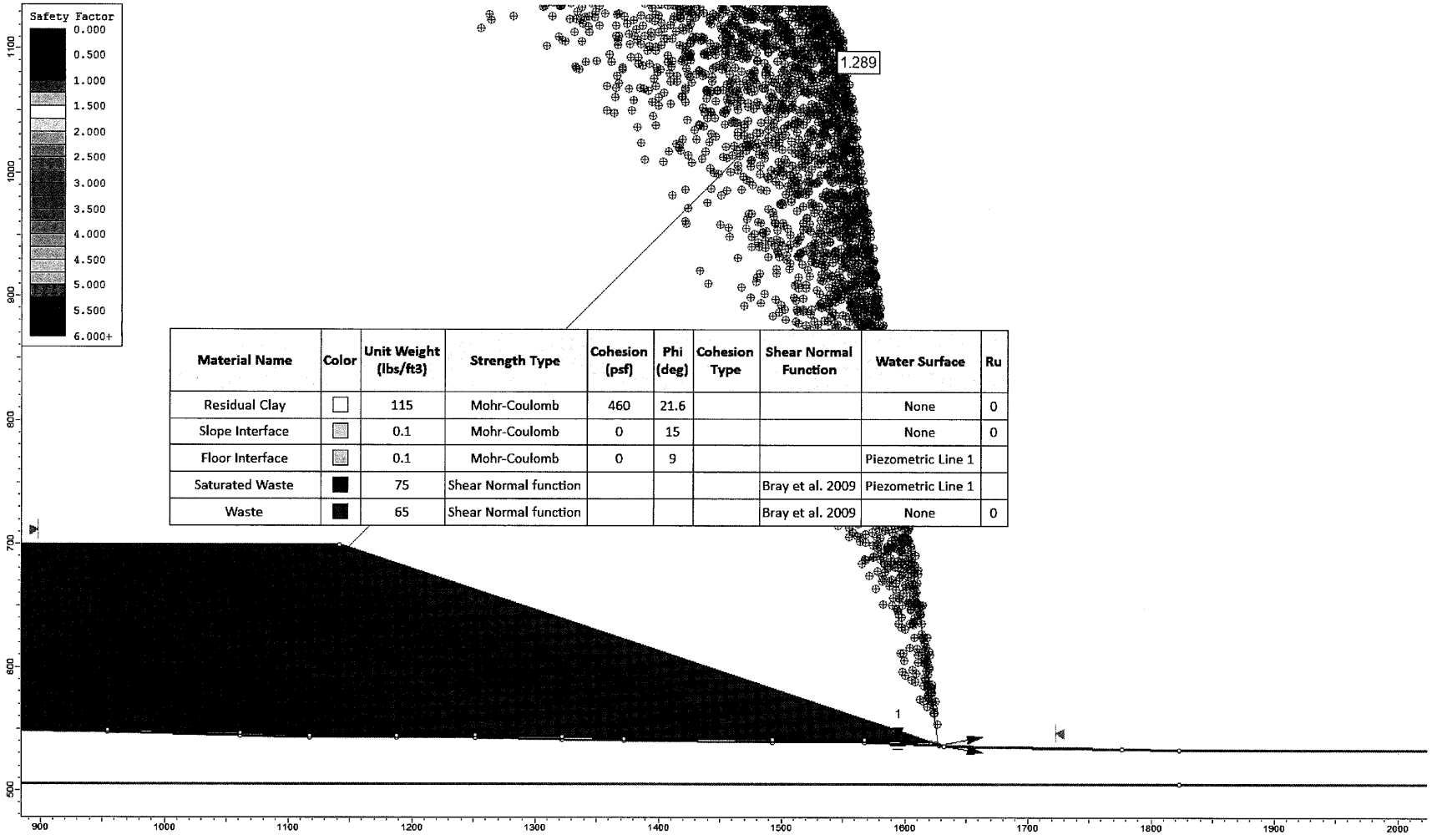
Revised: December 2016



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type	Shear Normal Function	Water Surface	Ru
Residual Clay		115	Mohr-Coulomb	460	21.6			None	0
Slope Interface		0.1	Mohr-Coulomb	0	15			None	0
Floor Interface		0.1	Mohr-Coulomb	0	9			Piezometric Line 1	
Saturated Waste		75	Shear Normal function				Bray et al. 2009	Piezometric Line 1	
Waste		65	Shear Normal function				Bray et al. 2009	None	0

FIGURE **3C3.1**

Interior Waste Slope Stability Analysis - 3H:1V

Permit Amendment Application MSW 692B Temple Recycling and Disposal Facility, Bell County, Texas

Slide Analysis Information

SLIDE - An Interactive Slope Stability Program

Project Summary

File Name: Section 3H-1V.slim
Slide Modeler Version: 6.03
Project Title: SLIDE - An Interactive Slope Stability Program
Date Created: 7/20/2015, 11:51:33 AM

General Settings

Units of Measurement: Imperial Units
Time Units: days
Permeability Units: feet/second
Failure Direction: Left to Right
Data Output: Standard
Maximum Material Properties: 20
Maximum Support Properties: 20

Analysis Options

Analysis Methods Used

Spencer

Number of slices: 25
Tolerance: 0.05
Maximum number of iterations: 50
Check malpha < 0.2: Yes
Initial trial value of FS: 1
Steffensen Iteration: Yes

Groundwater Analysis

Groundwater Method: Water Surfaces
Pore Fluid Unit Weight: 62.4 lbs/ft3
Advanced Groundwater Method: None

Random Numbers

Pseudo-random Seed: 10116
dom Number Generation Method: Park and Miller v.3

Surface Options

Surface Type: Non-Circular Block Search
Number of Surfaces: 5000
Pseudo-Random Surfaces: Enabled
vex Surfaces Only: Disabled
Projection Angle (Start Angle): 95
Left Projection Angle (End Angle): 265
Right Projection Angle (Start Angle): -10
Right Projection Angle (End Angle): 10
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Material Properties

Property	Residual Clay	Slope Interface	Floor Interface	Saturated Waste	Waste
Color					
Strength Type	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Shear Normal function	Shear Normal function
Unit Weight [lbs/ft3]	115	0.1	0.1	75	65
Cohesion [psf]	460	0	0		
Friction Angle [deg]	21.6	15	9		
Water Surface	None	None	Piezometric Line 1	Piezometric Line 1	None
Hu Value			1	1	
Ru Value	0	0			0

ear Normal Functions

Name: Bray et al. 2009

Normal (psf)	Shear (psf)
0	310
600	810
5200	3840
6300	4480
7300	5120
8400	5740
16700	10550

Global Minimums

Method: spencer

FS: 1.288900
Axis Location: 1547.134, 1096.632
Left Slip Surface Endpoint: 1147.681, 697.179
Right Slip Surface Endpoint: 1627.025, 537.398
Resisting Moment=2.91256e+008 lb-ft
Driving Moment=2.25973e+008 lb-ft
Resisting Horizontal Force=407064 lb
Driving Horizontal Force=315824 lb
Total Slice Area=26861.5 ft2

Slice Data

bal Minimum Query (spencer) - Safety Factor: 1.2889

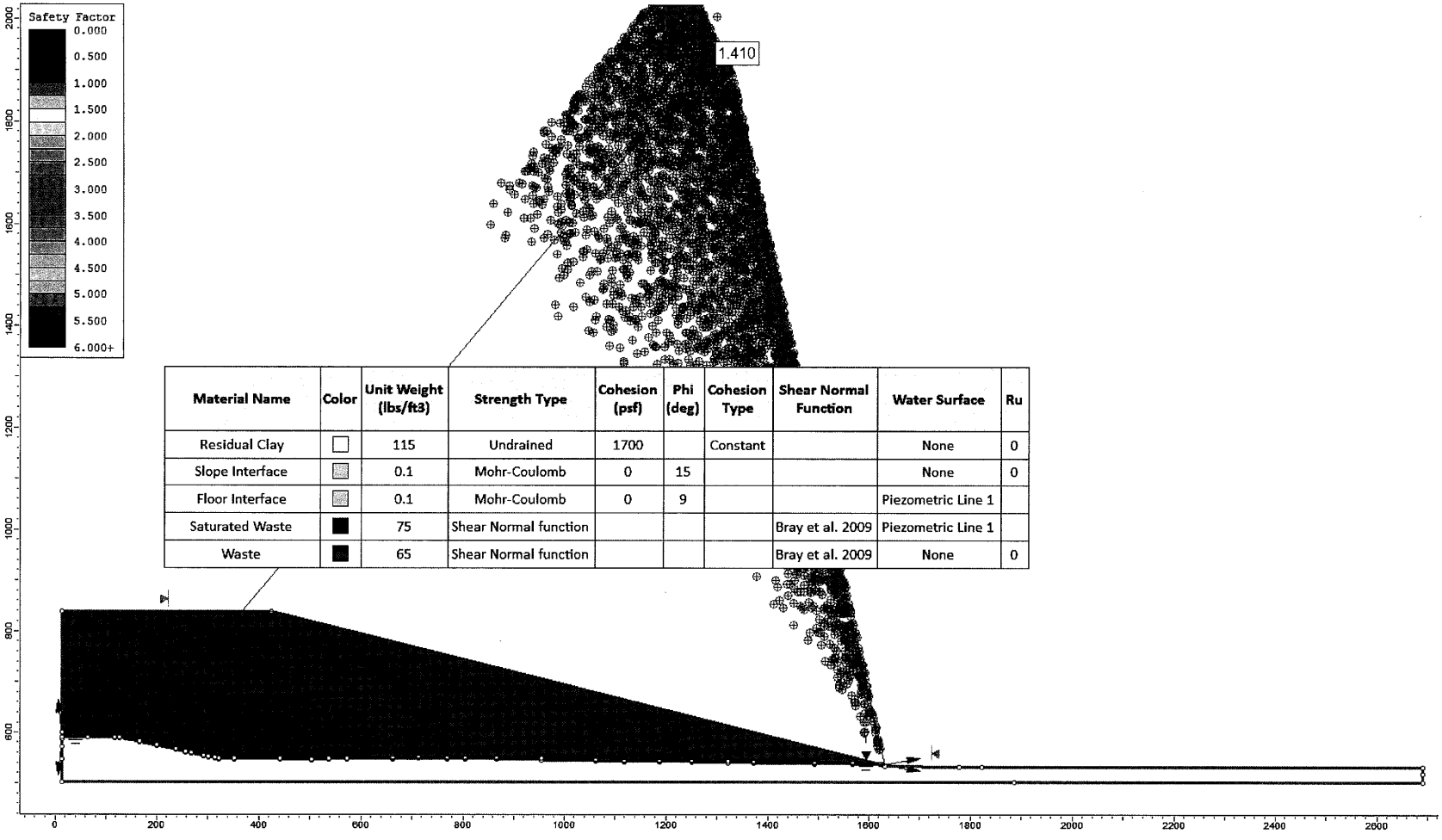
Slice Number	Width [ft]	Weight [lbs]	Base Material	Base Cohesion [psf]	Base Friction Angle [degrees]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]
1	18.0054	9249.61	Waste	310	39.8056	334.488	431.122	145.346	0	145.346
2	18.0054	27748.8	Waste	414.783	33.3727	680.116	876.602	701.11	0	701.11
3	18.0054	46248.1	Waste	414.783	33.3727	981.894	1265.56	1291.62	0	1291.62
4	18.0054	64747.3	Waste	414.783	33.3727	1283.67	1654.52	1882.12	0	1882.12
5	18.0054	83246.5	Waste	414.783	33.3727	1585.45	2043.48	2472.62	0	2472.62
6	18.0054	101746	Waste	414.783	33.3727	1887.22	2432.44	3063.12	0	3063.12
7	18.0054	120245	Waste	414.783	33.3727	2189.01	2821.41	3653.62	0	3653.62
8	0.838688	6056.09	Saturated Waste	414.783	33.3727	2337.12	3012.31	3974.65	31.2	3943.45
9	0.838688	6073.21	Floor Interface	0	9.00002	636.973	820.995	5277.16	93.6	5183.56
10	23.137	161874	Floor Interface	0	9.00002	858.274	1106.23	7109.29	124.8	6984.49
11	23.137	150932	Floor Interface	0	9.00002	799.201	1030.09	6628.54	124.8	6503.74
12	25.01	150972	Floor Interface	0	9.00002	736.992	949.909	6122.29	124.8	5997.49
13	25.01	138442	Floor Interface	0	9.00002	674.529	869.401	5613.98	124.8	5489.18
14	20.1533	102201	Floor Interface	0	9.00002	620.029	799.156	5170.49	124.8	5045.69
15	20.1533	93582.4	Floor Interface	0	9.00002	566.423	730.062	4734.23	124.8	4609.43
16	20.1533	84963.9	Floor Interface	0	9.00002	512.816	660.968	4297.99	124.8	4173.19
17	20.1533	76345.5	Floor Interface	0	9.00002	459.209	591.874	3861.74	124.8	3736.94
18	20.1533	67727	Floor Interface	0	9.00002	405.601	522.779	3425.5	124.8	3300.7
19	20.1533	59108.6	Floor Interface	0	9.00002	351.994	453.685	2989.26	124.8	2864.46
20	22.1902	55043	Floor Interface	0	9.00002	295.677	381.098	2530.96	124.8	2406.16
21	22.1902	44453.5	Floor Interface	0	9.00002	235.778	303.894	2043.51	124.8	1918.71
22	22.1902	33863.9	Floor Interface	0	9.00002	175.879	226.69	1556.06	124.8	1431.26
23	22.6147	23864.1	Floor Interface	0	9.00002	114.394	147.442	1066.95	136.038	930.912
24	22.6147	13967.8	Floor Interface	0	9.00002	61.4648	79.222	623.679	123.492	500.187
25	22.6147	4154.39	Floor Interface	0	9.00002	10.3563	13.3482	195.223	110.946	84.2775

Interslice Data

Global Minimum Query (spencer) - Safety Factor: 1.2889

Slice Number	X coordinate [ft]	Y coordinate - Bottom [ft]	Interslice Normal Force [lbs]	Interslice Shear Force [lbs]	Interslice Force Angle [degrees]
1	1147.68	697.179	0	0	0
2	1165.69	675.371	-2782.13	-488.824	9.96523
3	1183.69	653.562	405.966	71.3288	9.96523
4	1201.7	631.754	11102.1	1950.66	9.96526
5	1219.7	609.946	29306.3	5149.16	9.96524
6	1237.71	588.137	55018.5	9666.84	9.96525
7	1255.71	566.329	88238.8	15503.7	9.96525
8	1273.72	544.521	128967	22659.7	9.96524
9	1274.56	543.505	131068	23028.8	9.96522

10	1275.4	542.489	135900	23877.9	9.96527
11	1298.53	542.052	119380	20975.2	9.96522
12	1321.67	541.616	104000	18273	9.96526
13	1346.68	540.986	89636.5	15749.3	9.96526
14	1371.69	540.357	76496.8	13440.6	9.96524
15	1391.84	540.219	64864.6	11396.8	9.96523
16	1412	540.08	54239.6	9529.98	9.96524
17	1432.15	539.941	44621.9	7840.13	9.96523
18	1452.3	539.803	36011.3	6327.24	9.96524
19	1472.46	539.664	28407.9	4991.31	9.96524
20	1492.61	539.525	21811.7	3832.35	9.96524
21	1514.8	539.471	15466.7	2717.52	9.96523
22	1536.99	539.416	10408.4	1828.77	9.96523
23	1559.18	539.361	6636.9	1166.11	9.96521
24	1581.8	538.706	4778.37	839.567	9.96524
25	1604.41	538.052	3812.75	669.905	9.96523
26	1627.02	537.398	0	0	0



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type	Shear Normal Function	Water Surface	Ru
Residual Clay		115	Undrained	1700		Constant		None	0
Slope Interface		0.1	Mohr-Coulomb	0	15			None	0
Floor Interface		0.1	Mohr-Coulomb	0	9			Piezometric Line 1	
Saturated Waste		75	Shear Normal function				Bray et al. 2009	Piezometric Line 1	
Waste		65	Shear Normal function				Bray et al. 2009	None	0

FIGURE **3C3.2**

Interior Waste Slope Stability Analysis - 4H:1V Without Benches

Permit Amendment Application MSW 692B Temple Recycling and Disposal Facility, Bell County, Texas

Slide Analysis Information

SLIDE - An Interactive Slope Stability Program

Project Summary

File Name: Section 4H-1V.slim
Slide Modeler Version: 6.03
Project Title: SLIDE - An Interactive Slope Stability Program
Date Created: 7/20/2015, 11:51:33 AM

General Settings

Units of Measurement: Imperial Units
Time Units: days
Permeability Units: feet/second
Failure Direction: Left to Right
Data Output: Standard
Maximum Material Properties: 20
Maximum Support Properties: 20

Analysis Options

Analysis Methods Used

Spencer

Number of slices: 25
Tolerance: 0.05
Maximum number of iterations: 50
Check malpha < 0.2: Yes
Initial trial value of FS: 1
Steffensen Iteration: Yes

Groundwater Analysis

Groundwater Method: Water Surfaces
Pore Fluid Unit Weight: 62.4 lbs/ft3
Advanced Groundwater Method: None

Random Numbers

Pseudo-random Seed: 10116
dom Number Generation Method: Park and Miller v.3

Surface Options

Surface Type: Non-Circular Block Search
Number of Surfaces: 5000
Pseudo-Random Surfaces: Enabled
vex Surfaces Only: Disabled
Projection Angle (Start Angle): 95
Left Projection Angle (End Angle): 265
Right Projection Angle (Start Angle): -10
Right Projection Angle (End Angle): 10
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Material Properties

Property	Residual Clay	Slope Interface	Floor Interface	Saturated Waste	Waste
Color					
Strength Type	Undrained	Mohr-Coulomb	Mohr-Coulomb	Shear Normal function	Shear Normal function
Unit Weight [lbs/ft3]	115	0.1	0.1	75	65
Cohesion [psf]		0	0		
Friction Angle [deg]		15	9		
Cohesion Type	1700				
Water Surface	None	None	Piezometric Line 1	Piezometric Line 1	None
Hu Value			1	1	
Ru Value	0	0			0

Shear Normal Functions

Name: Bray et al. 2009

Normal (psf)	Shear (psf)
0	310
600	810
5200	3840
6300	4480
7300	5120
8400	5740
16700	10550

Global Minimums

Method: spencer

FS: 1.410110
Axis Location: 1300.935, 1950.943
Left Slip Surface Endpoint: 367.013, 838.162
Right Slip Surface Endpoint: 1630.807, 536.137
Resisting Moment=3.59531e+009 lb-ft
Driving Moment=2.54966e+009 lb-ft
Resisting Horizontal Force=2.09719e+006 lb
Driving Horizontal Force=1.48725e+006 lb
Total Slice Area=155128 ft2

Slice Data

oal Minimum Query (spencer) - Safety Factor: 1.41011

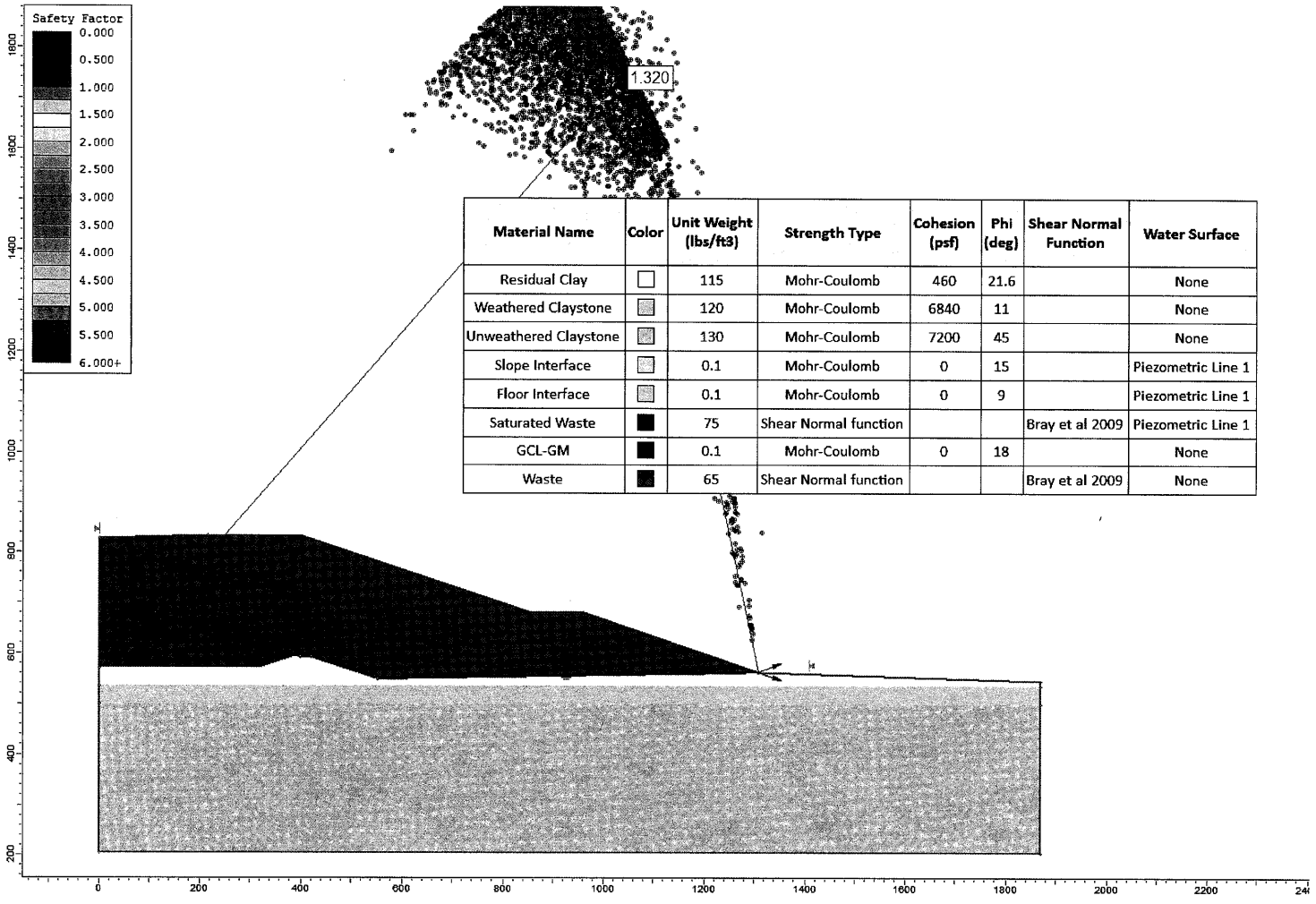
Slice Number	Width [ft]	Weight [lbs]	Base Material	Base Cohesion [psf]	Base Friction Angle [degrees]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]
1	46.2961	86411.9	Waste	414.783	33.3727	728.385	1027.1	929.595	0	929.595
2	46.2961	249364	Waste	414.783	33.3727	1722.75	2429.27	3058.31	0	3058.31
3	46.2961	388451	Waste	414.783	33.3727	2571.5	3626.09	4875.25	0	4875.25
4	46.2961	526478	Waste	448	32.6192	3368.79	4750.36	6722.45	0	6722.45
5	46.2961	664506	Waste	872.048	30.0931	4147.21	5848.03	8586.41	0	8586.41
6	0.806118	12797.2	Saturated Waste	872.048	30.0931	4531.15	6389.42	9551.83	31.2	9520.63
7	0.806118	12816.9	Floor Interface	0	9.00002	1405.05	1981.28	12602.9	93.6	12509.3
8	62.7242	964940	Floor Interface	0	9.00002	1733.54	2444.48	15558.6	124.8	15433.8
9	49.51	715571	Floor Interface	0	9.00002	1632.04	2301.36	14655	124.8	14530.2
10	57.11	778185	Floor Interface	0	9.00002	1523.67	2148.54	13690.1	124.8	13565.3
11	36.1	466934	Floor Interface	0	9.00002	1453.5	2049.59	13065.4	124.8	12940.6
12	60.17	729504	Floor Interface	0	9.00002	1368.5	1929.73	12308.7	124.8	12183.9
13	44.02	495966	Floor Interface	0	9.00002	1261.27	1778.53	11354	124.8	11229.2
14	44.02	466638	Floor Interface	0	9.00002	1185.85	1672.18	10682.5	124.8	10557.7
15	53.49	528249	Floor Interface	0	9.00002	1102.04	1554	9936.38	124.8	9811.58
16	53.49	486333	Floor Interface	0	9.00002	1013.47	1429.11	9147.85	124.8	9023.05
17	55.98	464973	Floor Interface	0	9.00002	922.928	1301.43	8341.73	124.8	8216.93
18	70.89	520035	Floor Interface	0	9.00002	819.269	1155.26	7418.82	124.8	7294.02
19	63.79	397840	Floor Interface	0	9.00002	694.727	979.642	6310.01	124.8	6185.21
20	70.27	364450	Floor Interface	0	9.00002	572.721	807.6	5223.79	124.8	5098.99
21	50.02	214785	Floor Interface	0	9.00002	471.104	664.308	4319.09	124.8	4194.29
22	60.46	208683	Floor Interface	0	9.00002	377.388	532.158	3484.72	124.8	3359.92
23	60.46	150973	Floor Interface	0	9.00002	269.106	379.469	2520.66	124.8	2395.86
24	73.2417	104822	Floor Interface	0	9.00002	148.333	209.166	1445.41	124.8	1320.61
25	64.9553	25514	Floor Interface	0	9.00002	29.3109	41.3316	411.967	151.009	260.958

Interslice Data

Global Minimum Query (spencer) - Safety Factor: 1.41011

Slice Number	X coordinate [ft]	Y coordinate - Bottom [ft]	Interslice Normal Force [lbs]	Interslice Shear Force [lbs]	Interslice Force Angle [degrees]
1	367.013	838.162	0	0	0
2	413.309	780.731	19982	1998.2	5.71059
3	459.605	723.3	116614	11661.4	5.71059
4	505.901	665.869	278669	27866.9	5.71059
5	552.198	608.438	510245	51024.5	5.71059
6	598.494	551.007	813169	81316.9	5.71059
7	599.3	550.007	819102	81910.2	5.71059
8	600.106	549.007	830583	83058.3	5.71059

9	662.83	549.007	722867	72286.7	5.71059
10	712.34	549.616	633908	63390.8	5.71059
11	769.45	547.823	572251	57225.1	5.71059
12	805.55	547.616	522977	52297.7	5.71059
13	865.72	548.713	427893	42789.3	5.71059
14	909.74	547.969	381346	38134.6	5.71059
15	953.76	547.224	337589	33758.9	5.71059
16	1007.25	545.92	292153	29215.3	5.71059
17	1060.74	544.616	250381	25038.1	5.71059
18	1116.72	542.762	214661	21466.1	5.71059
19	1187.61	542.782	156978	15697.8	5.71059
20	1251.4	542.942	112069	11206.9	5.71059
21	1321.67	541.616	79129.1	7912.91	5.71059
22	1371.69	540.357	61220.1	6122.01	5.71059
23	1432.15	539.941	40066.2	4006.62	5.71059
24	1492.61	539.525	24996.8	2499.68	5.71059
25	1565.85	539.344	14496.5	1449.65	5.71059
26	1630.81	536.137	0	0	0



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface
Residual Clay		115	Mohr-Coulomb	460	21.6		None
Weathered Claystone		120	Mohr-Coulomb	6840	11		None
Unweathered Claystone		130	Mohr-Coulomb	7200	45		None
Slope Interface		0.1	Mohr-Coulomb	0	15		Piezometric Line 1
Floor Interface		0.1	Mohr-Coulomb	0	9		Piezometric Line 1
Saturated Waste		75	Shear Normal function			Bray et al 2009	Piezometric Line 1
GCL-GM		0.1	Mohr-Coulomb	0	18		None
Waste		65	Shear Normal function			Bray et al 2009	None

Note: Cross-Section corresponds to Section A shown on Detail 4 of Fig. III-3.4

FIGURE **3C3.3**

Interior Waste Slope Stability Analysis - Section A

Permit Amendment Application MSW 692B Temple Recycling and Disposal Facility, Bell County, Texas

Slide Analysis Information

SLIDE - An Interactive Slope Stability Program

Project Summary

File Name: Section A.slim
Slide Modeler Version: 6.03
Project Title: SLIDE - An Interactive Slope Stability Program
Date Created: 11/30/2015, 4:19:09 PM

General Settings

Units of Measurement: Imperial Units
Time Units: days
Permeability Units: feet/second
Failure Direction: Left to Right
Data Output: Standard
Maximum Material Properties: 20
Maximum Support Properties: 20

Analysis Options

Analysis Methods Used

Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50
Check malpha < 0.2: Yes
Initial trial value of FS: 1
Steffensen Iteration: Yes

Groundwater Analysis

Groundwater Method: Water Surfaces
Pore Fluid Unit Weight: 62.4 lbs/ft3
Advanced Groundwater Method: None

Random Numbers

Pseudo-random Seed: 10116
dom Number Generation Method: Park and Miller v.3

Surface Options

Surface Type: Non-Circular Block Search
Number of Surfaces: 5000
Pseudo-Random Surfaces: Enabled
vex Surfaces Only: Disabled
Projection Angle (Start Angle): 150
Left Projection Angle (End Angle): 180
Right Projection Angle (Start Angle): -20
Right Projection Angle (End Angle): 20
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Material Properties

Property	Residual Clay	Weathered Claystone	Unweathered Claystone	Slope Interface	Floor Interface	Saturated Waste	GCL-GM	Waste
Color								
Strength Type	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Shear Normal function	Mohr-Coulomb	Shear Normal function
Unit Weight [lbs/ft3]	115	120	130	0.1	0.1	75	0.1	65
Cohesion [psf]	460	6840	7200	0	0		0	
Friction Angle [deg]	21.6	11	45	15	9		18	
Water Surface	None	None	None	Piezometric Line 1	Piezometric Line 1	Piezometric Line 1	None	None
Hu Value				1	1	1		
Ru Value	0	0	0				0	0

Shear Normal Functions

Name: Bray et al 2009

Normal (psf)	Shear (psf)
0	310
600	810
5200	3840
6300	4480
7300	5120
8400	5740
16700	10550

Global Minimums

ethod: spencer

FS: 1.320280
Axis Location: 1051.062, 1758.460

Left Slip Surface Endpoint: 248.357, 834.634
Right Slip Surface Endpoint: 1308.500, 562.000
Resisting Moment=2.82659e+009 lb-ft
Driving Moment=2.14091e+009 lb-ft
Resisting Horizontal Force=1.92199e+006 lb
Driving Horizontal Force=1.45575e+006 lb
Total Slice Area=141031 ft2

Slice Data

Global Minimum Query (spencer) - Safety Factor: 1.32028

Slice Number	Width [ft]	Weight [lbs]	Base Material	Base Cohesion [psf]	Base Friction Angle [degrees]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]
1	42.4891	82584.7	Waste	414.783	33.3727	724.715	956.827	822.905	0	822.905
2	42.4891	247754	Waste	414.783	33.3727	1745.05	2303.95	2868.05	0	2868.05
3	42.4891	412924	Waste	414.783	33.3727	2765.39	3651.08	4913.2	0	4913.2
4	42.4891	575096	Waste	448	32.6192	3717.01	4907.49	6967.96	0	6967.96
5	1.41031	21486.2	Floor Interface	0	9.00002	1259.84	1663.34	10564.3	62.4037	10501.9
6	43.7586	666647	Slope Interface	0	15	2814.07	3715.36	13973.1	107.156	13865.9
7	43.7586	665642	Slope Interface	0	15	2813.35	3714.41	13951.6	89.2538	13862.4
8	43.7586	664637	Slope Interface	0	15	2812.63	3713.46	13930.2	71.3513	13858.8
9	2.93815	44493.5	Floor Interface	0	9.00002	1669.18	2203.78	14007.7	93.5961	13914.1
10	50.3785	731919	Floor Interface	0	9.00002	1783.57	2354.81	14992.5	124.792	14867.7
11	50.3785	673366	Floor Interface	0	9.00002	1639.65	2164.8	13792.8	124.791	13668
12	50.3785	614813	Floor Interface	0	9.00002	1495.74	1974.79	12593.1	124.791	12468.4
13	50.3785	556260	Floor Interface	0	9.00002	1351.82	1784.78	11393.5	124.79	11268.7
14	50.3785	497707	Floor Interface	0	9.00002	1207.91	1594.78	10193.8	124.789	10069
15	50.3785	439157	Floor Interface	0	9.00002	1064	1404.78	8994.19	124.789	8869.4
16	50.3785	408932	Floor Interface	0	9.00002	989.707	1306.69	8374.94	124.788	8250.15
17	44.0812	355368	Floor Interface	0	9.00002	982.837	1297.62	8317.63	124.788	8192.84
18	44.0812	339921	Floor Interface	0	9.00002	939.445	1240.33	7955.92	124.787	7831.13
19	44.0812	295844	Floor Interface	0	9.00002	815.63	1076.86	6923.84	124.787	6799.05
20	44.0812	250772	Floor Interface	0	9.00002	689.027	909.708	5868.46	124.786	5743.67
21	44.0812	205701	Floor Interface	0	9.00002	562.42	742.552	4813.08	124.785	4688.29
22	44.0812	160629	Floor Interface	0	9.00002	435.814	575.396	3757.7	124.785	3632.91
23	44.0812	115557	Floor Interface	0	9.00002	309.207	408.24	2702.32	124.784	2577.54
24	44.0812	70485.3	Floor Interface	0	9.00002	182.601	241.084	1646.93	124.784	1522.14
25	49.2625	25489.3	Floor Interface	0	9.00002	48.6752	64.2649	530.544	124.792	405.752

Interslice Data

Global Minimum Query (spencer) - Safety Factor: 1.32028

Slice Number	X coordinate [ft]	Y coordinate - Bottom [ft]	Interslice Normal Force [lbs]	Interslice Shear Force [lbs]	Interslice Force Angle [degrees]
1	248.357	834.634	0	0	0
2	290.846	774.375	18794.4	3950.01	11.8691

3	333.335	714.117	117473	24689.2	11.8691
4	375.825	653.858	296035	62217.5	11.8691
5	418.314	593.6	557980	117270	11.869
6	419.724	591.6	577333	121338	11.8691
7	463.483	577.5	651213	136865	11.8691
8	507.241	563.4	724821	152335	11.8691
9	551	549.3	798159	167749	11.8691
10	553.938	548.353	806516	169505	11.8691
11	604.317	549.264	703002	147750	11.8691
12	654.695	550.176	607832	127748	11.8691
13	705.074	551.087	521004	109499	11.8691
14	755.452	551.998	442520	93004.2	11.8691
15	805.831	552.909	372379	78262.7	11.8691
16	856.209	553.82	310582	65274.7	11.8691
17	906.588	554.731	253091	53191.9	11.8691
18	950.669	555.529	203135	42692.7	11.8691
19	994.75	556.326	155380	32656.1	11.8691
20	1038.83	557.123	113906	23939.5	11.869
21	1082.91	557.92	78853.8	16572.7	11.8691
22	1126.99	558.718	50224.4	10555.6	11.869
23	1171.08	559.515	28017.4	5888.39	11.8691
24	1215.16	560.312	12232.7	2570.94	11.8691
25	1259.24	561.109	2870.41	603.273	11.8691
26	1308.5	562	0	0	0

APPENDIX III-3C-4

FINAL-FILLED CONFIGURATION STABILITY

FINAL-FILLED CONFIGURATION STABILITY

Made By: VK
Checked by: JBF / MX
Reviewed by: CGD

1.0 OBJECTIVE

Estimate the factors of safety against sliding and global stability for the final-filled configuration of lateral expansion cells.

2.0 GIVEN

Based on a review of the design grades, two most-critical cross-sections were selected:

Section C-C' (Figure III-3-4):
Section along Tract 5, Cell 2 and Tract 5, Cell 6, having 3H:1V excavation sideslopes and 4H:1V final cover slopes to a crest elevation of approximately 820 ft, with a maximum fill elevation of about 840 feet-msl.

Section D-D' (Figure III-3-4):
Section along Tract 5-Cell 1 and existing Tract 2A, Cell 1A, 1B and 1C. The section has 3H:1V excavation sideslopes and 4H:1V final cover slopes until Tract 2A, and approximately 3H:1V in Tract 2A. The crest elevation is approximately 820 ft, with a maximum fill elevation of about 836 feet-msl.

One feet of leachate is assumed over the liner interface (conservative since LCRS is designed to maintain < 1 foot of leachate).

The cell liner system consists of:

FLOOR: 24 inches of protective cover (clay)
6-oz nonwoven geotextile over geonet
60-mil HDPE smooth geomembrane
24-inch compacted clay liner
Subgrade

SIDEWALLS: 24 inches of protective cover (lean clay)
Double-sided geocomposite
60-mil HDPE textured geomembrane
24-inch compacted clay liner
Subgrade

GOLDER ASSOCIATES INC.
Professional Engineering Firm
Registration Number F-2578

INTENDED FOR PERMITTING PURPOSES ONLY

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Submitted: June 2016
Revised: December 2016

The following parameters were assigned to the materials based on available high load condition data.

Material	Strength Parameters		Unit Weight (pcf)		Reference
	ϕ	c	Moist	Saturated	
Waste	Bi-Linear Function		65	75	Ref. [3]
Protective cover (soil)	>28	0	115	132	Ref. [2](1)
Prot. cover (soil)/Geotextile layer of Geocomposite (F)	28	0	N/A	N/A	Golder(2)
Geotextile/Geonet (F)	11.8	0	N/A	N/A	Ref. [1]
Geocomposite/Text. Geomembrane (S)	15	0	N/A	N/A	Golder(2)
Geonet/Smooth Geomembrane (F)	9	0	N/A	N/A	Golder(2)
Textured Geomembrane/Clay Liner (S)	35	0	N/A	N/A	Golder(2)
Smooth Geomembrane/Clay Liner (F)	15	0	N/A	N/A	Golder(2)
Clay Liner	28	0	N/A	N/A	Ref. [2](1)
Clay Liner/Subgrade	28	0	N/A	N/A	Ref. [2](1)

(F) = Floor; (S) = Slope

(1) The shear strength of the protective cover soils, clay liner and the clay liner/subgrade interface is estimated based on the on-site soil shear strength. This is estimated using the average plasticity index (PI = 40) of the Stratum I and Stratum II soils described in Attachment 4, and Ref. [2].

(2) Based on unpublished data from tests performed in Golder's laboratory, on similar geosynthetic materials. Strength parameters were conservatively assigned to be equal to or a percentage of the peak strength (lower bound) to account for testing data variability and to avoid strains that result in residual interface shear strengths. This data is presented in this appendix.

Based on the data listed in the previous table, the weakest interface in the liner system along the floor of the cell is between the geonet and the smooth geomembrane. The weakest interface in the liner system along the sideslopes of the cell is between the textured geomembrane and the geocomposite. These interfaces were used in the analysis.

Subsurface profiles are determined based on available adjacent borehole information, and the same soil properties as the excavation stability analysis are used. These are shown in the below table and in Appendix III-3C-1.

Material	Unit Weight (pcf)		Strength Parameters		Analysis Stress State	Reference
	Moist	Saturated	ϕ (degrees)	c (psf)		
Residual Clay	115	120	21.6	460	Effective	Golder 2015
Weathered Claystone	120	125	11	6840	Effective	Jones & Neuse 1993
Unweathered	130	130	45	7200	Effective	Jones & Neuse 1993

Note: Jones & Neuse 1993 refers to the previous geotechnical investigation data performed during the MSW-692A permit application, which were based on consolidated undrained triaxial shear testing. Testing results are included in Part III, Attachment 4, Appendix III-4D.

3.0 METHOD

Use SLIDE v.6.0 (Ref. [4]) to analyze the final-filled configuration stability, based on limit equilibrium methods following Spencer's method of analyses.

4.0 RESULTS

Section	FS - Block Failure	FS - Circular Failure	Minimum Allowable FS(1)
C-C'	1.52	2.82	1.5
D-D'	1.50	2.87	1.5

(1) Based on generally accepted industry practice, the minimum allowable factor of safety is 1.5.

5.0 CONCLUSION

Using strength parameters that are conservatively estimated or based on test results for similar conditions, and the reasonable worst possible case configuration, the analysis indicates that the final-filled configuration will be stable.

6.0 REFERENCES

[1] Bergado D. T., Youwai S., and Voottipreux P., (2004) "Interface shear strength of different Geosynthetics in landfill liner syatem: A case of Sakaew landfill, Thailand" Geoasia-204, 507-514.

[2] Bjerrum, L. and Simons, N. E. (1960). "Comparison of shear strength characteristics of normally consolidated clays." Proceedings of the Research Conference on Shear Strength of Cohesive Soils, ASCE, Boulder, Colorado, 1960, pp. 711–726.

[3] Bray, J.D., D. Zekkos, E. Kavazanjian, Jr., G.A. Athanasopoulos, and F. Riemer. 2009. Shear strength of municipal solid waste. J. Geotech. Geoenviron. Eng. (ASCE) 135(6): 709–22.

[4] Rocscience 2015, SLIDE - 2D Limit Equilibrium Slope Stability for Soil and Rock Slopes.

Smooth Geomembrane vs. Geonet

Date	Interface	Condition (Dry/Wet)	Shear Rate (in/min)	Normal Stress (psf)	Peak Shear Stress (psf)
Jun-03	Solmax 460 Smooth HDPE GM vs SKAPS Transnet 220 GN	Wet	0.2	2000	161
				5000	755
				8000	1295
Jul-10	Agru 40 mil Smooth HDPE GM vs SKAPS GN	Hydrated	0.2	750	206
				1500	408
				3000	1295

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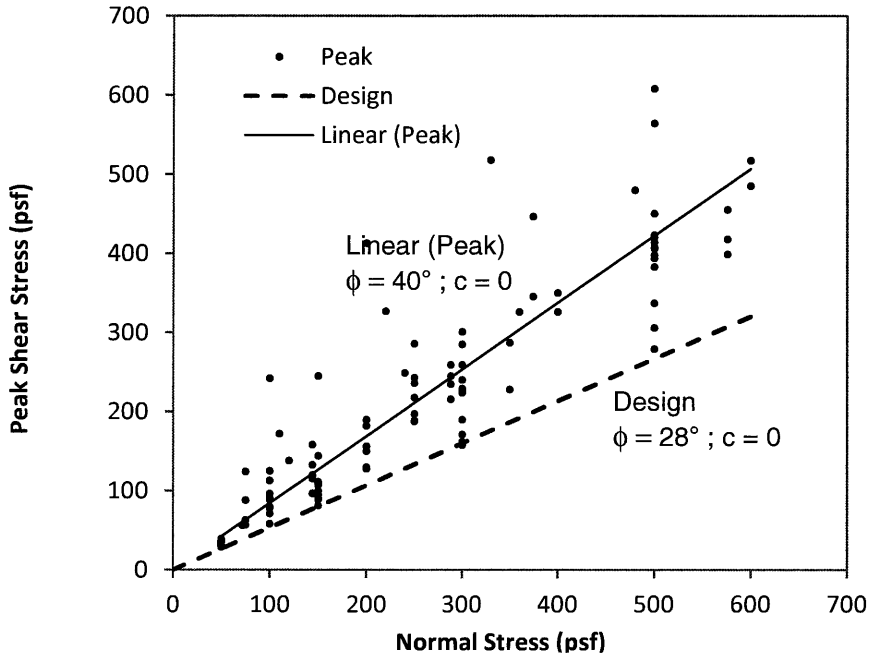
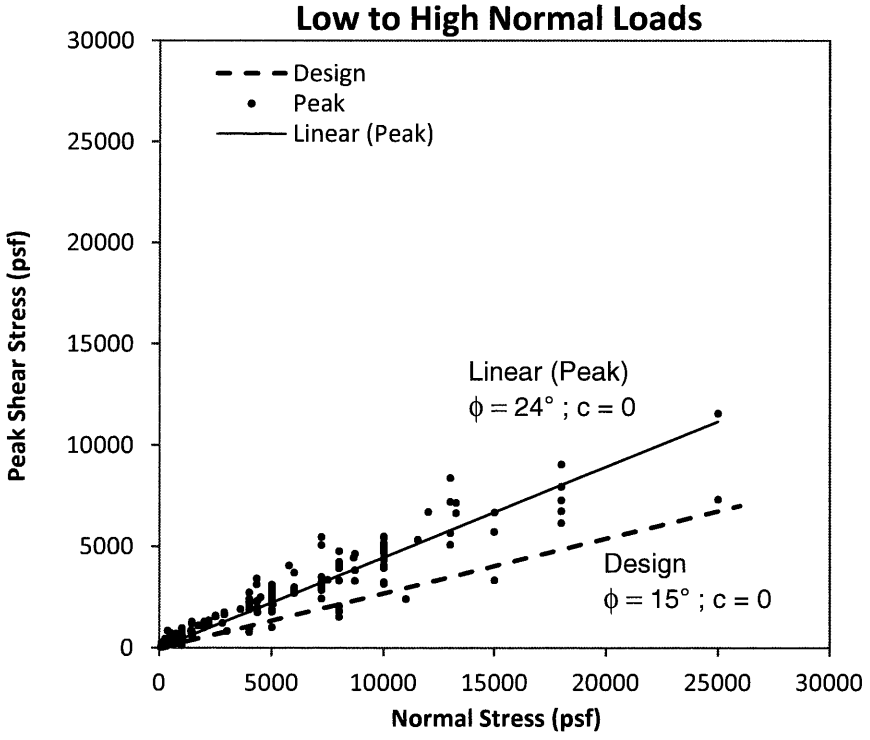
Submitted: June 2016
Revised: December 2016

Direct Shear - Geocomposite vs Protective Cover
Low Normal Loads



Direct Shear - TGM vs GC
Low to High Normal Loads



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Submitted: June 2016
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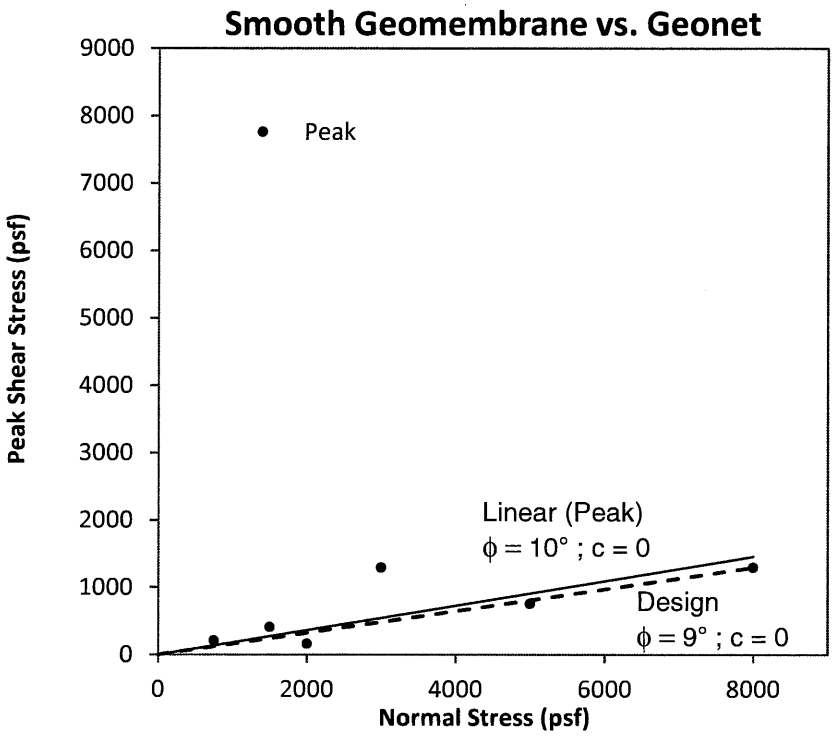

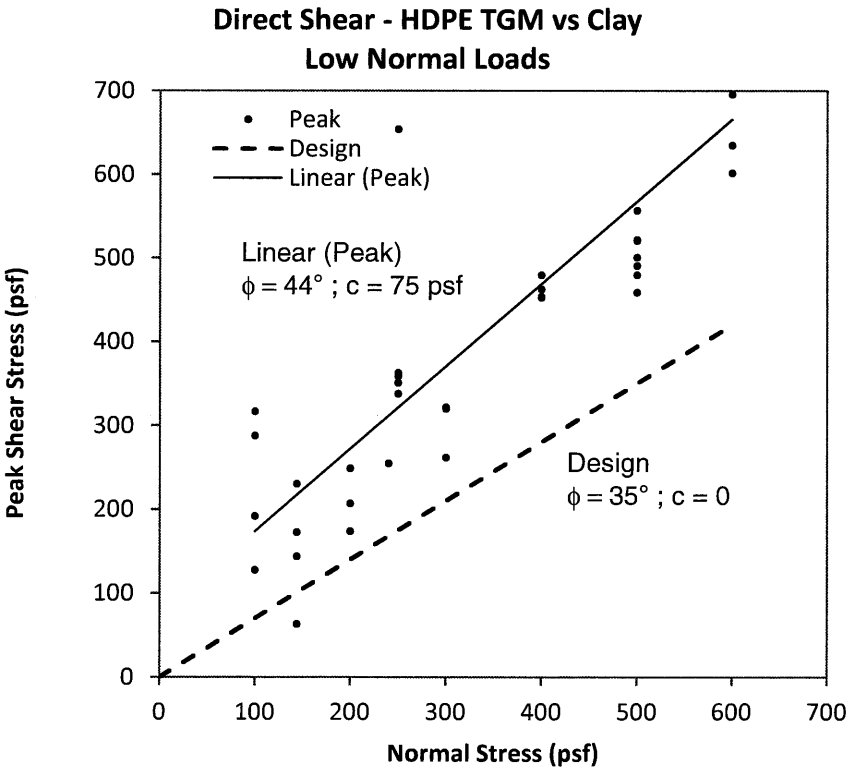

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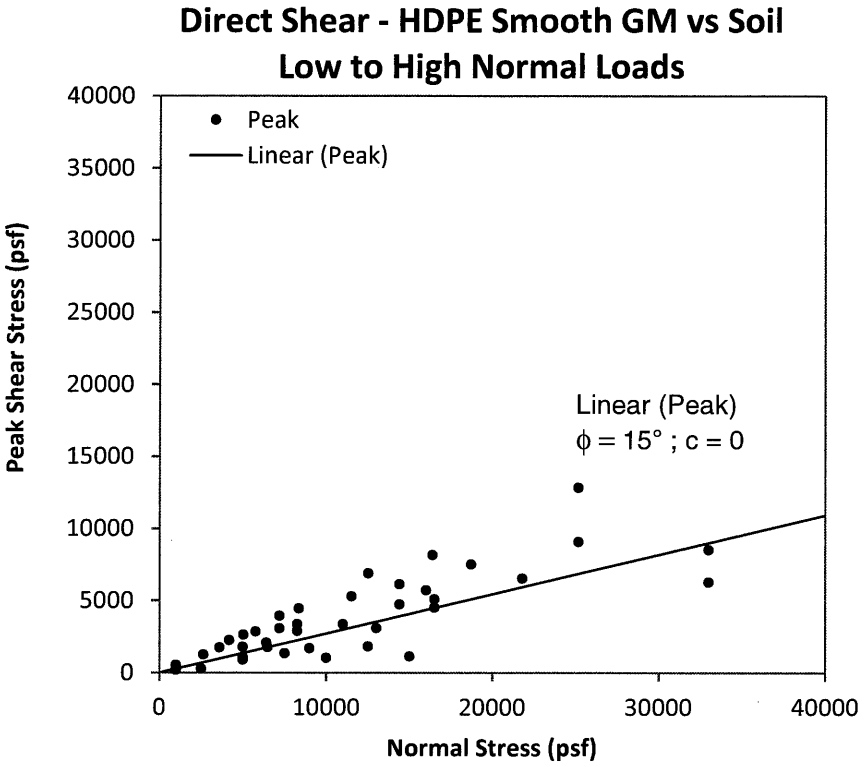
Submitted: June 2016
Revised: December 2016



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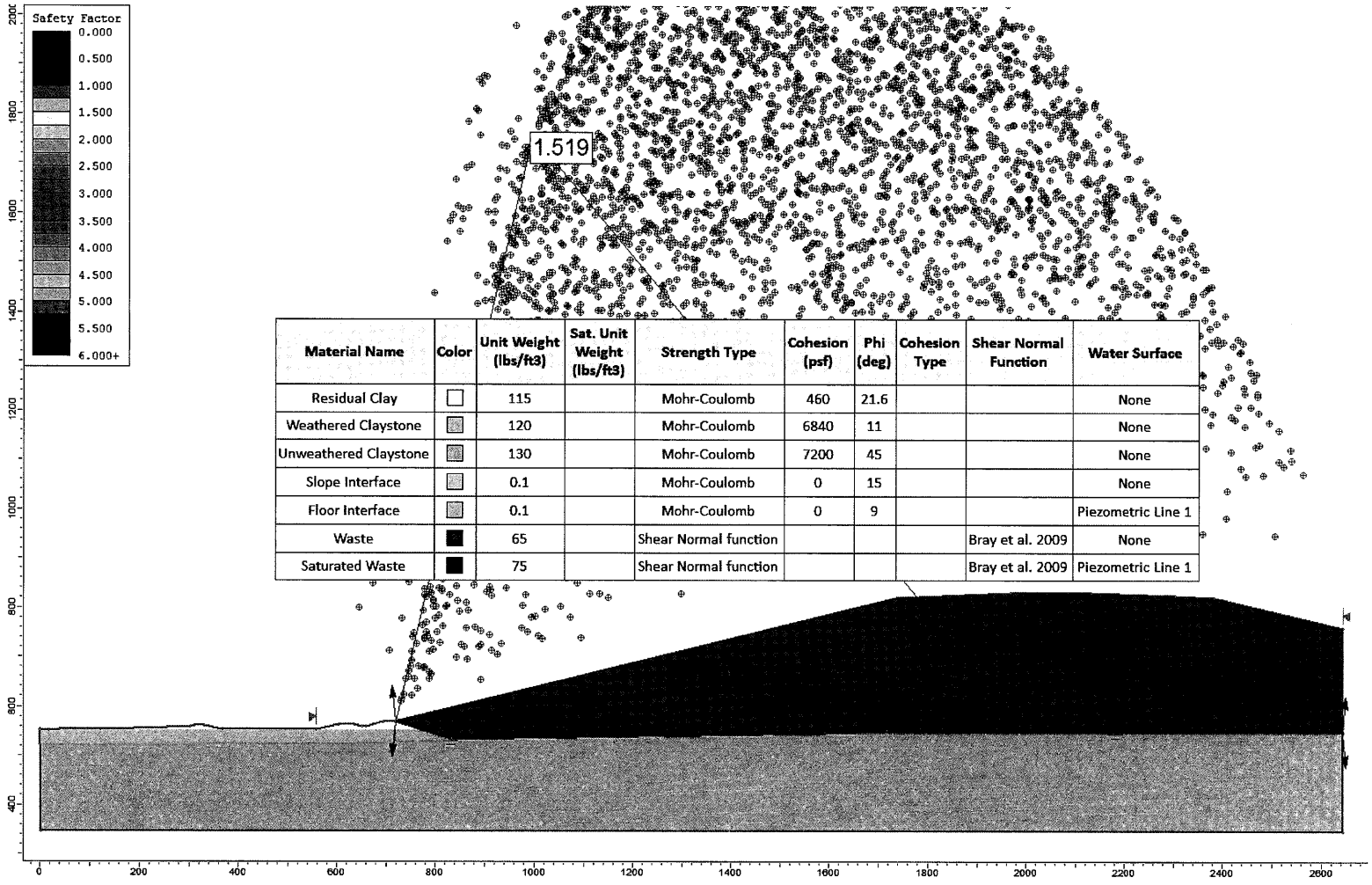
Submitted: June 2016
Revised: December 2016



Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type	Shear Normal Function	Water Surface
Residual Clay		115		Mohr-Coulomb	460	21.6			None
Weathered Claystone		120		Mohr-Coulomb	6840	11			None
Unweathered Claystone		130		Mohr-Coulomb	7200	45			None
Slope Interface		0.1		Mohr-Coulomb	0	15			None
Floor Interface		0.1		Mohr-Coulomb	0	9			Piezometric Line 1
Waste		65		Shear Normal function				Bray et al. 2009	None
Saturated Waste		75		Shear Normal function				Bray et al. 2009	Piezometric Line 1

FIGURE **3C4.1**

Final Configuration Stability Analysis - Section C-C' - Block Failure

Permit Amendment Application MSW 692B Temple Recycling and Disposal Facility, Bell County, Texas

Slide Analysis Information

SLIDE - An Interactive Slope Stability Program

Project Summary

File Name: FinalConfig_D-D'_Block.slim
Slide Modeler Version: 6.03
Project Title: SLIDE - An Interactive Slope Stability Program
Date Created: 6/2/2015, 3:44:21 PM

General Settings

Units of Measurement: Imperial Units
Time Units: days
Permeability Units: feet/second
Failure Direction: Right to Left
Data Output: Standard
Maximum Material Properties: 20
Maximum Support Properties: 20

Analysis Options

Analysis Methods Used

Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50
Check malpha < 0.2: Yes
Initial trial value of FS: 1
Steffensen Iteration: Yes

Groundwater Analysis

Groundwater Method: Water Surfaces
Pore Fluid Unit Weight: 62.4 lbs/ft3
Advanced Groundwater Method: None

Random Numbers

Pseudo-random Seed: 10116
dom Number Generation Method: Park and Miller v.3

Surface Options

Surface Type: Non-Circular Block Search
Number of Surfaces: 5000
Pseudo-Random Surfaces: Enabled
Convex Surfaces Only: Disabled
Left Projection Angle (Start Angle): 95
Left Projection Angle (End Angle): 265
Right Projection Angle (Start Angle): -85
Right Projection Angle (End Angle): 85
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Material Properties

Property	Residual Clay	Weathered Claystone	Unweathered Claystone	Slope Interface	Floor Interface	Waste	Saturated Waste
Color							
Strength Type	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Shear Normal function	Shear Normal function
Unit Weight [lbs/ft3]	115	120	130	0.1	0.1	65	75
Cohesion [psf]	460	6840	7200	0	0		
Friction Angle [deg]	21.6	11	45	15	9		
Water Surface	None	None	None	None	Piezometric Line 1	None	Piezometric Line 1
Ru Value					1		1
Ru Value	0	0	0	0		0	

Shear Normal Functions

Name: Bray et al. 2009

Normal (psf)	Shear (psf)
0	310
600	810
5200	3840
6300	4480
7300	5120
8400	5740
16700	10550

Global Minimums

Method: spencer

FS: 1.519100
Axis Location: 997.238, 1755.875
Left Slip Surface Endpoint: 719.653, 569.556
Right Slip Surface Endpoint: 1779.742, 822.016
Resisting Moment=2.85347e+009 lb-ft

Driving Moment=1.87839e+009 lb-ft
Resisting Horizontal Force=1.94479e+006 lb
Driving Horizontal Force=1.28022e+006 lb
Total Slice Area=132006 ft2

Slice Data

Global Minimum Query (spencer) - Safety Factor: 1.5191

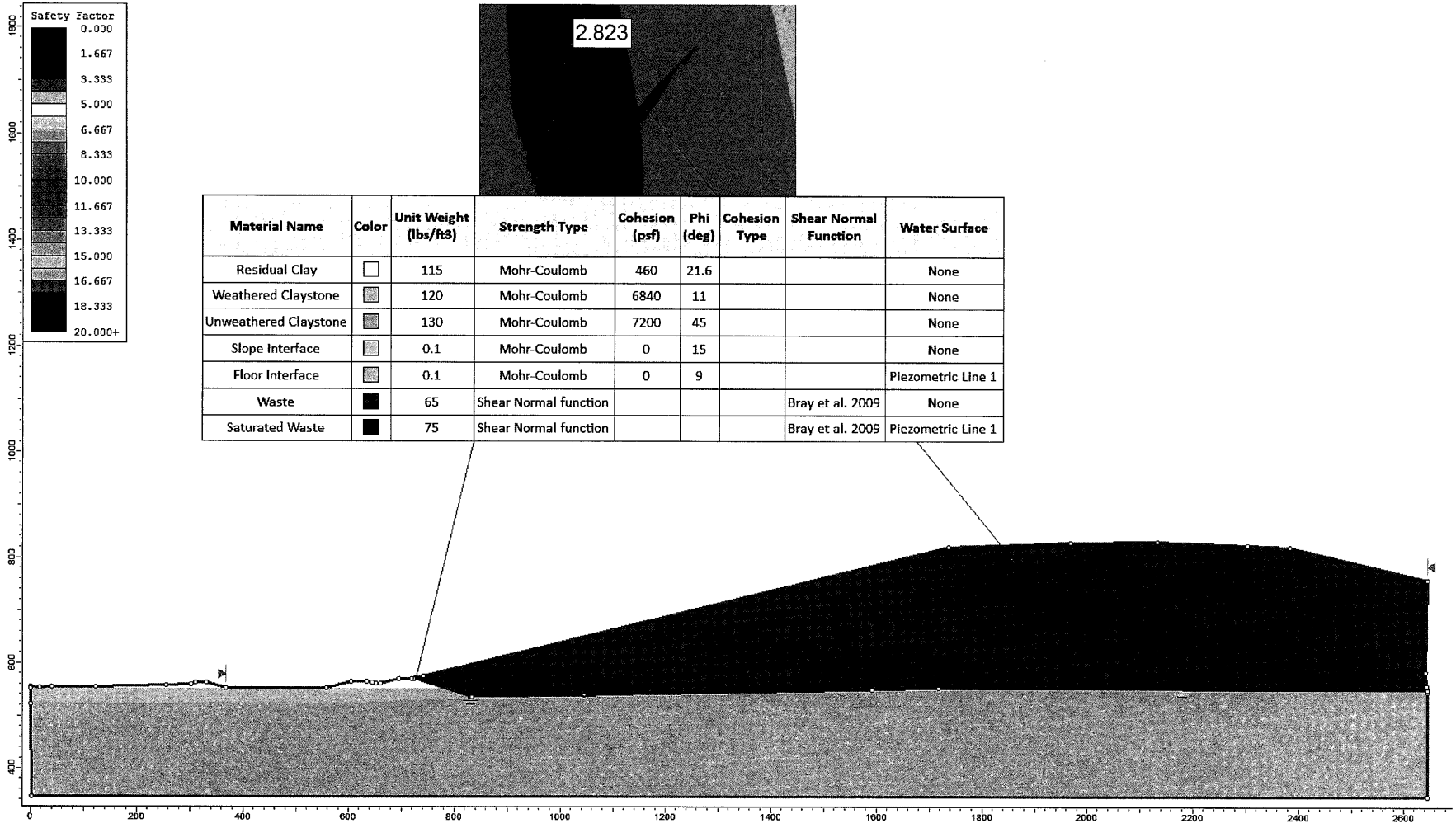
Slice Number	Width [ft]	Weight [lbs]	Base Material	Base Cohesion [psf]	Base Friction Angle [degrees]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]
1	2.32327	0.0856154	Slope Interface	0	15	0.00694418	0.0105489	0.039369	0	0.039369
2	55.2336	56871.9	Slope Interface	0	15	216.707	329.2	1228.59	0	1228.59
3	55.2336	170802	Slope Interface	0	15	650.831	988.677	3689.78	0	3689.78
4	46.0746	205857	Floor Interface	0	9.00002	461.172	700.566	4539.31	116.111	4423.2
5	46.0746	237585	Floor Interface	0	9.00002	534.484	811.934	5239.35	112.998	5126.35
6	46.0746	269312	Floor Interface	0	9.00002	607.796	923.303	5939.39	109.885	5829.51
7	46.0746	301039	Floor Interface	0	9.00002	681.107	1034.67	6639.43	106.771	6532.66
8	46.0746	332751	Floor Interface	0	9.00002	754.381	1145.98	7339.12	103.658	7235.47
9	46.0746	364288	Floor Interface	0	9.00002	826.805	1256	8034.89	104.837	7930.05
10	46.0746	395777	Floor Interface	0	9.00002	899.032	1365.72	8729.55	106.712	8622.83
11	46.0746	427265	Floor Interface	0	9.00002	971.266	1475.45	9424.21	108.586	9315.62
12	46.0746	458754	Floor Interface	0	9.00002	1043.5	1585.18	10118.9	110.461	10008.4
13	46.0746	490242	Floor Interface	0	9.00002	1115.73	1694.9	10813.5	112.336	10701.2
14	46.0746	521730	Floor Interface	0	9.00002	1187.96	1804.63	11508.2	114.21	11394
15	46.0746	553219	Floor Interface	0	9.00002	1260.19	1914.36	12202.9	116.085	12086.8
16	46.0746	584707	Floor Interface	0	9.00002	1332.43	2024.09	12897.5	117.96	12779.6
17	46.0746	616195	Floor Interface	0	9.00002	1404.65	2133.81	13592.2	119.834	13472.4
18	46.0746	647684	Floor Interface	0	9.00002	1476.89	2243.54	14286.9	121.709	14165.1
19	0.909233	13098.1	Floor Interface	0	9.00002	1138.76	1729.89	11014.6	92.5232	10922.1
20	0.941736	13543.9	Saturated Waste	872.048	30.0931	3966.28	6025.18	8923.27	31.2	8892.07
21	50.8659	659893	Waste	1005.45	29.4072	3633.65	5519.88	8009.48	0	8009.48
22	50.8659	519689	Waste	814.545	30.1916	2932.43	4454.65	6256.45	0	6256.45
23	50.8659	379485	Waste	414.783	33.3727	2227.26	3383.43	4506.86	0	4506.86
24	50.8659	239281	Waste	414.783	33.3727	1481.39	2250.38	2786.72	0	2786.72
25	50.8659	87017.6	Waste	414.783	33.3727	671.995	1020.83	920.068	0	920.068

Interslice Data

Global Minimum Query (spencer) - Safety Factor: 1.5191

Slice ımber	X coordinate [ft]	Y coordinate - Bottom [ft]	Interslice Normal Force [lbs]	Interslice Shear Force [lbs]	Interslice Force Angle [degrees]
1	719.653	569.556	0	0	0
2	721.977	569.391	0.0225933	0.00471099	11.7781
3	777.21	551.285	34201.9	7131.54	11.7782

4	832.444	533.179	136919	28549.5	11.7782
5	878.518	533.988	154471	32209.2	11.7782
6	924.593	534.797	174830	36454.3	11.7781
7	970.667	535.607	197996	41284.9	11.7782
8	1016.74	536.416	223971	46700.8	11.7781
9	1062.82	537.226	252751	52701.9	11.7782
10	1108.89	538.035	284302	59280.6	11.7781
11	1154.97	538.844	318614	66435.2	11.7782
12	1201.04	539.654	355689	74165.8	11.7782
13	1247.11	540.463	395526	82472.3	11.7782
14	1293.19	541.272	438125	91354.8	11.7782
15	1339.26	542.082	483487	100813	11.7781
16	1385.34	542.891	531610	110848	11.7782
17	1431.41	543.7	582496	121458	11.7782
18	1477.49	544.51	636144	132644	11.7781
19	1523.56	545.319	692555	144407	11.7782
20	1524.47	546.301	682772	142367	11.7782
21	1525.41	547.318	677427	141252	11.7781
22	1576.28	602.258	422019	87996.6	11.7782
23	1627.14	657.197	227293	47393.6	11.7782
24	1678.01	712.137	92857.4	19362	11.7782
25	1728.88	767.077	15027.6	3133.44	11.7781
26	1779.74	822.016	0	0	0



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type	Shear Normal Function	Water Surface
Residual Clay		115	Mohr-Coulomb	460	21.6			None
Weathered Claystone		120	Mohr-Coulomb	6840	11			None
Unweathered Claystone		130	Mohr-Coulomb	7200	45			None
Slope Interface		0.1	Mohr-Coulomb	0	15			None
Floor Interface		0.1	Mohr-Coulomb	0	9			Piezometric Line 1
Waste		65	Shear Normal function				Bray et al. 2009	None
Saturated Waste		75	Shear Normal function				Bray et al. 2009	Piezometric Line 1

FIGURE **3C4.2**

Final Configuration Stability Analysis – Section C-C' - Circular Failure

Permit Amendment Application MSW 692B Temple Recycling and Disposal Facility, Bell County, Texas

Slide Analysis Information

SLIDE - An Interactive Slope Stability Program

Project Summary

File Name: FinalConfig_D-D'_Circular.slim
Slide Modeler Version: 6.03
Project Title: SLIDE - An Interactive Slope Stability Program
Date Created: 6/2/2015, 3:44:21 PM

General Settings

Units of Measurement: Imperial Units
Time Units: days
Permeability Units: feet/second
Failure Direction: Right to Left
Data Output: Standard
Maximum Material Properties: 20
Maximum Support Properties: 20

Analysis Options

Analysis Methods Used

Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50
Check malpha < 0.2: Yes
Initial trial value of FS: 1
Steffensen Iteration: Yes

Groundwater Analysis

Groundwater Method: Water Surfaces
Pore Fluid Unit Weight: 62.4 lbs/ft3
Advanced Groundwater Method: None

Random Numbers

Pseudo-random Seed: 10116
dom Number Generation Method: Park and Miller v.3

Surface Options

Surface Type: Circular
Search Method: Grid Search
Radius Increment: 10
Composite Surfaces: Disabled
Reverse Curvature: Create Tension Crack
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Material Properties

Property	Residual Clay	Weathered Claystone	Unweathered Claystone	Slope Interface	Floor Interface	Waste	Saturated Waste
Color							
Strength Type	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Shear Normal function	Shear Normal function
Unit Weight [lbs/ft3]	115	120	130	0.1	0.1	65	75
Cohesion [psf]	460	6840	7200	0	0		
Friction Angle [deg]	21.6	11	45	15	9		
Water Surface	None	None	None	None	Piezometric Line 1	None	Piezometric Line 1
Hu Value					1		1
Ru Value	0	0	0	0		0	

Shear Normal Functions

Name: Bray et al. 2009

Normal (psf)	Shear (psf)
0	310
600	810
5200	3840
6300	4480
7300	5120
8400	5740
16700	10550

Global Minimums

Method: spencer

FS: 2.823050
Center: 1027.996, 1812.477
Radius: 1277.321
Left Slip Surface Endpoint: 726.510, 571.245
Right Slip Surface Endpoint: 1837.336, 824.288
Resisting Moment=5.78883e+009 lb-ft
Driving Moment=2.05056e+009 lb-ft
Resisting Horizontal Force=4.29506e+006 lb

Driving Horizontal Force=1.52142e+006 lb
Total Slice Area=113200 ft2

;e Data

Global Minimum Query (spencer) - Safety Factor: 2.82305

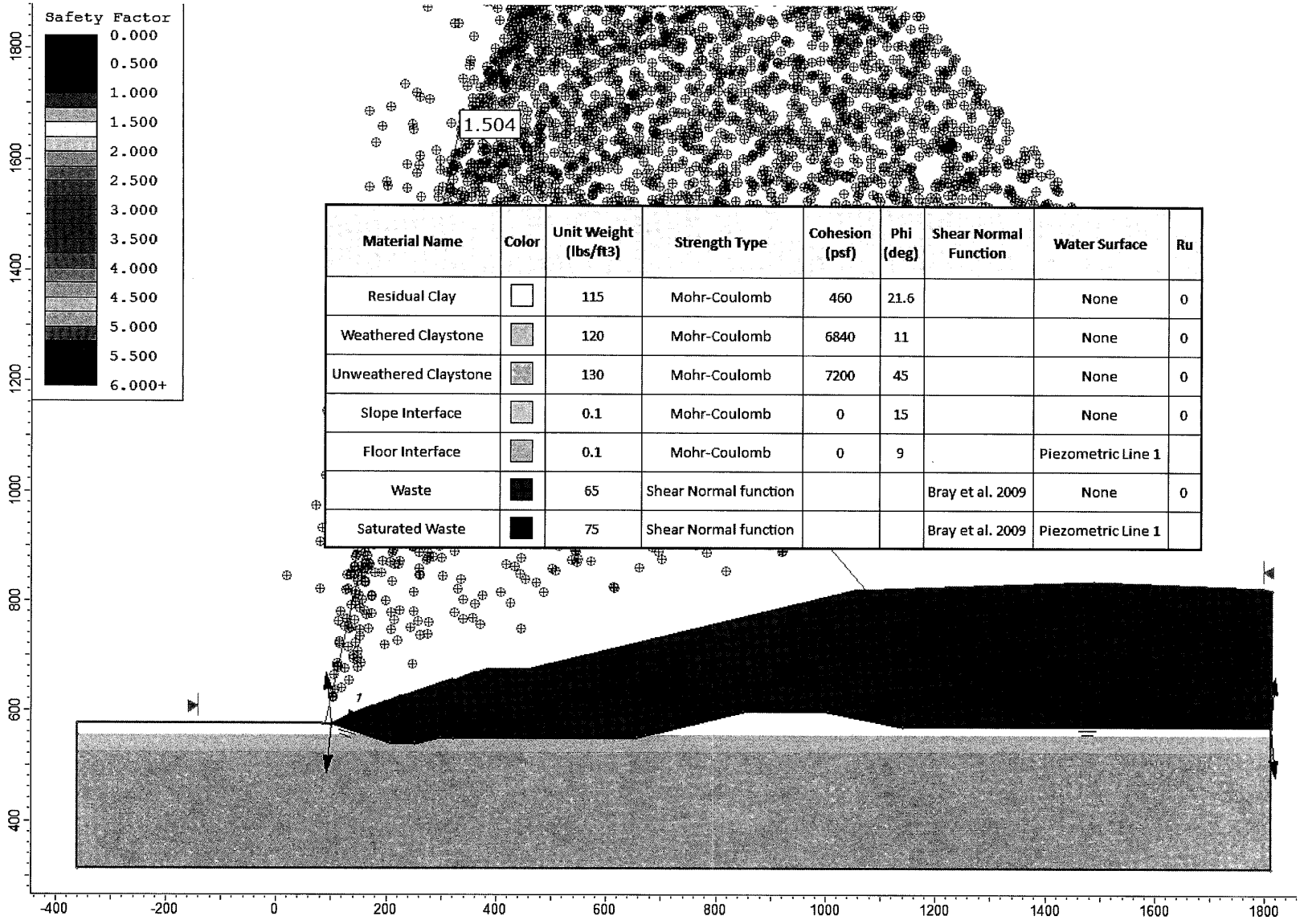
Slice Number	Width [ft]	Weight [lbs]	Base Material	Base Cohesion [psf]	Base Friction Angle [degrees]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]
1	46.133	32495.2	Waste	414.783	33.3727	357.409	1008.98	902.086	0	902.086
2	46.133	94828.6	Waste	414.783	33.3727	714.781	2017.86	2433.73	0	2433.73
3	46.133	151902	Waste	414.783	33.3727	1028.79	2904.32	3779.5	0	3779.5
4	46.133	203811	Waste	414.783	33.3727	1302.58	3677.24	4952.9	0	4952.9
5	46.133	250628	Waste	814.545	30.1916	1516.69	4281.7	5959.16	0	5959.16
6	15.1365	91777.3	Saturated Waste	448	32.6192	1639.06	4627.16	6561.14	31.2	6529.94
7	48.79	320971	Floor Interface	0	9.00002	368.945	1041.55	6700.92	124.8	6576.12
8	58.408	430977	Floor Interface	0	9.00002	406.45	1147.43	7430.41	185.841	7244.57
9	48.5211	396527	Floor Interface	0	9.00002	449.592	1269.22	8138.32	124.8	8013.52
10	15.0823	129804	Saturated Waste	872.048	30.0931	2092.05	5905.97	8717.56	31.2	8686.36
11	46.2816	411332	Waste	872.048	30.0931	2136.51	6031.49	8902.98	0	8902.98
12	46.2816	427894	Waste	872.048	30.0931	2178.53	6150.11	9107.69	0	9107.69
13	46.2816	439244	Waste	872.048	30.0931	2196.4	6200.56	9194.72	0	9194.72
14	46.2816	445286	Waste	872.048	30.0931	2190.66	6184.35	9166.76	0	9166.76
15	46.2816	445900	Waste	872.048	30.0931	2161.73	6102.66	9025.8	0	9025.8
16	46.2816	440935	Waste	872.048	30.0931	2109.93	5956.43	8773.46	0	8773.46
17	46.2816	430210	Waste	872.048	30.0931	2035.49	5746.3	8410.87	0	8410.87
18	46.2816	413509	Waste	1005.45	29.4072	1941.08	5479.76	7938.28	0	7938.28
19	46.2816	390570	Waste	1005.45	29.4072	1824.83	5151.6	7356.07	0	7356.07
20	46.2816	361084	Waste	448	32.6192	1670.35	4715.49	6667.96	0	6667.96
21	46.2816	324679	Waste	814.545	30.1916	1498.25	4229.63	5869.68	0	5869.68
22	46.2816	280913	Waste	414.783	33.3727	1304.39	3682.35	4960.67	0	4960.67
23	46.2816	228882	Waste	414.783	33.3727	1066.57	3010.99	3941.44	0	3941.44
24	46.2816	150033	Waste	414.783	33.3727	730.477	2062.17	2500.99	0	2500.99
25	46.2816	51644.5	Waste	414.783	33.3727	332.507	938.683	795.36	0	795.36

Interslice Data

Global Minimum Query (spencer) - Safety Factor: 2.82305

Slice Number	X coordinate [ft]	Y coordinate - Bottom [ft]	Interslice Normal Force [lbs]	Interslice Shear Force [lbs]	Interslice Force Angle [degrees]
1	726.51	571.245	0	0	0
2	772.643	560.94	25791.4	5475.17	11.9852
3	818.776	552.407	79547.8	16886.9	11.9852
4	864.909	545.61	152718	32419.9	11.9852
5	911.041	540.521	238038	50532.3	11.9852
6	957.174	537.12	328302	69694.1	11.9852

7	972.311	536.37	358046	76008.4	11.9852
8	1021.1	535.174	384068	81532.3	11.9852
9	1079.51	536.195	400234	84964.3	11.9852
10	1128.03	539.079	398587	84614.6	11.9852
11	1143.11	540.353	419040	88956.5	11.9852
12	1189.39	545.393	473092	100431	11.9852
13	1235.68	552.152	512406	108777	11.9852
14	1281.96	560.657	535901	113764	11.9851
15	1328.24	570.944	543031	115278	11.9852
16	1374.52	583.058	533781	113314	11.9851
17	1420.8	597.054	508681	107986	11.9852
18	1467.08	612.997	468829	99526.1	11.9852
19	1513.37	630.967	416055	88322.9	11.9852
20	1559.65	651.056	352764	74887	11.9852
21	1605.93	673.379	281257	59707.1	11.9852
22	1652.21	698.068	205710	43669.4	11.9852
23	1698.49	725.285	131089	27828.4	11.9852
24	1744.77	755.226	62464.3	13260.3	11.9852
25	1791.05	788.128	13997.9	2971.56	11.9852
26	1837.34	824.288	0	0	0



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface	Ru
Residual Clay		115	Mohr-Coulomb	460	21.6		None	0
Weathered Claystone		120	Mohr-Coulomb	6840	11		None	0
Unweathered Claystone		130	Mohr-Coulomb	7200	45		None	0
Slope Interface		0.1	Mohr-Coulomb	0	15		None	0
Floor Interface		0.1	Mohr-Coulomb	0	9		Piezometric Line 1	
Waste		65	Shear Normal function			Bray et al. 2009	None	0
Saturated Waste		75	Shear Normal function			Bray et al. 2009	Piezometric Line 1	

FIGURE **3C4.3**

Final Configuration Stability Analysis – Section D-D' - Block Failure

Permit Amendment Application MSW 692B Temple Recycling and Disposal Facility, Bell County, Texas

Slide Analysis Information

SLIDE - An Interactive Slope Stability Program

Project Summary

File Name:	Final Config_Block.slim
Slide Modeler Version:	6.03
Project Title:	SLIDE - An Interactive Slope Stability Program
Date Created:	11/2/2016, 4:04:21 PM

General Settings

Units of Measurement:	Imperial Units
Time Units:	days
Permeability Units:	feet/second
Failure Direction:	Right to Left
Data Output:	Standard
Maximum Material Properties:	20
Maximum Support Properties:	20

Analysis Options

Slices Type:	Vertical
Analysis Methods Used	
GLE/Morgenstern-Price with interslice force function:	Half Sine Spencer
Number of slices:	50
Tolerance:	0.005
Maximum number of iterations:	75
Check malpha < 0.2:	Yes
Create Interslice boundaries at intersections with water tables and piezos:	Yes
Initial trial value of FS:	1
Steffensen Iteration:	Yes

Groundwater Analysis

Groundwater Method:	Water Surfaces
Pore Fluid Unit Weight [lbs/ft3]:	62.4
Advanced Groundwater Method:	None

Random Numbers

Pseudo-random Seed:	10116
Random Number Generation Method:	Park and Miller v.3

Surface Options

Surface Type:	Non-Circular Block Search
Number of Surfaces:	5000
Multiple Groups:	Disabled
Pseudo-Random Surfaces:	Enabled
Convex Surfaces Only:	Disabled
Left Projection Angle (Start Angle):	95
Left Projection Angle (End Angle):	265
Right Projection Angle (Start Angle):	-85
Right Projection Angle (End Angle):	85
Minimum Elevation:	Not Defined
Minimum Depth:	Not Defined
Minimum Area:	Not Defined
Minimum Weight:	Not Defined

Seismic

Advanced seismic analysis:	No
Staged pseudostatic analysis:	No

Material Properties

Property	Residual Clay	Weathered Claystone	Unweathered Claystone	Slope Interface	Floor Interface	Waste	Saturated Waste
Color							
Strength Type	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Shear Normal function	Shear Normal function
Unit Weight [lbs/ft3]	115	120	130	0.1	0.1	65	75
Cohesion [psf]	460	6840	7200	0	0		
Friction Angle [deg]	21.6	11	45	15	9		
Water Surface	None	None	None	None	Piezometric Line 1	None	Piezometric Line 1
Hu Value					1		1
Ru Value	0	0	0	0		0	

Shear Normal Functions

Name: Bray et al. 2009

Normal (psf)	Shear (psf)
0	310
600	810
5200	3840
6300	4480
7300	5120
8400	5740
16700	10550

Global Minimums

Method: spencer

FS	1.504160
Axis Location:	338.392, 1682.436
Left Slip Surface Endpoint:	89.970, 576.722
Right Slip Surface Endpoint:	1073.910, 820.270
Resisting Moment:	2.4393e+009 lb-ft
Driving Moment:	1.62171e+009 lb-ft
Resisting Horizontal Force:	1.86911e+006 lb
Driving Horizontal Force:	1.24263e+006 lb
Total Slice Area:	112268 ft2
Surface Horizontal Width:	983.94 ft
Surface Average Height:	114.1 ft

Method: gle/morgenstern-price

FS	1.485250
Axis Location:	307.222, 1577.288
Left Slip Surface Endpoint:	86.892, 577.000
Right Slip Surface Endpoint:	975.254, 800.852
Resisting Moment:	1.84127e+009 lb-ft
Driving Moment:	1.2397e+009 lb-ft
Resisting Horizontal Force:	1.51881e+006 lb
Driving Horizontal Force:	1.0226e+006 lb
Total Slice Area:	103748 ft2
Surface Horizontal Width:	888.362 ft
Surface Average Height:	116.786 ft

Global Minimum Coordinates

Method: spencer

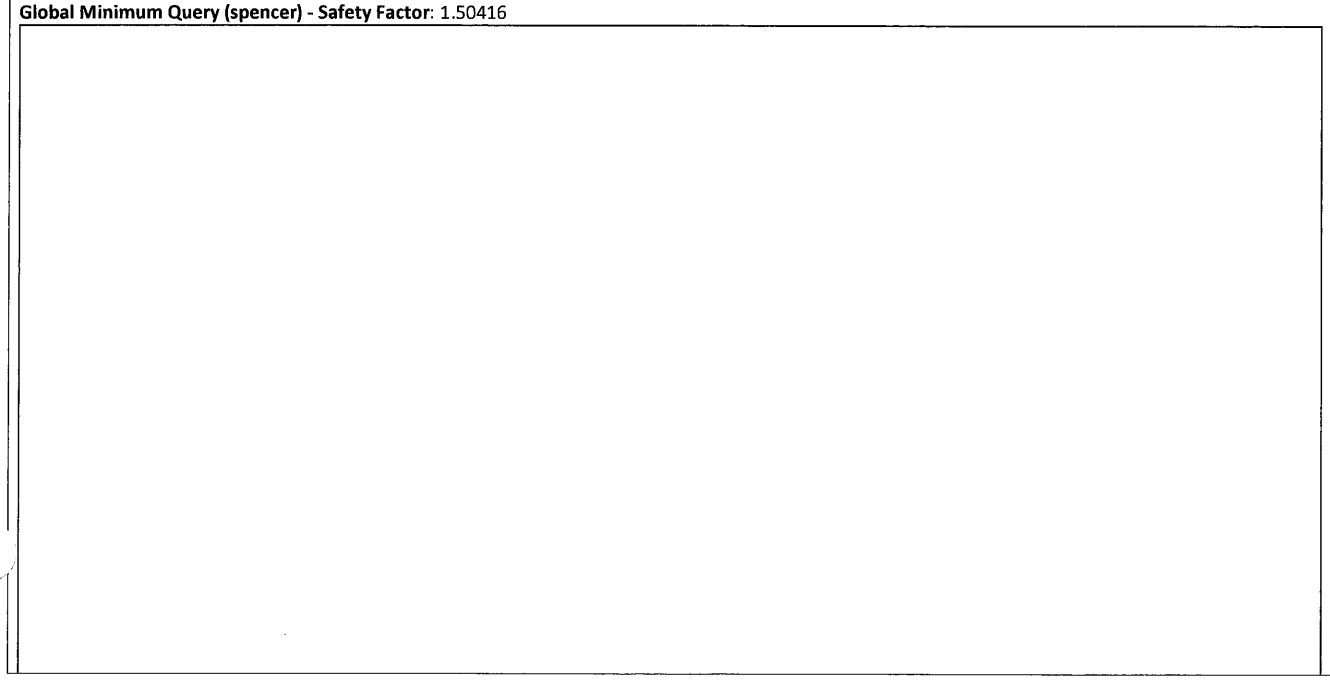
X	Y
89.9702	576.722
112.76	572.589
206.721	541.239
251.328	540.909
297.518	551.011
321.096	550.025
655.424	552.312
834.995	595.839
1073.91	820.27

Method: gle/morgenstern-price

X	Y
86.8923	577
105.875	574.886
206.721	541.239
251.328	540.909
297.518	551.011
321.096	550.025
655.424	552.312
839.841	597.013
975.254	800.852

Slice Data

Global Minimum Query (spencer) - Safety Factor: 1.50416



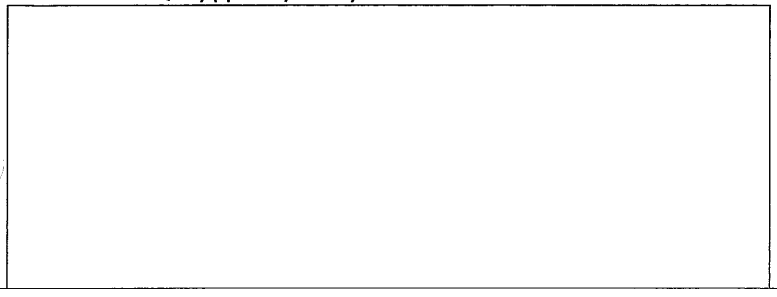
Slice Number	Width [ft]	Weight [lbs]	Angle of Slice Base [degrees]	Base Material	Base Cohesion [psf]	Base Friction Angle [degrees]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]
1	15.7151	1152.71	-10.279	Residual Clay	460	21.6	361.73	544.101	212.413	0	212.413
2	7.07499	2695.17	-10.279	Slope Interface	0	15	75.2599	113.203	422.479	0	422.479
3	18.7921	20047.9	-18.4512	Slope Interface	0	15	224.364	337.48	1259.49	0	1259.49
4	18.7921	37536.9	-18.4512	Slope Interface	0	15	420.091	631.884	2358.22	0	2358.22
5	18.7921	54572.4	-18.4512	Slope Interface	0	15	610.743	918.655	3428.47	0	3428.47
6	18.7921	70382.2	-18.4512	Slope Interface	0	15	787.676	1184.79	4421.71	0	4421.71
7	18.7921	85826.7	-18.4512	Slope Interface	0	15	960.523	1444.78	5391.98	0	5391.98
8	22.3035	117084	-0.423863	Floor Interface	0	9.00002	551.236	829.147	5362.51	127.501	5235.01
9	22.3035	126509	-0.423863	Floor Interface	0	9.00002	596.498	897.228	5794.4	129.525	5664.88
10	23.095	139327	12.3366	Slope Interface	0	15	1026.97	1544.73	5765.01	0	5765.01
11	23.095	144013	12.3366	Slope Interface	0	15	1061.52	1596.69	5958.96	0	5958.96
12	23.578	156511	-2.39464	Floor Interface	0	9.00002	708.236	1065.3	6850.83	124.821	6726.01
13	20.8955	146841	0.391931	Floor Interface	0	9.00002	739.662	1112.57	7149.65	125.175	7024.47
14	20.8955	156636	0.391931	Floor Interface	0	9.00002	789.909	1188.15	7626.73	125.062	7501.66
15	20.8955	163353	0.391931	Floor Interface	0	9.00002	824.367	1239.98	7953.87	124.95	7828.92
16	20.8955	167696	0.391931	Floor Interface	0	9.00002	846.652	1273.5	8165.39	124.838	8040.56
17	20.8955	168519	0.391931	Floor Interface	0	9.00002	850.887	1279.87	8205.5	124.725	8080.77
18	20.8955	169343	0.391931	Floor Interface	0	9.00002	855.122	1286.24	8245.65	124.613	8121.04
19	20.8955	170204	0.391931	Floor Interface	0	9.00002	859.556	1292.91	8287.57	124.501	8163.07
20	20.8955	174579	0.391931	Floor Interface	0	9.00002	882.001	1326.67	8500.67	124.388	8376.29
21	20.8955	181256	0.391931	Floor Interface	0	9.00002	916.252	1378.19	8825.86	124.276	8701.58
22	20.8955	187932	0.391931	Floor Interface	0	9.00002	950.504	1429.71	9151.04	124.163	9026.88
23	20.8955	194608	0.391931	Floor Interface	0	9.00002	984.756	1481.23	9476.22	124.051	9352.17
24	20.8955	201284	0.391931	Floor Interface	0	9.00002	1019.01	1532.76	9801.35	123.939	9677.42
25	20.8955	207961	0.391931	Floor Interface	0	9.00002	1053.27	1584.28	10126.5	123.826	10002.7
26	20.8955	214637	0.391931	Floor Interface	0	9.00002	1087.52	1635.8	10451.7	123.714	10328
27	20.8955	221313	0.391931	Floor Interface	0	9.00002	1121.77	1687.32	10776.9	123.602	10653.3
28	20.8955	227990	0.391931	Floor Interface	0	9.00002	1156.02	1738.84	11102.1	123.489	10978.6
29	19.9523	220877	13.6253	Slope Interface	0	15	1869.19	2811.56	10492.8	0	10492.8
30	19.9523	220869	13.6253	Slope Interface	0	15	1869.12	2811.45	10492.5	0	10492.5
31	19.9523	220860	13.6253	Slope Interface	0	15	1869.04	2811.34	10492.1	0	10492.1
32	19.9523	220852	13.6253	Slope Interface	0	15	1868.97	2811.23	10491.7	0	10491.7
33	19.9523	220843	13.6253	Slope Interface	0	15	1868.9	2811.12	10491.2	0	10491.2
34	19.9523	220835	13.6253	Slope Interface	0	15	1868.82	2811.01	10490.9	0	10490.9
35	19.9523	220826	13.6253	Slope Interface	0	15	1868.76	2810.91	10490.5	0	10490.5
36	19.9523	220818	13.6253	Slope Interface	0	15	1868.68	2810.8	10490	0	10490
37	19.9523	220809	13.6253	Slope Interface	0	15	1868.61	2810.69	10489.6	0	10489.6
38	1.3908	15391.4	43.2096	Slope Interface	0	15	1509.97	2271.23	8476.32	0	8476.32
39	1.43462	15822.4	43.2096	Saturated Waste	448	32.6192	3363.55	5059.32	7236.39	31.2	7205.19
40	21.4627	225467	43.2096	Waste	448	32.6192	3224.7	4850.47	6878.86	0	6878.86
41	21.4627	204586	43.2096	Waste	814.545	30.1916	2949.96	4437.22	6226.47	0	6226.47
42	21.4627	183705	43.2096	Waste	814.545	30.1916	2693.13	4050.91	5562.5	0	5562.5
43	21.4627	162824	43.2096	Waste	414.783	33.3727	2424.15	3646.31	4905.97	0	4905.97
44	21.4627	141943	43.2096	Waste	414.783	33.3727	2140.84	3220.16	4258.98	0	4258.98
45	21.4627	121062	43.2096	Waste	414.783	33.3727	1857.52	2794.01	3612.03	0	3612.03
46	21.4627	100181	43.2096	Waste	414.783	33.3727	1574.21	2367.86	2965.07	0	2965.07
47	21.4627	79299.6	43.2096	Waste	414.783	33.3727	1290.9	1941.71	2318.11	0	2318.11
48	21.4627	58418.6	43.2096	Waste	414.783	33.3727	1007.57	1515.55	1671.14	0	1671.14
49	21.4627	37537.5	43.2096	Waste	414.783	33.3727	724.26	1089.4	1024.18	0	1024.18
50	21.4627	13532.4	43.2096	Waste	310	39.8056	370.758	557.68	297.215	0	297.215

Global Minimum Query (gle/morgenstern-price) - Safety Factor: 1.48525

Slice Number	Width [ft]	Weight [lbs]	Angle of Slice Base [degrees]	Base Material	Base Cohesion [psf]	Base Friction Angle [degrees]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]
1	14.1135	220.146	-6.35406	Residual Clay	460	21.6	324.562	482.055	55.7047	0	55.7047
2	4.86962	383.138	-6.35406	Slope Interface	0	15	15.2926	22.7134	84.7675	0	84.7675
3	20.1691	14888.9	-18.4512	Slope Interface	0	15	145.132	215.557	804.468	0	804.468
4	20.1691	35759.9	-18.4512	Slope Interface	0	15	352.153	523.035	1951.99	0	1951.99
5	20.1691	55022.4	-18.4512	Slope Interface	0	15	549.098	815.548	3043.67	0	3043.67
6	20.1691	73859.2	-18.4512	Slope Interface	0	15	747.093	1109.62	4141.16	0	4141.16
7	20.1691	91492.8	-18.4512	Slope Interface	0	15	937.97	1393.12	5199.2	0	5199.2
8	22.3035	117084	-0.423863	Floor Interface	0	9.00002	567.367	842.682	5448.01	127.501	5320.51
9	22.3035	126509	-0.423863	Floor Interface	0	9.00002	614.525	912.723	5892.23	129.525	5762.71
10	23.095	139327	12.3366	Slope Interface	0	15	1064.07	1580.41	5898.17	0	5898.17
11	23.095	144013	12.3366	Slope Interface	0	15	1096.5	1628.57	6077.9	0	6077.9
12	23.578	156511	-2.39464	Floor Interface	0	9.00002	728.685	1082.28	6958.08	124.821	6833.26
13	17.5962	123010	0.391931	Floor Interface	0	9.00002	757.852	1125.6	7231.96	125.184	7106.77
14	17.5962	130051	0.391931	Floor Interface	0	9.00002	801.852	1190.95	7644.42	125.089	7519.33
15	17.5962	135236	0.391931	Floor Interface	0	9.00002	834.257	1239.08	7948.23	124.994	7823.24
16	17.5962	140221	0.391931	Floor Interface	0	9.00002	865.268	1285.14	8238.97	124.9	8114.07
17	17.5962	141418	0.391931	Floor Interface	0	9.00002	872.634	1296.08	8307.96	124.805	8183.15
18	17.5962	142002	0.391931	Floor Interface	0	9.00002	875.954	1301.01	8338.99	124.71	8214.28
19	17.5962	142586	0.391931	Floor Interface	0	9.00002	879.01	1305.55	8367.57	124.616	8242.96
20	17.5962	143171	0.391931	Floor Interface	0	9.00002	881.804	1309.7	8393.6	124.521	8269.08
21	17.5962	145157	0.391931	Floor Interface	0	9.00002	893.015	1326.35	8498.68	124.427	8374.25
22	17.5962	149825	0.391931	Floor Interface	0	9.00002	920.613	1367.34	8757.36	124.332	8633.03
23	17.5962	154560	0.391931	Floor Interface	0	9.00002	948.359	1408.55	9017.47	124.237	8893.23
24	17.5962	159294	0.391931	Floor Interface	0	9.00002	975.829	1449.35	9275.02	124.143	9150.88
25	17.5962	164029	0.391931	Floor Interface	0	9.00002	1003.03	1489.75	9529.95	124.048	9405.91
26	17.5962	168763	0.391931	Floor Interface	0	9.00002	1029.93	1529.71	9782.16	123.954	9658.21
27	17.5962	173497	0.391931	Floor Interface	0	9.00002	1056.55	1569.24	10031.6	123.859	9907.78
28	17.5962	178232	0.391931	Floor Interface	0	9.00002	1082.87	1608.34	10278.4	123.764	10154.6
29	17.5962	182966	0.391931	Floor Interface	0	9.00002	1108.9	1646.99	10522.4	123.67	10398.7
30	17.5962	187701	0.391931	Floor Interface	0	9.00002	1134.63	1685.21	10763.6	123.575	10640
31	17.5962	192435	0.391931	Floor Interface	0	9.00002	1160.08	1723.01	11002.1	123.48	10878.6
32	18.4417	204155	13.6253	Slope Interface	0	15	1856.46	2757.3	10290.4	0	10290.4
33	18.4417	204148	13.6253	Slope Interface	0	15	1853.98	2753.63	10276.7	0	10276.7
34	18.4417	204140	13.6253	Slope Interface	0	15	1851.95	2750.61	10265.4	0	10265.4
35	18.4417	204133	13.6253	Slope Interface	0	15	1850.36	2748.25	10256.6	0	10256.6
36	18.4417	204126	13.6253	Slope Interface	0	15	1849.21	2746.54	10250.2	0	10250.2
37	18.4417	204119	13.6253	Slope Interface	0	15	1848.49	2745.47	10246.3	0	10246.3
38	18.4417	204111	13.6253	Slope Interface	0	15	1848.2	2745.04	10244.6	0	10244.6
39	18.4417	204104	13.6253	Slope Interface	0	15	1848.33	2745.23	10245.4	0	10245.4
40	18.4417	204097	13.6253	Slope Interface	0	15	1848.86	2746.02	10248.3	0	10248.3
41	18.4417	204089	13.6253	Slope Interface	0	15	1849.79	2747.4	10253.4	0	10253.4
42	0.767341	8491.78	56.4032	Slope Interface	0	15	1373.17	2039.5	7611.49	0	7611.49
43	0.79178	8732.48	56.4032	Saturated Waste	814.545	30.1916	2824.3	4194.78	5840.99	31.2	5809.79
44	19.122	195165	56.4032	Waste	814.545	30.1916	2662.25	3954.11	5396.1	0	5396.1
45	19.122	165140	56.4032	Waste	414.783	33.3727	2310.74	3432.03	4580.64	0	4580.64
46	19.122	135115	56.4032	Waste	414.783	33.3727	1944.61	2888.23	3755.08	0	3755.08
47	19.122	105089	56.4032	Waste	414.783	33.3727	1569.13	2330.54	2908.4	0	2908.4
48	19.122	75063.6	56.4032	Waste	414.783	33.3727	1183.19	1757.33	2038.2	0	2038.2
49	19.122	45038.2	56.4032	Waste	414.783	33.3727	785.846	1167.18	1142.25	0	1142.25
50	19.122	15012.7	56.4032	Waste	310	39.8056	351.931	522.706	255.247	0	255.247

Interslice Data

Global Minimum Query (spencer) - Safety Factor: 1.50416



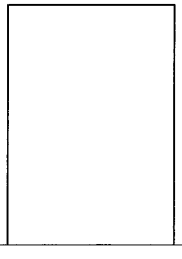
Slice Number	X coordinate [ft]	Y coordinate - Bottom [ft]	Interslice Normal Force [lbs]	Interslice Shear Force [lbs]	Interslice Force Angle [degrees]
1	89.9702	576.722	0	0	0
2	105.685	573.872	6294.64	1158.77	10.4307
3	112.76	572.589	7369.61	1356.66	10.4307
4	131.552	566.319	19486.4	3587.21	10.4307
5	150.345	560.049	42173.3	7763.6	10.4307
6	169.137	553.779	75156.3	13835.4	10.4307
7	187.929	547.509	117695	21666.2	10.4307
8	206.721	541.239	169567	31215.4	10.4307
9	229.024	541.074	182757	33643.4	10.4307
10	251.328	540.909	197028	36270.5	10.4307
11	274.423	545.96	191646	35279.8	10.4307
12	297.518	551.011	186083	34255.7	10.4307
13	321.096	550.025	209551	38575.8	10.4307
14	341.991	550.168	223997	41235.2	10.4307
15	362.887	550.311	239426	44075.5	10.4307
16	383.783	550.454	255529	47039.8	10.4307
17	404.678	550.597	272067	50084.3	10.4307
18	425.574	550.74	288688	53144.1	10.4307
19	446.469	550.883	305393	56219.2	10.4307
20	467.365	551.026	322184	59310.2	10.4307
21	488.26	551.168	339413	62482	10.4307
22	509.156	551.311	357313	65777.2	10.4307
23	530.051	551.454	375883	69195.6	10.4307
24	550.947	551.597	395122	72737.3	10.4307
25	571.842	551.74	415031	76402.4	10.4307
26	592.737	551.883	435610	80190.7	10.4307
27	613.633	552.026	456859	84102.4	10.4307
28	634.528	552.169	478778	88137.4	10.4307
29	655.424	552.312	501366	92295.6	10.4307
30	675.376	557.148	487945	89824.9	10.4307
31	695.329	561.985	474524	87354.2	10.4307
32	715.281	566.821	461103	84883.6	10.4307
33	735.233	571.657	447683	82413.2	10.4307
34	755.185	576.494	434263	79942.8	10.4307
35	775.138	581.33	420844	77472.5	10.4307
36	795.09	586.166	407426	75002.3	10.4307
37	815.042	591.002	394008	72532.2	10.4307
38	834.995	595.839	380590	70062.2	10.4307
39	836.385	597.145	371618	68410.5	10.4307
40	837.82	598.493	366695	67504.3	10.4307
41	859.283	618.654	297274	54724.7	10.4307
42	880.746	638.816	235105	43280	10.4307
43	902.208	658.978	180805	33284.1	10.4307
44	923.671	679.139	133965	24661.3	10.4307
45	945.134	699.301	94082.5	17319.5	10.4307
46	966.596	719.462	61158.3	11258.5	10.4307
47	988.059	739.624	35192.3	6478.48	10.4307
48	1009.52	759.786	16184.3	2979.34	10.4307
49	1030.98	779.947	4134.46	761.106	10.4307
50	1052.45	800.109	-957.238	-176.216	10.4307
51	1073.91	820.27	0	0	0

Global Minimum Query (gle/morgenstern-price) - Safety Factor: 1.48525

Slice Number	X coordinate [ft]	Y coordinate - Bottom [ft]	Interslice Normal Force [lbs]	Interslice Shear Force [lbs]	Interslice Force Angle [degrees]
1	86.8923	577	0	0	0
2	101.006	575.428	4665.05	56.3053	0.691504
3	105.875	574.886	4785.43	77.6607	0.929747
4	126.045	568.157	13124.2	438.205	1.91234
5	146.214	561.427	33357.6	1680.56	2.88413
6	166.383	554.698	64906.7	4356.19	3.83963
7	186.552	547.968	107832	9004.83	4.77358
8	206.721	541.239	161724	16087.8	5.68092
9	229.024	541.074	175269	20426.4	6.64744
10	251.328	540.909	189937	25239.8	7.56941
11	274.423	545.96	184703	27508.7	8.47107
12	297.518	551.011	179309	29405.2	9.31314
13	321.096	550.025	203339	36242	10.106
14	338.692	550.145	215795	40582.8	10.6507
15	356.288	550.266	228974	45144.9	11.1535
16	373.885	550.386	242687	49871.8	11.6125
17	391.481	550.506	256910	54732	12.0265
18	409.077	550.627	271254	59609.7	12.3941
19	426.673	550.747	285653	64449.5	12.7143
20	444.269	550.868	300102	69207.8	12.9862
21	461.866	550.988	314598	73840.4	13.209
22	479.462	551.108	329277	78336.7	13.3822
23	497.058	551.229	344411	82719	13.5052
24	514.654	551.349	360002	86946	13.5778
25	532.251	551.469	376044	90973	13.5998
26	549.847	551.59	392534	94753.9	13.571
27	567.443	551.71	409467	98241.3	13.4917
28	585.039	551.831	426838	101387	13.3619
29	602.635	551.951	444641	104143	13.1821
30	620.232	552.071	462874	106460	12.9526
31	637.828	552.192	481529	108290	12.6743
32	655.424	552.312	500604	109585	12.3476
33	673.866	556.782	488816	103496	11.9546
34	692.307	561.252	477045	97150.7	11.5109
35	710.749	565.722	465286	90594.8	11.0181
36	729.191	570.193	453537	83875.6	10.4777
37	747.632	574.663	441796	77039.9	9.89171
38	766.074	579.133	430059	70134	9.26226
39	784.516	583.603	418324	63203.6	8.5917
40	802.957	588.073	406589	56293.3	7.88264
41	821.399	592.543	394850	49446.7	7.13794
42	839.841	597.013	383105	42706	6.36069
43	840.608	598.169	375366	41624.4	6.32769
44	841.4	599.36	370639	40876.9	6.29358
45	860.522	628.145	266186	25417.1	5.45442
46	879.644	656.929	178490	14323.5	4.58805
47	898.766	685.714	107561	6953.09	3.69864
48	917.888	714.498	53827.9	2623.72	2.79055
49	937.01	743.283	17768.6	579.603	1.8683
50	956.132	772.067	-93.9757	-1.53623	0.936536
51	975.254	800.852	0	0	0

List Of Coordinates

Piezoline



X	Y
103.457	577.613
162.429	558
206.73	543.266
251.32	543.001
297.52	553.004
321.11	552.032
655.41	554.29
670.72	558
849.14	601.236
1003.58	601
1140.6	573.052
1811.45	573.052

Block Search Polyline

X	Y
101.107	576.477
206.721	541.239
251.328	540.909
297.518	551.011
321.096	550.025
655.424	552.312
849.105	599.259
1003.58	598.998
1140.6	571.023
1811.44	571.356

External Boundary

X	Y
-360.438	577.337
-360.438	555
-360.438	525
-360.438	313.863
1811.44	313.863
1811.44	525
1811.44	555
1811.44	570.101
1811.45	572.545
1811.45	573.052
1812.11	819.481
1797.44	822.689
1488.7	834.984
1052.34	819.505
465	677.371
381.66	674.389
364.86	668.55
358.92	668.959
324.03	656.142
320.69	657.492
228.76	625.161
224.6	626.084
201.4	615.787
196.41	616.3
179.63	608.247
173.4	608.775
149.93	597.848
133.63	592.197
103.457	577.613
102.231	577.021
99.78	575.836
83.16	577.337

Material Boundary

X	Y
99.78	575.836
162.429	555
206.73	540.266
251.32	540.001
297.52	550.004
321.11	549.032
655.41	551.29
670.72	555
849.14	598.236
1003.58	598
1140.6	570.052
1811.44	570.101

Material Boundary

X	Y
670.72	555
1811.44	555

Material Boundary

X	Y
-360.438	555
162.429	555

Material Boundary

X	Y
-360.438	525
1811.44	525

Material Boundary

X	Y
102.231	577.021
162.429	557
206.73	542.266
251.32	542.001
297.52	552.004
321.11	551.032
655.41	553.29
670.72	557
849.14	600.236
1003.58	600
1140.6	572.052
1811.45	572.545

Material Boundary

X	Y
103.457	577.613
162.429	558
206.73	543.266
251.32	543.001
297.52	553.004
321.11	552.032
655.41	554.29
670.72	558
849.14	601.236
1003.58	601
1140.6	573.052
1811.45	573.052

Material Boundary

X	Y
1003.58	598
1003.58	600

Material Boundary

X	Y
1140.6	570.052
1140.6	572.052

Material Boundary

X	Y
849.14	598.236
849.14	600.236

Material Boundary

X	Y
655.41	551.29
655.41	553.29

Material Boundary

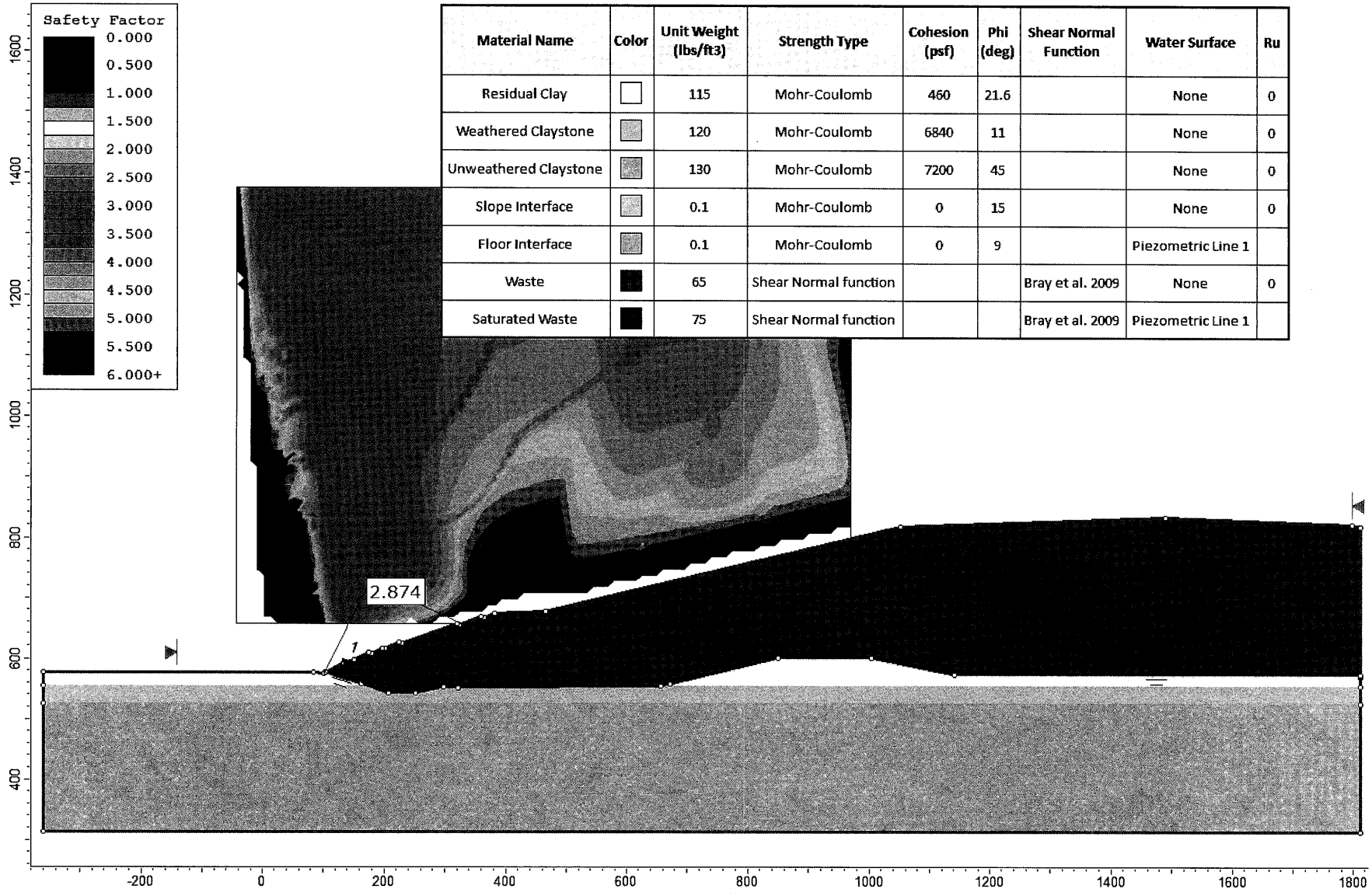
X	Y
251.32	540.001
251.32	542.001

Material Boundary

X	Y
297.52	550.004
297.52	552.004

Material Boundary

X	Y
206.73	540.266
206.73	542.266



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface	Ru
Residual Clay		115	Mohr-Coulomb	460	21.6		None	0
Weathered Claystone		120	Mohr-Coulomb	6840	11		None	0
Unweathered Claystone		130	Mohr-Coulomb	7200	45		None	0
Slope Interface		0.1	Mohr-Coulomb	0	15		None	0
Floor Interface		0.1	Mohr-Coulomb	0	9		Piezometric Line 1	
Waste		65	Shear Normal function			Bray et al. 2009	None	0
Saturated Waste		75	Shear Normal function			Bray et al. 2009	Piezometric Line 1	

FIGURE **3C4.4**

Final Configuration Stability Analysis – Section D-D' - Circular Failure

Permit Amendment Application MSW 692B Temple Recycling and Disposal Facility, Bell County, Texas

Slide Analysis Information

SLIDE - An Interactive Slope Stability Program

Project Summary

File Name:	Final Config_Circular.slim
Slide Modeler Version:	6.03
Project Title:	SLIDE - An Interactive Slope Stability Program
Date Created:	11/2/2016, 4:04:21 PM

General Settings

Units of Measurement:	Imperial Units
Time Units:	days
Permeability Units:	feet/second
Failure Direction:	Right to Left
Data Output:	Standard
Maximum Material Properties:	20
Maximum Support Properties:	20

Analysis Options

Slices Type:	Vertical
Analysis Methods Used	
GLE/Morgenstern-Price with interslice force function:	Half Sine Spencer
Number of slices:	50
Tolerance:	0.005
Maximum number of iterations:	75
Check malpha < 0.2:	Yes
Create Interslice boundaries at intersections with water tables and piezos:	Yes
Initial trial value of FS:	1
Steffensen Iteration:	Yes

Groundwater Analysis

Groundwater Method:	Water Surfaces
Pore Fluid Unit Weight [lbs/ft3]:	62.4
Advanced Groundwater Method:	None

Random Numbers

Pseudo-random Seed:	10116
Random Number Generation Method:	Park and Miller v.3

Surface Options

Surface Type:	Circular
Search Method:	Grid Search
Radius Increment:	10
Composite Surfaces:	Disabled
Reverse Curvature:	Invalid Surfaces
Minimum Elevation:	Not Defined
Minimum Depth:	Not Defined
Minimum Area:	Not Defined
Minimum Weight:	Not Defined

Seismic

Advanced seismic analysis:	No
Staged pseudostatic analysis:	No

Material Properties

Property	Residual Clay	Weathered Claystone	Unweathered Claystone	Slope Interface	Floor Interface	Waste	Saturated Waste
Color							
Strength Type	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Shear Normal function	Shear Normal function
Unit Weight [lbs/ft3]	115	120	130	0.1	0.1	65	75
Cohesion [psf]	460	6840	7200	0	0		
Friction Angle [deg]	21.6	11	45	15	9		
Water Surface	None	None	None	None	Piezometric Line 1	None	Piezometric Line 1
Hu Value					1		1
Ru Value	0	0	0	0		0	

Shear Normal Functions

Name: Bray et al. 2009

Normal (psf)	Shear (psf)
0	310
600	810
5200	3840
6300	4480
7300	5120
8400	5740
16700	10550

Global Minimums

Method: spencer

FS	2.874380
Center:	175.470, 727.010
Radius:	166.917
Left Slip Surface Endpoint:	102.231, 577.021
Right Slip Surface Endpoint:	327.124, 657.278
Resisting Moment:	7.61705e+007 lb-ft
Driving Moment:	2.64998e+007 lb-ft
Resisting Horizontal Force:	407143 lb
Driving Horizontal Force:	141646 lb
Total Slice Area:	9027.15 ft2
Surface Horizontal Width:	224.892 ft
Surface Average Height:	40.1399 ft

Method: gle/morgenstern-price

FS	2.884540
Center:	163.953, 866.871
Radius:	303.435
Left Slip Surface Endpoint:	73.165, 577.337
Right Slip Surface Endpoint:	399.032, 675.011
Resisting Moment:	1.9889e+008 lb-ft
Driving Moment:	6.89503e+007 lb-ft
Resisting Horizontal Force:	604757 lb
Driving Horizontal Force:	209655 lb
Total Slice Area:	12363.2 ft2
Surface Horizontal Width:	325.867 ft
Surface Average Height:	37.9393 ft

Slice Data

Global Minimum Query (spencer) - Safety Factor: 2.87438

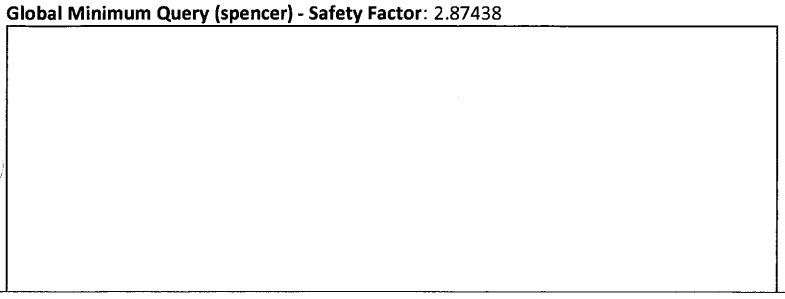
Slice Number	Width [ft]	Weight [lbs]	Angle of Slice Base [degrees]	Base Material	Base Cohesion [psf]	Base Friction Angle [degrees]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]
1	4.67411	620.098	-25.1549	Slope Interface	0	15	15.8082	45.4387	169.58	0	169.58
2	4.67411	1785.16	-23.3793	Slope Interface	0	15	44.6611	128.373	479.095	0	479.095
3	4.67411	2944.01	-21.6422	Slope Interface	0	15	72.3655	208.006	776.29	0	776.29
4	4.67411	4102.78	-19.9258	Slope Interface	0	15	99.1727	285.06	1063.86	0	1063.86
5	4.67411	5261.48	-18.2279	Slope Interface	0	15	125.164	359.768	1342.67	0	1342.67
6	4.67411	6420.11	-16.5463	Slope Interface	0	15	150.405	432.322	1613.45	0	1613.45
7	4.67411	7570.93	-14.8794	Slope Interface	0	15	174.776	502.372	1874.88	0	1874.88
8	4.67411	8585.33	-13.2252	Slope Interface	0	15	195.402	561.659	2096.14	0	2096.14
9	4.67411	9549.7	-11.5822	Slope Interface	0	15	214.39	616.238	2299.83	0	2299.83
10	6.17761	13870.8	-9.6876	Saturated Waste	414.783	33.3727	770.129	2213.64	2762.14	31.2	2730.94
11	4.41619	10752.7	-7.8468	Waste	414.783	33.3727	814.653	2341.62	2925.23	0	2925.23
12	4.41619	11500.5	-6.31906	Waste	414.783	33.3727	847.029	2434.68	3066.51	0	3066.51
13	4.41619	12214	-4.79582	Waste	414.783	33.3727	876.44	2519.22	3194.86	0	3194.86
14	4.41619	12893.7	-3.27598	Waste	414.783	33.3727	903.027	2595.64	3310.88	0	3310.88
15	4.41619	13539.6	-1.75844	Waste	414.783	33.3727	926.914	2664.3	3415.11	0	3415.11
16	4.41619	13923.6	-0.242129	Waste	414.783	33.3727	935.424	2688.76	3452.24	0	3452.24
17	4.41619	13874.3	1.27401	Waste	414.783	33.3727	919.772	2643.77	3383.96	0	3383.96
18	4.41619	14308.1	2.79104	Waste	414.783	33.3727	930.817	2675.52	3432.14	0	3432.14
19	4.41619	14837.8	4.31003	Waste	414.783	33.3727	946.619	2720.94	3501.1	0	3501.1
20	4.41619	15333.7	5.83207	Waste	414.783	33.3727	960.097	2759.68	3559.92	0	3559.92
21	4.41619	15663.1	7.35825	Waste	414.783	33.3727	964.428	2772.13	3578.82	0	3578.82
22	4.41619	15487.4	8.8897	Waste	414.783	33.3727	942.629	2709.47	3483.69	0	3483.69
23	4.41619	15736.5	10.4276	Waste	414.783	33.3727	942.747	2709.81	3484.2	0	3484.2
24	4.41619	16048.1	11.9731	Waste	414.783	33.3727	945.788	2718.55	3497.47	0	3497.47
25	4.41619	16323.8	13.5275	Waste	414.783	33.3727	946.772	2721.38	3501.76	0	3501.76
26	4.41619	16563	15.0922	Waste	414.783	33.3727	945.718	2718.35	3497.17	0	3497.17
27	4.41619	16745.4	16.6685	Waste	414.783	33.3727	941.71	2706.83	3479.69	0	3479.69
28	4.41619	16352.2	18.2578	Waste	414.783	33.3727	910.521	2617.18	3343.59	0	3343.59
29	4.41619	16168	19.8619	Waste	414.783	33.3727	889.574	2556.97	3252.17	0	3252.17
30	4.41619	16135.4	21.4824	Waste	414.783	33.3727	875.783	2517.33	3191.98	0	3191.98
31	4.41619	16061.1	23.1211	Waste	414.783	33.3727	860.141	2472.37	3123.72	0	3123.72
32	4.41619	15943.7	24.7802	Waste	414.783	33.3727	842.635	2422.05	3047.35	0	3047.35
33	4.41619	15781.4	26.4617	Waste	414.783	33.3727	823.257	2366.35	2962.77	0	2962.77
34	4.41619	15572.4	28.1682	Waste	414.783	33.3727	801.979	2305.19	2869.93	0	2869.93
35	4.41619	15314.3	29.9024	Waste	414.783	33.3727	778.778	2238.5	2768.7	0	2768.7
36	4.41619	15004.7	31.6673	Waste	414.783	33.3727	753.624	2166.2	2658.91	0	2658.91
37	4.41619	14640.5	33.4665	Waste	414.783	33.3727	726.471	2088.15	2540.45	0	2540.45
38	4.41619	14218.5	35.3039	Waste	414.783	33.3727	697.282	2004.25	2413.06	0	2413.06
39	4.41619	13734.7	37.1841	Waste	414.783	33.3727	666.002	1914.34	2276.55	0	2276.55
40	4.41619	13184.3	39.1124	Waste	414.783	33.3727	632.565	1818.23	2130.65	0	2130.65
41	4.41619	12562	41.0951	Waste	414.783	33.3727	596.909	1715.74	1975.06	0	1975.06
42	4.41619	11861	43.1397	Waste	414.783	33.3727	558.956	1606.65	1809.44	0	1809.44
43	4.41619	11073.4	45.2553	Waste	414.783	33.3727	518.614	1490.69	1633.39	0	1633.39
44	4.41619	10189.1	47.453	Waste	414.783	33.3727	475.792	1367.61	1446.53	0	1446.53
45	4.41619	9195.71	49.7471	Waste	414.783	33.3727	430.386	1237.09	1248.39	0	1248.39
46	4.41619	8077.06	52.1557	Waste	414.783	33.3727	382.293	1098.85	1038.52	0	1038.52
47	4.41619	6811.75	54.7031	Waste	414.783	33.3727	331.42	952.628	816.53	0	816.53
48	4.41619	5370.3	57.4228	Waste	310	39.8056	276.975	796.13	583.356	0	583.356
49	4.41619	3610.07	60.3635	Waste	310	39.8056	205.316	590.155	336.186	0	336.186
50	4.41619	1087.97	63.6015	Waste	310	39.8056	115.027	330.632	24.7586	0	24.7586

Global Minimum Query (gle/morgenstern-price) - Safety Factor: 2.88454

Slice Number	Width [ft]	Weight [lbs]	Angle of Slice Base [degrees]	Base Material	Base Cohesion [psf]	Base Friction Angle [degrees]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]
1	6.53539	739.854	-16.7652	Residual Clay	460	21.6	183.28	528.679	173.464	0	173.464
2	6.53539	2110.75	-15.4806	Residual Clay	460	21.6	214.576	618.952	401.465	0	401.465
3	6.53539	3031.09	-14.2038	Residual Clay	460	21.6	236.323	681.683	559.907	0	559.907
4	6.53539	3773.12	-12.9342	Residual Clay	460	21.6	254.289	733.507	690.801	0	690.801
5	6.53539	4265.61	-11.6711	Residual Clay	460	21.6	266.703	769.315	781.241	0	781.241
6	6.53539	5667.91	-10.4136	Residual Clay	460	21.6	299.472	863.84	1019.98	0	1019.98
7	6.53539	7146.93	-9.16127	Residual Clay	460	21.6	333.935	963.248	1271.06	0	1271.06
8	6.53539	8515.96	-7.9133	Residual Clay	460	21.6	365.74	1054.99	1502.78	0	1502.78
9	6.53539	9776.08	-6.6691	Residual Clay	460	21.6	394.752	1138.68	1714.14	0	1714.14
10	8.31493	14840.2	-5.25949	Slope Interface	0	15	180.776	521.457	1946.1	0	1946.1
11	3.83492	7734.41	-4.10812	Saturated Waste	414.783	33.3727	666.405	1922.27	2319.8	31.2	2288.6
12	6.53586	14049.3	-3.12713	Waste	414.783	33.3727	706.349	2037.49	2463.51	0	2463.51
13	6.53586	15333.9	-1.89172	Waste	414.783	33.3727	752.96	2171.94	2667.63	0	2667.63
14	6.53586	16688.4	-0.65719	Waste	414.783	33.3727	800.482	2309.02	2875.74	0	2875.74
15	6.53586	17983.1	0.577035	Waste	414.783	33.3727	843.917	2434.31	3065.96	0	3065.96
16	6.53586	19009.6	1.81153	Waste	414.783	33.3727	875.562	2525.59	3204.52	0	3204.52
17	6.53586	19084.7	3.04686	Waste	414.783	33.3727	870.75	2511.71	3183.44	0	3183.44
18	6.53586	20093.7	4.28362	Waste	414.783	33.3727	898.425	2591.54	3304.66	0	3304.66
19	6.53586	21188.1	5.52238	Waste	414.783	33.3727	927.435	2675.22	3431.68	0	3431.68
20	6.53586	21453.1	6.76373	Waste	414.783	33.3727	925.504	2669.65	3423.24	0	3423.24
21	6.53586	21885	8.00829	Waste	414.783	33.3727	928.426	2678.08	3436.03	0	3436.03
22	6.53586	22695.8	9.25666	Waste	414.783	33.3727	943.444	2721.4	3501.81	0	3501.81
23	6.53586	23444.4	10.5095	Waste	414.783	33.3727	955.238	2755.42	3553.45	0	3553.45
24	6.53586	23694.1	11.7674	Waste	414.783	33.3727	949.369	2738.49	3527.76	0	3527.76
25	6.53586	23434.1	13.0311	Waste	414.783	33.3727	926.274	2671.87	3426.6	0	3426.6
26	6.53586	23735.4	14.3013	Waste	414.783	33.3727	921.801	2658.97	3407.01	0	3407.01
27	6.53586	23970.9	15.5787	Waste	414.783	33.3727	915.128	2639.72	3377.8	0	3377.8
28	6.53586	24139.5	16.8642	Waste	414.783	33.3727	906.44	2614.66	3339.74	0	3339.74
29	6.53586	24239.9	18.1584	Waste	414.783	33.3727	895.901	2584.26	3293.61	0	3293.61
30	6.53586	24270.4	19.4623	Waste	414.783	33.3727	883.664	2548.96	3240.01	0	3240.01
31	6.53586	24229.6	20.7768	Waste	414.783	33.3727	869.849	2509.11	3179.51	0	3179.51
32	6.53586	24115.6	22.1028	Waste	414.783	33.3727	854.56	2465.01	3112.57	0	3112.57
33	6.53586	23926.3	23.4414	Waste	414.783	33.3727	837.875	2416.88	3039.48	0	3039.48
34	6.53586	23659.6	24.7937	Waste	414.783	33.3727	819.841	2364.86	2960.52	0	2960.52
35	6.53586	23312.8	26.161	Waste	414.783	33.3727	800.482	2309.02	2875.74	0	2875.74
36	6.53586	22883.3	27.5444	Waste	414.783	33.3727	779.8	2249.36	2785.17	0	2785.17
37	6.53586	22367.9	28.9456	Waste	414.783	33.3727	757.758	2185.78	2688.65	0	2688.65
38	6.53586	21763.2	30.3659	Waste	414.783	33.3727	734.302	2118.12	2585.94	0	2585.94
39	6.53586	20286.1	31.8073	Waste	414.783	33.3727	687.161	1982.14	2379.49	0	2379.49
40	6.53586	19239.6	33.2714	Waste	414.783	33.3727	653.516	1885.09	2232.15	0	2232.15
41	6.53586	18385.2	34.7606	Waste	414.783	33.3727	626.371	1806.79	2113.28	0	2113.28
42	6.53586	17422.7	36.2772	Waste	414.783	33.3727	597.195	1722.63	1985.52	0	1985.52
43	6.53586	16346	37.8239	Waste	414.783	33.3727	565.752	1631.93	1847.82	0	1847.82
44	6.53586	15136.2	39.4037	Waste	414.783	33.3727	531.441	1532.96	1697.56	0	1697.56
45	6.53586	13077.7	41.0202	Waste	414.783	33.3727	474.399	1368.42	1447.77	0	1447.77
46	6.53586	11210.8	42.6775	Waste	414.783	33.3727	423.036	1220.26	1222.84	0	1222.84
47	6.53586	9537.14	44.3803	Waste	414.783	33.3727	377.157	1087.93	1021.93	0	1021.93
48	6.53586	7511.78	46.1342	Waste	414.783	33.3727	321.588	927.633	778.584	0	778.584
49	6.53586	4678.4	47.9459	Waste	310	39.8056	235.791	680.149	444.179	0	444.179
50	6.53586	1594.56	49.8237	Waste	310	39.8056	132.753	382.932	87.5185	0	87.5185

Interslice Data

Global Minimum Query (spencer) - Safety Factor: 2.87438



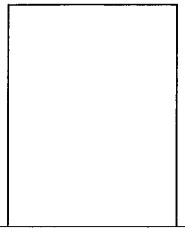
Slice Number	X coordinate [ft]	Y coordinate - Bottom [ft]	Interslice Normal Force [lbs]	Interslice Shear Force [lbs]	Interslice Force Angle [degrees]
1	102.231	577.021	0	0	0
2	106.905	574.826	446.087	138.403	17.237
3	111.579	572.805	1622.86	503.508	17.237
4	116.254	570.951	3400.69	1055.1	17.2371
5	120.928	569.256	5666.67	1758.14	17.237
6	125.602	567.717	8318.26	2580.82	17.237
7	130.276	566.328	11261.5	3494	17.2371
8	134.95	565.086	14406.6	4469.78	17.237
9	139.624	563.988	17622.1	5467.44	17.237
10	144.298	563.03	20827	6461.78	17.237
11	150.476	561.975	28495.8	8841.12	17.2371
12	154.892	561.367	33872.6	10509.3	17.237
13	159.308	560.878	39111.7	12134.8	17.237
14	163.724	560.507	44164.6	13702.5	17.237
15	168.141	560.254	48988.1	15199.1	17.2371
16	172.557	560.119	53543.2	16612.3	17.237
17	176.973	560.1	57737.2	17913.5	17.237
18	181.389	560.198	61465.4	19070.2	17.237
19	185.805	560.414	64835.7	20115.9	17.237
20	190.222	560.746	67849.5	21051	17.237
21	194.638	561.198	70482.2	21867.8	17.237
22	199.054	561.768	72698.9	22555.6	17.2371
23	203.47	562.459	74454	23100.1	17.237
24	207.886	563.271	75784.2	23512.8	17.237
25	212.302	564.208	76684.1	23792	17.237
26	216.719	565.27	77143.3	23934.5	17.237
27	221.135	566.461	77153.4	23937.6	17.237
28	225.551	567.784	76709.7	23799.9	17.237
29	229.967	569.24	75858.1	23535.7	17.237
30	234.383	570.836	74597	23144.5	17.2371
31	238.8	572.574	72915.6	22622.8	17.237
32	243.216	574.459	70822.8	21973.5	17.237
33	247.632	576.498	68330.1	21200.1	17.237
34	252.048	578.696	65451.9	20307.1	17.237
35	256.464	581.061	62205.6	19299.9	17.237
36	260.881	583.601	58612.2	18185	17.237
37	265.297	586.325	54696.2	16970	17.237
38	269.713	589.244	50487.1	15664.1	17.237
39	274.129	592.371	46019	14277.9	17.2371
40	278.545	595.721	41332.4	12823.8	17.237
41	282.962	599.312	36474.8	11316.7	17.2371
42	287.378	603.164	31502.4	9773.93	17.237
43	291.794	607.302	26481.9	8216.29	17.2371
44	296.21	611.758	21493.5	6668.57	17.237
45	300.626	616.569	16634	5160.86	17.237
46	305.043	621.785	12022.3	3730.04	17.237
47	309.459	627.47	7806.81	2422.14	17.237
48	313.875	633.708	4176.48	1295.79	17.237
49	318.291	640.619	1367.4	424.248	17.237
50	322.707	648.381	-335.804	-104.187	17.2371
51	327.124	657.278	0	0	0

Global Minimum Query (gle/morgenstern-price) - Safety Factor: 2.88454

Slice Number	X coordinate [ft]	Y coordinate - Bottom [ft]	Interslice Normal Force [lbs]	Interslice Shear Force [lbs]	Interslice Force Angle [degrees]
1	73.1654	577.337	0	0	0
2	79.7007	575.368	1538.4	33.2238	1.23719
3	86.2361	573.558	3666.31	158.044	2.46833
4	92.7715	571.904	6135.75	395.428	3.68742
5	99.3069	570.403	8833.17	755.505	4.88864
6	105.842	569.053	11629.5	1235.92	6.06631
7	112.378	567.852	14810.2	1874.93	7.2151
8	118.913	566.798	18330.6	2683.92	8.32991
9	125.448	565.89	22084.1	3658.38	9.40601
10	131.984	565.125	25971.8	4785.02	10.4391
11	140.299	564.36	28963.4	5990.04	11.6848
12	144.134	564.085	32156	6971	12.2317
13	150.67	563.728	37648.6	8775.66	13.121
14	157.205	563.512	43141.9	10719.7	13.954
15	163.741	563.437	48585.3	12771.7	14.7282
16	170.277	563.503	53894.9	14887	15.4414
17	176.813	563.709	58950.6	17006	16.0917
18	183.349	564.057	63529.8	19032.8	16.6776
19	189.885	564.547	67779.4	20978.5	17.1979
20	196.421	565.179	71667.7	22805	17.6513
21	202.956	565.954	75058.5	24441.6	18.037
22	209.492	566.873	77962.3	25865.8	18.3545
23	216.028	567.938	80393.6	27060	18.6029
24	222.564	569.151	82323.6	27996.5	18.7821
25	229.1	570.512	83720.6	28650.4	18.8917
26	235.636	572.025	84586.6	29012.4	18.9315
27	242.172	573.691	84930.1	29080.7	18.9016
28	248.707	575.514	84751.5	28854.8	18.8018
29	255.243	577.495	84054.3	28340.5	18.6325
30	261.779	579.638	82845	27548.9	18.3938
31	268.315	581.948	81132.7	26496.6	18.0862
32	274.851	584.428	78929.3	25204.9	17.7101
33	281.387	587.082	76248.5	23699.5	17.2662
34	287.923	589.916	73106.8	22010.2	16.7554
35	294.458	592.935	69522.9	20170.2	16.1787
36	300.994	596.146	65518	18215.8	15.5374
37	307.53	599.554	61116.6	16185.4	14.833
38	314.066	603.169	56346.5	14119.1	14.0673
39	320.602	606.999	51239.7	12058.3	13.2425
40	327.138	611.052	46082	10098.9	12.361
41	333.674	615.341	40777.2	8241.16	11.4257
42	340.21	619.877	35282.3	6500.78	10.4397
43	346.745	624.674	29657.8	4913.34	9.40662
44	353.281	629.748	23976.5	3510.83	8.3305
45	359.817	635.117	18332.5	2321.01	7.21562
46	366.353	640.803	13199.2	1402.85	6.06679
47	372.889	646.829	8592.7	734.99	4.88898
48	379.425	653.225	4519.58	291.292	3.68768
49	385.961	660.025	1325.52	57.1433	2.4685
50	392.496	667.27	-352.675	-7.61704	1.23728
51	399.032	675.011	0	0	0

List Of Coordinates

Piezoline



X	Y
103.457	577.613
162.429	558
206.73	543.266
251.32	543.001
297.52	553.004
321.11	552.032
655.41	554.29
670.72	558
849.14	601.236
1003.58	601
1140.6	573.052
1811.45	573.052

External Boundary

X	Y
-360.438	577.337
-360.438	555
-360.438	525
-360.438	313.863
1811.44	313.863
1811.44	525
1811.44	555
1811.44	570.101
1811.45	572.545
1811.45	573.052
1812.11	819.481
1797.44	822.689
1488.7	834.984
1052.34	819.505
465	677.371
381.66	674.389
364.86	668.55
358.92	668.959
324.03	656.142
320.69	657.492
228.76	625.161
224.6	626.084
201.4	615.787
196.41	616.3
179.63	608.247
173.4	608.775
149.93	597.848
133.63	592.197
103.457	577.613
102.231	577.021
99.78	575.836
83.16	577.337

Material Boundary

X	Y
99.78	575.836
162.429	555
206.73	540.266
251.32	540.001
297.52	550.004
321.11	549.032
655.41	551.29
670.72	555
849.14	598.236
1003.58	598
1140.6	570.052
1811.44	570.101

Material Boundary

X	Y
670.72	555
1811.44	555

Material Boundary

X	Y
-360.438	555
162.429	555

Material Boundary

X	Y
-360.438	525
1811.44	525

Material Boundary

X	Y
102.231	577.021
162.429	557
206.73	542.266
251.32	542.001
297.52	552.004
321.11	551.032
655.41	553.29
670.72	557
849.14	600.236
1003.58	600
1140.6	572.052
1811.45	572.545

Material Boundary

X	Y
103.457	577.613
162.429	558
206.73	543.266
251.32	543.001
297.52	553.004
321.11	552.032
655.41	554.29
670.72	558
849.14	601.236
1003.58	601
1140.6	573.052
1811.45	573.052

Material Boundary

X	Y
1003.58	598
1003.58	600

Material Boundary

X	Y
1140.6	570.052
1140.6	572.052

Material Boundary

X	Y
849.14	598.236
849.14	600.236

Material Boundary

X	Y
655.41	551.29
655.41	553.29

Material Boundary

X	Y
251.32	540.001
251.32	542.001

Material Boundary

X	Y
297.52	550.004
297.52	552.004

Material Boundary

X	Y
206.73	540.266
206.73	542.266

APPENDIX III-3C-5

FINAL COVER STABILITY

FINAL COVER STABILITY

Made By: VK
Checked by: JBF / MX
Reviewed by: CGD

1.0 OBJECTIVE

To investigate the stability of the final cover lining system.

2.0 GIVEN

Final cover slopes are as follows:

(i) Future final cover area: 4H:1V (S = 25%) with a maximum length of slope conservatively assumed to be 1300 ft.

(ii) Existing final cover areas: The as-constructed slope of the final cover in Tract 2A is 3.16H:1V (S = 31.7%) with a maximum length of slope 300 ft. The area in Tract 3 that currently has final cover has flatter slopes (~4H:1V), and hence, the steeper slope in Tract 2A represents the critical case and is considered in the analysis.

Based on generally accepted industry practice, the minimum allowable factor of safety is 1.5 for long-term conditions.

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12/5/16
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LICENSED
PROFESSIONAL ENGINEER

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Professional Engineering Firm
Registration Number F-2578

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3.0 ASSUMPTIONS

Proposed final cover liner system consists of (from top to bottom):

18-inch Soil Cover consisting of on-site soils
Double-sided geocomposite
40-mil LLDPE textured Geomembrane
18-inch Clay Liner

The geocomposite drainage layer is adequate to prevent the buildup of excess pore water pressures at the geocomposite/geomembrane interface if the geocomposite is daylighted at the appropriate interval (see calculations in Appendix III-3D-2).

Based on a review of available data, the following parameters were assigned to the materials.

Material	Strength Parameters		Unit Weight (pcf)		Reference
	ϕ	c	Moist	Saturated	
Soil cover	28	0	115	132	Ref. [1](1)
Soil cover/Geocomposite	28	0	N/A	N/A	Golder(2)
Geocomposite/Textured Geomembrane(3)	21	0	N/A	N/A	Golder(2)
Textured Geomembrane/Clay Liner	35	0	N/A	N/A	Golder(2)
Clay Liner	28	0	115	132	Ref. [1](1)
Clay Liner/Subgrade	28	0	N/A	N/A	Ref. [1](1)

(1) The shear strength of the protective cover soils, clay liner and clay liner/subgrade interface is estimated based on the on-site soil shear strength. This is estimated using the average plasticity index (PI = 40) of the Stratum I and Stratum II soils described in Attachment 4, and Ref. [1].

(2) Based on unpublished data from tests performed in Golder's laboratory, on similar geosynthetic materials. Strength parameters were conservatively assigned to be equal to or a percentage of the peak strength (lower bound) to account for testing data variability and to avoid strains that result in residual interface shear strengths. This data is presented in this appendix.

(3) The data indicates a lower-bound angle of 24°, but since the final cover pertains to a long-term condition a conservative angle of 21° is assumed for the calculation.

Based on the shear strength parameters, the critical interface occurs along the geocomposite/ textured geomembrane interface; this interface has a friction angle of 21 degrees.

4.0 METHOD

A model was created representing the final cover slopes. A limit equilibrium analysis was performed to determine the minimum factor of safety against a sliding block failure along the critical interface.

Case (i) 4H:1V (S = 25%)
Infinite Slope Analysis

$$FS = \frac{c + (\gamma b \cos\beta - \gamma_w d \cos\beta)\tan\phi}{\gamma b \sin\beta}$$

Sliding at Geocomposite-Textured Geomembrane Interface

ϕ =	21	interface friction angle
c =	0	interface adhesion (psf)
β =	14.0	slope angle (degrees)
γ =	132	saturated unit weight of soil (pcf)
b =	1.5	soil thickness (ft)
d =	0	water depth in cover (ft)
γ_w =	62.4	unit weight of water (pcf)
FS =	**1.54**	**> 1.5**

Case (ii) 3.16H:1V (S = 31.7%)

The existing final cover consists of (top to bottom):

6" top soil consisting of on-site soils

36" clay liner consisting of on-site soils ($k = 1 \times 10^{-7}$ cm/s)

Based on a review of available data, the following parameters were assigned to the materials.

Material	Strength Parameters		Unit Weight (pcf)		Reference
	ϕ	c	Moist	Saturated	
Top Soil	28	0	115	132	Ref. [1](1)
Top Soil/Soil Cover	28	0	N/A	N/A	Ref. [1](1)
Clay Liner	28	0	115	132	Ref. [1](1)
Clay Liner/Subgrade	28	0	N/A	N/A	Ref. [1](1)

(1) The shear strength of the protective cover soils, clay liner and clay liner/subgrade interface is estimated based on the on-site soil shear strength. This is estimated using the average plasticity index (PI = 40) of the Stratum I and Stratum II soils described in Attachment 4, and Ref. [1].

ϕ =	28	interface friction angle
c =	0	interface adhesion (psf)
β =	17.6	slope angle (degrees)
γ =	132	saturated unit weight of soil (pcf)
b =	3.5	soil thickness (ft)
d =	0.5	water depth in cover (ft) (assuming the top soil is fully saturated)
γ_w =	62.4	unit weight of water (pcf)

Factor of safety against sliding of the entire final cover = **1.57** **> 1.5**

5.0 RESULTS

The future 4H:1V final cover slope will have a minimum factor of safety of 1.54.
The existing 3.16H:1V final cover slope has a minimum factor of safety of 1.57.

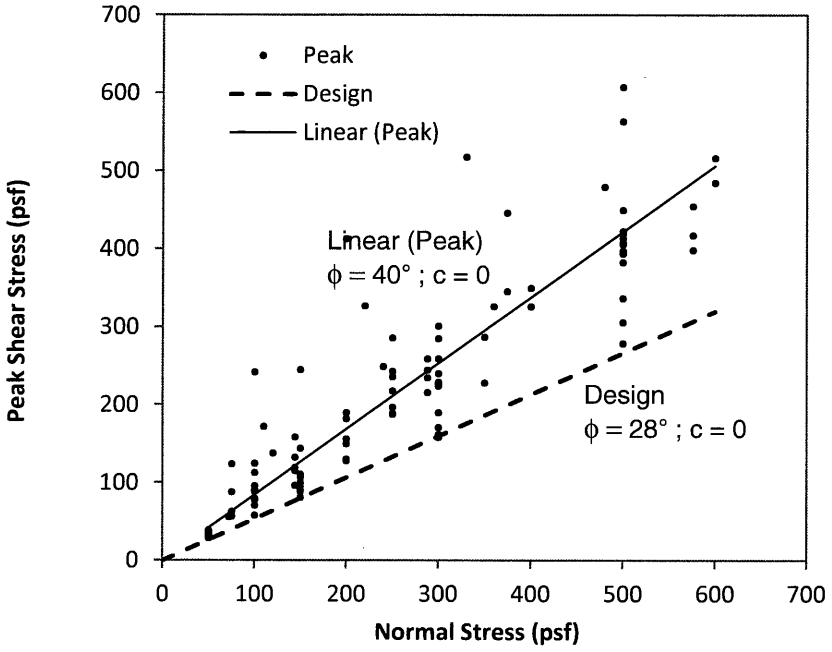
6.0 CONCLUSION

Through analysis of the lining system, the final cover slope is found to be stable.

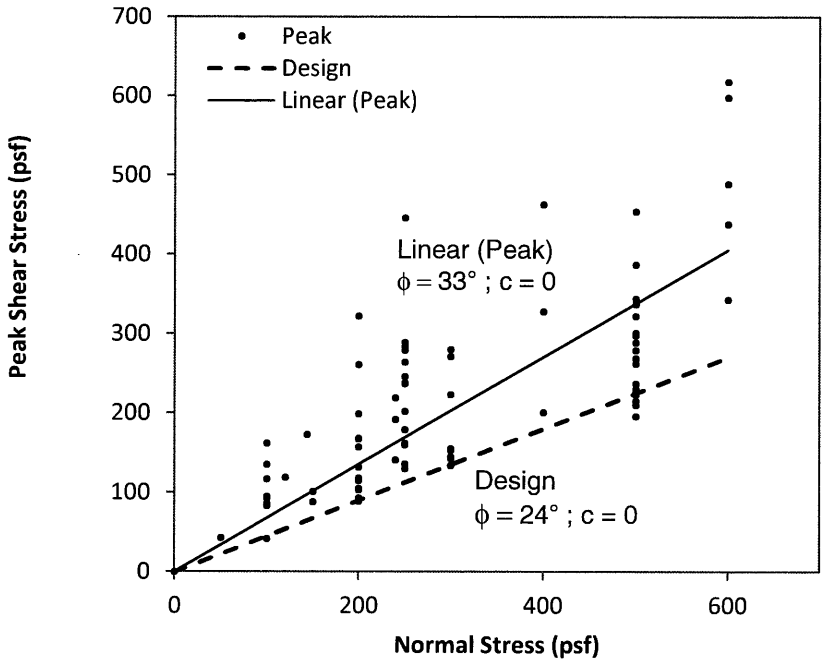
7.0 REFERENCES

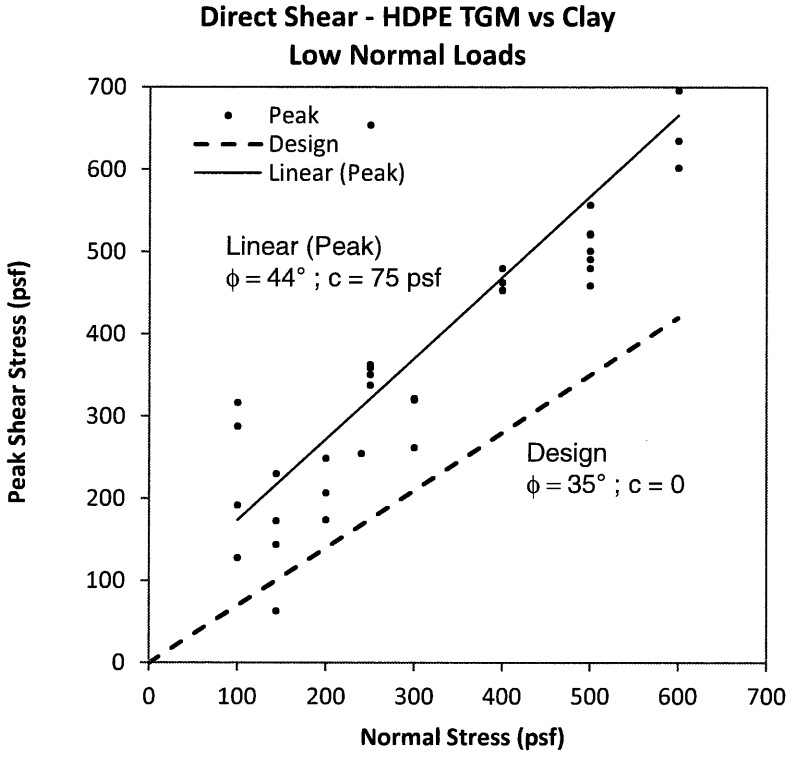
[1] Bjerrum, L. and Simons, N. E. (1960). "Comparison of shear strength characteristics of normally consolidated clays." Proceedings of the Research Conference on Shear Strength of Cohesive Soils, ASCE, Boulder, Colorado, 1960, pp. 711–726.

Direct Shear - Geocomposite vs Protective Cover
Low Normal Loads



Direct Shear - HDPE TGM vs GC
Low Normal Loads





P:_2014 Project Folders\1400336 - Temple Expansion\PERMIT APPLICATION\Response to 1st NOD\Part III\Att 3\III-3C - Stability Analysis\III-3C5 - Final Cover Stability\III-3C5_rev1.xlsx
Submitted: June 2016
Revised: December 2016

APPENDIX III-3E-1

HELP MODEL EVALUATION

HELP MODEL EVALUATIONS

Made By: VK
Checked by: JBF / MX
Reviewed by: CGD

1.0 OBJECTIVE

I) Estimate the leachate production rate (impingement rate) for various conditions during the life of the landfill.

II) Determine the minimum design transmissivity (θ_{design}) of the leachate collection system geocomposite drainage layer.

III) Determine the minimum required transmissivity ($\theta_{required}$) of the leachate collection system geocomposite drainage layer.

IV) Estimate the peak and average annual leachate production rates.

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2.0 METHOD

I) Use the Hydrologic Evaluation of Landfill Performance (HELP) Model (Ref. 1) with layers simulating the proposed liner, waste, and cover materials, along with climatic data and evapotranspiration parameters consistent with anticipated site conditions, to estimate the peak leachate flow rate (impingement rate) into the geocomposite for:

(i) open condition
(ii) intermediate condition
(iii) final condition prior to final cover placement
(iv) final condition with final cover

The intermediate, final condition, and final condition with final cover cases are considered with and without leachate recirculation - i.e. recirculating leachate collected in the geocomposite drainage layer back into the waste layer. Lechate recirculation is not expected for the open condition which considers only 10 feet of waste in place.

II) Determine the transmissivity needed to maintain a hydraulic head less than the thickness of the geocomposite for each condition (θ_{design}) using the following equation (Ref. 2)

$$\theta_{design} = \frac{q_i L}{sin\beta} = \frac{q_i L}{Slope}$$

Where: θ_{design} = design transmissivity (m^2/sec)
q_i = impingement rate (m/sec)
L = horizontal length of slope (m)
β = slope angle (degrees)

III) Establish a required transmissivity, $\theta_{required}$, for each condition, by applying reduction factors and safety factor to the θ_{design}. The maximum value will be included in the Liner Quality Control Plan.

$$\theta_{required} = \theta_{design} [RF_{cr} * RF_{cc} * RF_{bc} * RF_{in}] \times FS$$

Where:
- RF_{cr} = Reduction factor for long-term creep
- RF_{cc} = Reduction factor for chemical clogging
- RF_{br} = Reduction factor for biological clogging
- RF_{in} = Reduction factor for intrusion of geotextile or geomembrane

3.0 EVALUATION

I) Impingement Rate

Help Model Input

GENERAL:

Climate data synthetically generated using coefficients for Temple TX, and historic temperature and rainfall data for Temple, TX.

Slope and slope length of the landfill floor are variable; however, as long as the leachate head is not greater than the thickness of the leachate drainage layer, the impingement rate (i.e. the percolation/leakage into the LCRS) is not affected by slope angle or slope length of the cell floor.

Liner System (top to bottom):

24 inches of protective cover soil ($k = 1 \times 10^{-5}$ cm/s)
Geocomposite drainage layer (k = 15 cm/s; thickness = 0.2 inches)

60-mil HDPE geomembrane

24-inch compacted clay liner (default material texture No. 16, $k=1.0 \times 10^{-7}$)

Cover System (top to bottom):

The slope of the top of final cover is 4% for modeling purposes.

18 inches of cover soil (default material texture No. 25 - clay)

200-mil Geocomposite drainage layer ($\theta = 3.2 \times 10^{-4}$ m^2/s; ~k = 6.3 cm/s; 4% slope; 400 ft slope length)

40-mil LLDPE geomembrane

18-inch compacted clay liner ($k = 1 \times 10^{-5}$ cm/s)

12 inches of intermediate cover (default material texture No.14 - clay)

ASSUMPTIONS

Bottom liner final cover geomembranes modeled as having 1 pinhole/acre, 1 installation defect/acre, good placement quality

Initial soil and waste moisture contents calculated by model.

Open Condition (Daily Cover) - Methodology/Assumptions

10 ft of waste with k = 1 x 10^{-3} cm/sec (default material texture No.18)
6 in daily cover soil (default material texture No. 14)
Bare ground
Leaf area index = 0
Evaporative zone depth = 6 in (recommended by model)
0% of area allowed to have runoff
5-yr simulation period

Intermediate Cover Condition - Methodology/Assumptions

100 ft of waste with k = 1 x 10^{-3} cm/sec (default material texture No.18)
12 in intermediate cover soil (default material texture No. 14)
Bare ground
Leaf area index = 0
Evaporative zone depth = 10 in (recommended by model)
75% of area allowed to have runoff
Surface Slope = 1%
10-yr simulation period

Final - No Cover Condition - Methodology/Assumptions

250 ft of waste with k = 1 x 10^{-3} cm/s (default material texture No.18)
Fair grass
Leaf area index = 2
Evaporative zone depth = 22 in (recommended by model)
100% of area allowed to have runoff
Surface Slope = 3%
30-yr simulation period

Final Cover Condition - Methodology/Assumptions

250 ft of waste with k = 1 x 10^{-3} cm/s (default material texture No.18)
Fair grass
Leaf area index = 2
Evaporative zone depth = 18 in
100% of area allowed to have runoff
Surface Slope = 4%
30-yr simulation period

Note that the groundwater inflow to the leachate drainage layer (calculated in Appendix 3E-1a) is included in all scenarios. 100% recirculation is considered for the intermediate condition, and 80% recirculation is considered for the final (no cover) and final cover conditions.

HELP Model results for different conditions

Run	Condition Modeled	Peak Daily Values			Ave. Annual Leachate Gen. (cf/ac)
		Head (in)	q_i (in)	Leachate Gen. (cf/ac/day)	
No Leachate Recirculation					
TLGO	Open	0.190	0.278	1,009	46,590
TLGI	Intermediate	0.195	0.152	554	6,244
TLGF	Final - No cover	0.192	0.053	191	463
TLGFWC	Final Cover	0.191	1.10E-04	0.4	145
With Leachate Recirculation					
TLGIR	Intermediate(1)	0.193	0.151	546	80,911
TLGFR	Final - no cover(2)	0.199	0.068	248	31,006
TLGFWCR	Final(2)	0.191	0.028	102	37,053

(1) 100% leachate recirculation is considered for the intermediate condition.

(2) 80% leachate recircluation is considered for the final (no cover) and final cover conditions

Results of the HELP modeling indicate that recirculation does not cause substantial change to the peak daily value for the intermediate case; however, the average annual leachate generation rate increases as expected, by over 10 times.

For final (no cover) and final cover cases, the impact of recirculation on peak daily values gradually increases and the increase in average annual leachate generation rate is high.

II) Design Transmissivity

Using the equation from Ref. 2, solve for θ_{design}. Evaluate various combinations of slope and slope length to determine the most critical case.

Condition	q_i		L (ft)	Slope (%)	θ_{design} (m^2/sec)
	in/day	cm/sec			
Open	0.278	1.27E-06	240	0.8	**1.16E-04**
			290	1.0	1.12E-04
			565	2.0	1.09E-04
			840	3.0	1.08E-04
			1140	4.0	1.10E-04
Intermediate	0.152	6.93E-07	240	0.8	**6.33E-05**
			290	1.0	6.12E-05
			565	2.0	5.96E-05
			840	3.0	5.91E-05
			1140	4.0	6.02E-05
Final - no cover	0.053	2.40E-07	240	0.8	**2.19E-05**
			290	1.0	2.12E-05
			565	2.0	2.06E-05
			840	3.0	2.05E-05
			1140	4.0	2.08E-05
Final	1.10E-04	5.01E-10	240	0.8	**4.58E-08**
			290	1.0	4.43E-08
			565	2.0	4.32E-08
			840	3.0	4.28E-08
			1140	4.0	4.35E-08
Intermediate with 100% recirculation	0.151	6.88E-07	240	0.8	**6.29E-05**
			290	1.0	6.08E-05
			565	2.0	5.92E-05
			840	3.0	5.87E-05
			1140	4.0	5.98E-05
Final (no cover) with 80% recirculation	0.068	3.11E-07	240	0.8	**2.84E-05**
			290	1.0	2.75E-05
			565	2.0	2.68E-05
			840	3.0	2.65E-05
			1140	4.0	2.70E-05
Final with 80% recirculation	0.028	1.28E-07	240	0.8	**1.17E-05**
			290	1.0	1.13E-05
			565	2.0	1.10E-05
			840	3.0	1.09E-05
			1140	4.0	1.11E-05

III) Required Transmissivity

Apply reduction factors and safety factor to design transmissivity.

Each reduction factor is selected to reflect differences from laboratory tested transmissivity values to field conditions.

Condition	θ_{design} (m^2/sec)	RF_{cr}	RF_{cc}	RF_{bc}	R_{in}	FS	$\theta_{required}$ (m^2/sec)
Open	1.16E-04	1.4	1.2	1.1	1.1	2	4.71E-04
Intermediate	6.33E-05	1.5	1.7	1.3	1.1	3	6.93E-04
Final - no cover	2.19E-05	2	2	2	1.2	4	8.42E-04
Final	4.58E-08	2	2	2	1.2	4	1.76E-06
Intermediate(1)	6.29E-05	1.5	1.7	1.3	1.1	3	6.88E-04
Final - no cover(2)	2.84E-05	2	2	2	1.2	4	1.09E-03
Final(2)	1.17E-05	2	2	2	1.2	4	4.48E-04

(1) 100% leachate recirculation is considered for the intermediate condition.

(2) 80% leachate recircluation is considered for the final (no cover) and final cover conditions

4.0 CONCLUSION

I) Based on the HELP model, the impingement rate varies from 0.278 in/day for the open condition to 1.1 x 10^{-4} in/day following closure.

II) The critical design transmissivity (θ_{design}) occurs for an 0.8% slope with a length of 240 ft for each stage of landfill development.

III) The required transmissivity ($\theta_{required}$) (i.e. the transmissivity required during QC and conformance testing) was determined by applying reduction factors and a factor of safety appropriate for each condition. The maximum value is **1.09x10^{-3} m^2/sec**.

IV) The maximum peak daily value occurs during the open condition and the peak average annual leachate production rate occurs during the intermediate condition with recirculation. The values are:

Peak Daily Leachate Production =	**1,009**	**cf/ac/day**	**7,549**	**gal/ac/day**
Average Annual Leachate Production =	**80,911**	**cf/ac/yr**	**1,658**	**gal/ac/day**

5.0 REFERENCES

1.) *Hydrologic Evaluation of Landfill Performance (HELP) Model, Version 3.07*, U.S. EPA and U.S. Army Engineering Waterways Experiment Station, Corps of Engineers, Vicksburg, MS, November 1997.

2.) Giroud, J.P., Zornberg, J.G., and Zhao, A., "Hydraulic Design of Geosynthetics and Granular Liquid Collection Layers", Geosynthetics International, Vol. 7, Nos. 4-6, pp. 285-380, 2000.

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE        **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)        **
**                   DEVELOPED BY ENVIRONMENTAL LABORATORY          **
**                     USAE WATERWAYS EXPERIMENT STATION            **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY      **
**                                                                  **
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PRECIPITATION DATA FILE:    C:\T200m\Reqk\TLGO.D4
TEMPERATURE DATA FILE:      C:\T200m\Reqk\TLGO.D7
SOLAR RADIATION DATA FILE:  C:\T200m\Reqk\TLGO.D13
EVAPOTRANSPIRATION DATA:    C:\T200m\Reqk\TLGO.D11
SOIL AND DESIGN DATA FILE:  C:\T200m\Reqk\TLGO.D10
OUTPUT DATA FILE:           C:\T200m\Reqk\TLGO.OUT


TIME:  10:42     DATE:  11/25/2015


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     TITLE:  Temple Expansion: Open condition; 0.8% grade

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                              LAYER  1
                              --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER  14
     THICKNESS                    =      6.00   INCHES
     POROSITY                     =      0.4790 VOL/VOL
     FIELD CAPACITY               =      0.3710 VOL/VOL
     WILTING POINT                =      0.2510 VOL/VOL
     INITIAL SOIL WATER CONTENT   =      0.2510 VOL/VOL
     EFFECTIVE SAT. HYD. COND.    =  0.249999994000E-04 CM/SEC


                              LAYER  2
                              --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER  18
     THICKNESS                    =    120.00   INCHES
     POROSITY                     =      0.6710 VOL/VOL
     FIELD CAPACITY               =      0.2920 VOL/VOL
     WILTING POINT                =      0.0770 VOL/VOL
     INITIAL SOIL WATER CONTENT   =      0.2992 VOL/VOL
     EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                              LAYER  3
                              --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER  0
     THICKNESS                    =     24.00   INCHES
     POROSITY                     =      0.4520 VOL/VOL
     FIELD CAPACITY               =      0.4110 VOL/VOL
     WILTING POINT                =      0.3110 VOL/VOL
     INITIAL SOIL WATER CONTENT   =      0.4334 VOL/VOL
     EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-05 CM/SEC


                              LAYER  4
                              --------

               TYPE 2 - LATERAL DRAINAGE LAYER
                   MATERIAL TEXTURE NUMBER  0
     THICKNESS                    =      0.20   INCHES
     POROSITY                     =      0.8500 VOL/VOL
     FIELD CAPACITY               =      0.0100 VOL/VOL
     WILTING POINT                =      0.0050 VOL/VOL
     INITIAL SOIL WATER CONTENT   =      0.1280 VOL/VOL
     EFFECTIVE SAT. HYD. COND.    =   15.0000000000     CM/SEC
     SLOPE                        =      0.80   PERCENT
     DRAINAGE LENGTH              =    240.0    FEET
     SUBSURFACE INFLOW            =      0.04   INCHES/YR


                              LAYER  5
                              --------

               TYPE 4 - FLEXIBLE MEMBRANE LINER
                   MATERIAL TEXTURE NUMBER  0
     THICKNESS                    =      0.06   INCHES
     POROSITY                     =      0.0000 VOL/VOL
     FIELD CAPACITY               =      0.0000 VOL/VOL
     WILTING POINT                =      0.0000 VOL/VOL
     INITIAL SOIL WATER CONTENT   =      0.0000 VOL/VOL
     EFFECTIVE SAT. HYD. COND.    =  0.199999996000E-12 CM/SEC
     FML PINHOLE DENSITY          =      1.00   HOLES/ACRE
     FML INSTALLATION DEFECTS     =      1.00   HOLES/ACRE
     FML PLACEMENT QUALITY        =  3 - GOOD


                              LAYER  6
                              --------

               TYPE 3 - BARRIER SOIL LINER
                   MATERIAL TEXTURE NUMBER  16
     THICKNESS                    =     24.00   INCHES
     POROSITY                     =      0.4270 VOL/VOL
     FIELD CAPACITY               =      0.4180 VOL/VOL
     WILTING POINT                =      0.3670 VOL/VOL
     INITIAL SOIL WATER CONTENT   =      0.4270 VOL/VOL
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EFFECTIVE SAT. HYD. COND. = 0.100000001000E-06 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #14 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 1.% AND A SLOPE LENGTH OF 240. FEET.

SCS RUNOFF CURVE NUMBER	=	96.30	
FRACTION OF AREA ALLOWING RUNOFF	=	0.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	6.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	1.506	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	2.874	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.506	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	58.088	INCHES
TOTAL INITIAL WATER	=	58.088	INCHES
TOTAL SUBSURFACE INFLOW	=	0.04	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM Temple TX

STATION LATITUDE	=	31.00 DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00
START OF GROWING SEASON (JULIAN DATE)	=	56
END OF GROWING SEASON (JULIAN DATE)	=	336
EVAPORATIVE ZONE DEPTH	=	6.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	10.30 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	64.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	68.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR TEMPLE TEXAS

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.94	2.57	1.97	3.56	4.65	2.94
1.75	2.50	3.51	3.30	2.69	2.37

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR TEMPLE TEXAS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.60	50.30	57.70	66.70	73.50	80.80
84.60	84.50	78.70	69.00	56.90	49.70

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR TEMPLE TEXAS AND STATION LATITUDE = 31.00 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.95	2.10	2.38	3.16	3.54	2.71
	1.73	4.28	3.13	3.25	1.15	2.49
STD. DEVIATIONS	0.98	1.47	1.30	2.56	1.84	1.50
	2.15	3.62	1.62	2.18	1.00	0.85
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.795	1.215	1.803	1.895	2.273	1.476
	0.994	2.034	1.835	1.788	0.981	1.224
STD. DEVIATIONS	0.853	0.921	0.874	1.134	1.354	0.724
	1.025	0.935	0.802	0.912	0.617	0.361
SUBSURFACE INFLOW INTO LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED FROM LAYER 4						
TOTALS	1.0304	0.3227	0.9558	0.8027	1.3220	0.8264
	1.2334	0.9783	1.8138	1.5288	1.4855	0.5348
STD. DEVIATIONS	0.6758	0.4083	0.9308	0.5539	1.2677	0.7803
	1.3538	1.3723	1.5891	1.3045	0.8650	0.5228
PERCOLATION/LEAKAGE THROUGH LAYER 6						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 5

AVERAGES	0.0117	0.0040	0.0109	0.0094	0.0150	0.0097
	0.0140	0.0111	0.0213	0.0174	0.0175	0.0061
STD. DEVIATIONS	0.0077	0.0050	0.0106	0.0065	0.0144	0.0092
	0.0154	0.0156	0.0187	0.0148	0.0102	0.0060

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	30.88 (5.966)	112094.4	100.00
RUNOFF	0.000 (0.0000)	0.00	0.000
EVAPOTRANSPIRATION	18.313 (3.2068)	66475.74	59.303
SUBSURFACE INFLOW INTO LAYER 4	0.00000	0.000	0.00000
LATERAL DRAINAGE COLLECTED FROM LAYER 4	12.83464 (4.73436)	46589.754	41.56296
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00001 (0.00000)	0.030	0.00003
AVERAGE HEAD ON TOP OF LAYER 5	0.012 (0.005)		
CHANGE IN WATER STORAGE	-0.228 (1.5407)	-825.83	-0.737

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	3.95	14338.500
RUNOFF	0.000	0.0000
DRAINAGE COLLECTED FROM LAYER 4	0.27800	1009.13696
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00045
AVERAGE HEAD ON TOP OF LAYER 5	0.098	
MAXIMUM HEAD ON TOP OF LAYER 5	0.190	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	7.7 FEET	
SNOW WATER	0.65	2360.6431

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4699
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.2510

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	1.7965	0.2994
2	35.0399	0.2920
3	9.8640	0.4110
4	0.0020	0.0102
5	0.0000	0.0000
6	10.2480	0.4270
SNOW WATER	0.000	

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE        **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)        **
**                   DEVELOPED BY ENVIRONMENTAL LABORATORY          **
**                     USAE WATERWAYS EXPERIMENT STATION            **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY      **
**                                                                  **
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PRECIPITATION DATA FILE:    C:\T200m\Reqk\TLGI.D4
TEMPERATURE DATA FILE:      C:\T200m\Reqk\TLGI.D7
SOLAR RADIATION DATA FILE:  C:\T200m\Reqk\TLGI.D13
EVAPOTRANSPIRATION DATA:    C:\T200m\Reqk\TLGI.D11
SOIL AND DESIGN DATA FILE:  C:\T200m\Reqk\TLGI.D10
OUTPUT DATA FILE:           C:\T200m\Reqk\TLGI.OUT

TIME:  20:36     DATE:  11/30/2015

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     TITLE:  Temple Expansion: Intermediate Condition

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

                              LAYER  1
                              --------

                TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER  14
     THICKNESS                    =     12.00   INCHES
     POROSITY                     =      0.4790 VOL/VOL
     FIELD CAPACITY               =      0.3710 VOL/VOL
     WILTING POINT                =      0.2510 VOL/VOL
     INITIAL SOIL WATER CONTENT   =      0.2938 VOL/VOL
     EFFECTIVE SAT. HYD. COND.    =  0.249999994000E-04 CM/SEC

                              LAYER  2
                              --------

                TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER  18
     THICKNESS                    =   1200.00   INCHES
     POROSITY                     =      0.6710 VOL/VOL
     FIELD CAPACITY               =      0.2920 VOL/VOL
     WILTING POINT                =      0.0770 VOL/VOL
     INITIAL SOIL WATER CONTENT   =      0.2921 VOL/VOL
     EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC

                              LAYER  3
                              --------

                TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER   0
     THICKNESS                    =     24.00   INCHES
     POROSITY                     =      0.4520 VOL/VOL
     FIELD CAPACITY               =      0.4110 VOL/VOL
     WILTING POINT                =      0.3110 VOL/VOL
     INITIAL SOIL WATER CONTENT   =      0.4217 VOL/VOL
     EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-05 CM/SEC

                              LAYER  4
                              --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                    MATERIAL TEXTURE NUMBER   0
     THICKNESS                    =      0.20   INCHES
     POROSITY                     =      0.8500 VOL/VOL
     FIELD CAPACITY               =      0.0100 VOL/VOL
     WILTING POINT                =      0.0050 VOL/VOL
     INITIAL SOIL WATER CONTENT   =      0.1132 VOL/VOL
     EFFECTIVE SAT. HYD. COND.    =   8.00000000000     CM/SEC
     SLOPE                        =      0.80   PERCENT
     DRAINAGE LENGTH              =    240.0    FEET
     SUBSURFACE INFLOW            =      0.04   INCHES/YR

                              LAYER  5
                              --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                    MATERIAL TEXTURE NUMBER  35
     THICKNESS                    =      0.06   INCHES
     POROSITY                     =      0.0000 VOL/VOL
     FIELD CAPACITY               =      0.0000 VOL/VOL
     WILTING POINT                =      0.0000 VOL/VOL
     INITIAL SOIL WATER CONTENT   =      0.0000 VOL/VOL
     EFFECTIVE SAT. HYD. COND.    =  0.199999996000E-12 CM/SEC
     FML PINHOLE DENSITY          =      1.00   HOLES/ACRE
     FML INSTALLATION DEFECTS     =      1.00   HOLES/ACRE
     FML PLACEMENT QUALITY        =  3 - GOOD

                              LAYER  6
                              --------

                TYPE 3 - BARRIER SOIL LINER
                    MATERIAL TEXTURE NUMBER  16
     THICKNESS                    =     24.00   INCHES
     POROSITY                     =      0.4270 VOL/VOL
     FIELD CAPACITY               =      0.4180 VOL/VOL
     WILTING POINT                =      0.3670 VOL/VOL
     INITIAL SOIL WATER CONTENT   =      0.4270 VOL/VOL
```

EFFECTIVE SAT. HYD. COND. = 0.100000001000E-06 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #14 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 1.% AND A SLOPE LENGTH OF 240. FEET.

SCS RUNOFF CURVE NUMBER	=	96.30	
FRACTION OF AREA ALLOWING RUNOFF	=	75.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.783	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.790	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.510	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	374.487	INCHES
TOTAL INITIAL WATER	=	374.487	INCHES
TOTAL SUBSURFACE INFLOW	=	0.04	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM Temple TX

STATION LATITUDE	=	31.00	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	56	
END OF GROWING SEASON (JULIAN DATE)	=	336	
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	10.30	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	64.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	68.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR TEMPLE TEXAS

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.94	2.57	1.97	3.56	4.65	2.94
1.75	2.50	3.51	3.30	2.69	2.37

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR TEMPLE TEXAS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.60	50.30	57.70	66.70	73.50	80.80
84.60	84.50	78.70	69.00	56.90	49.70

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR TEMPLE TEXAS AND STATION LATITUDE = 31.00 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 10

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.17	2.37	1.95	3.89	2.71	3.21
	1.93	3.37	2.51	3.97	2.24	2.26
STD. DEVIATIONS	0.79	1.41	1.19	2.50	1.85	1.68
	2.06	3.04	1.50	2.92	2.00	1.02
RUNOFF						
TOTALS	0.098	0.532	0.354	1.501	0.742	1.212
	0.815	1.234	0.743	1.614	0.595	0.559
STD. DEVIATIONS	0.099	0.529	0.429	1.364	0.713	0.810
	1.147	1.516	0.725	1.652	0.903	0.462
EVAPOTRANSPIRATION						
TOTALS	1.128	1.630	1.761	2.105	1.929	1.830
	1.304	1.578	1.525	2.179	1.459	1.552
STD. DEVIATIONS	0.606	0.983	1.095	1.143	1.257	0.887
	1.161	1.101	0.815	0.986	0.702	0.599
SUBSURFACE INFLOW INTO LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED FROM LAYER 4						
TOTALS	0.1251	0.0883	0.1442	0.0285	0.1157	0.1142
	0.0986	0.0445	0.2390	0.2810	0.2104	0.2305
STD. DEVIATIONS	0.1978	0.1491	0.3006	0.0468	0.1521	0.2423
	0.2921	0.0724	0.4271	0.3150	0.2987	0.2917
PERCOLATION/LEAKAGE THROUGH LAYER 6						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 5

AVERAGES	0.0027	0.0021	0.0031	0.0006	0.0025	0.0025
	0.0021	0.0009	0.0053	0.0060	0.0046	0.0049
STD. DEVIATIONS	0.0042	0.0035	0.0064	0.0010	0.0032	0.0053
	0.0062	0.0015	0.0094	0.0067	0.0066	0.0062

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 10

	INCHES	CU. FEET	PERCENT
PRECIPITATION	31.60 (6.065)	114708.0	100.00
RUNOFF	9.998 (3.5087)	36293.07	31.640
EVAPOTRANSPIRATION	19.979 (2.9620)	72523.55	63.224
SUBSURFACE INFLOW INTO LAYER 4	0.00000	0.000	0.00000
LATERAL DRAINAGE COLLECTED FROM LAYER 4	1.72008 (0.81157)	6243.879	5.44328
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000 (0.00000)	0.015	0.00001
AVERAGE HEAD ON TOP OF LAYER 5	0.003 (0.001)		
CHANGE IN WATER STORAGE	-0.057 (0.5726)	-207.23	-0.181

PEAK DAILY VALUES FOR YEARS 1 THROUGH 10

	(INCHES)	(CU. FT.)
PRECIPITATION	4.22	15318.600
RUNOFF	3.129	11356.9883
DRAINAGE COLLECTED FROM LAYER 4	0.15250	553.58783
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00047
AVERAGE HEAD ON TOP OF LAYER 5	0.101	
MAXIMUM HEAD ON TOP OF LAYER 5	0.195	
LOCATION OF MAXIMUM HEAD IN LAYER 4		
(DISTANCE FROM DRAIN)	7.9 FEET	
SNOW WATER	0.65	2360.6431

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4448

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.2510

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

FINAL WATER STORAGE AT END OF YEAR 10

LAYER	(INCHES)	(VOL/VOL)
1	3.4020	0.2835
2	350.4000	0.2920
3	9.8640	0.4110
4	0.0021	0.0103
5	0.0000	0.0000
6	10.2480	0.4270
SNOW WATER	0.000	

```
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**                                                                           **
**                                                                           **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE                **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                 **
**                   DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                     USAE WATERWAYS EXPERIMENT STATION                     **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY               **
**                                                                           **
**                                                                           **
*******************************************************************************
*******************************************************************************

PRECIPITATION DATA FILE:    C:\T200m\Reqk\TLGF.D4
TEMPERATURE DATA FILE:      C:\T200m\Reqk\TLGF.D7
SOLAR RADIATION DATA FILE:  C:\T200m\Reqk\TLGF.D13
EVAPOTRANSPIRATION DATA:    C:\T200m\Reqk\TLGF.D11
SOIL AND DESIGN DATA FILE:  C:\T200m\Reqk\TLGF.D10
OUTPUT DATA FILE:           C:\T200m\Reqk\TLGF.OUT

TIME:  20:53     DATE:  11/30/2015

*******************************************************************************

     TITLE:  Temple Expansion: Final Condition, 0.8% grade

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

                              LAYER  1
                              --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                      MATERIAL TEXTURE NUMBER  14
        THICKNESS                     =     12.00   INCHES
        POROSITY                      =      0.4790 VOL/VOL
        FIELD CAPACITY                =      0.3710 VOL/VOL
        WILTING POINT                 =      0.2510 VOL/VOL
        INITIAL SOIL WATER CONTENT    =      0.3146 VOL/VOL
        EFFECTIVE SAT. HYD. COND.     =  0.249999994000E-04 CM/SEC
      NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
               FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.

                              LAYER  2
                              --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                      MATERIAL TEXTURE NUMBER  18
        THICKNESS                     =   3000.00   INCHES
        POROSITY                      =      0.6710 VOL/VOL
        FIELD CAPACITY                =      0.2920 VOL/VOL
        WILTING POINT                 =      0.0770 VOL/VOL
        INITIAL SOIL WATER CONTENT    =      0.2916 VOL/VOL
        EFFECTIVE SAT. HYD. COND.     =  0.100000005000E-02 CM/SEC

                              LAYER  3
                              --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                      MATERIAL TEXTURE NUMBER  0
        THICKNESS                     =     24.00   INCHES
        POROSITY                      =      0.4520 VOL/VOL
        FIELD CAPACITY                =      0.4110 VOL/VOL
        WILTING POINT                 =      0.3110 VOL/VOL
        INITIAL SOIL WATER CONTENT    =      0.4110 VOL/VOL
        EFFECTIVE SAT. HYD. COND.     =  0.999999975000E-05 CM/SEC

                              LAYER  4
                              --------

                  TYPE 2 - LATERAL DRAINAGE LAYER
                      MATERIAL TEXTURE NUMBER  0
        THICKNESS                     =      0.20   INCHES
        POROSITY                      =      0.8500 VOL/VOL
        FIELD CAPACITY                =      0.0100 VOL/VOL
        WILTING POINT                 =      0.0050 VOL/VOL
        INITIAL SOIL WATER CONTENT    =      0.0123 VOL/VOL
        EFFECTIVE SAT. HYD. COND.     =   2.79999995000      CM/SEC
        SLOPE                         =      0.80   PERCENT
        DRAINAGE LENGTH               =    240.0    FEET
        SUBSURFACE INFLOW             =      0.04   INCHES/YR

                              LAYER  5
                              --------

                  TYPE 4 - FLEXIBLE MEMBRANE LINER
                      MATERIAL TEXTURE NUMBER  35
        THICKNESS                     =      0.06   INCHES
        POROSITY                      =      0.0000 VOL/VOL
        FIELD CAPACITY                =      0.0000 VOL/VOL
        WILTING POINT                 =      0.0000 VOL/VOL
        INITIAL SOIL WATER CONTENT    =      0.0000 VOL/VOL
        EFFECTIVE SAT. HYD. COND.     =  0.199999996000E-12 CM/SEC
        FML PINHOLE DENSITY           =      0.00   HOLES/ACRE
        FML INSTALLATION DEFECTS      =      0.00   HOLES/ACRE
        FML PLACEMENT QUALITY         =  4 - POOR

                              LAYER  6
                              --------

                  TYPE 3 - BARRIER SOIL LINER
                      MATERIAL TEXTURE NUMBER  16
        THICKNESS                     =     24.00   INCHES
        POROSITY                      =      0.4270 VOL/VOL
        FIELD CAPACITY                =      0.4180 VOL/VOL
```

WILTING POINT	=	0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #14 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 3.% AND A SLOPE LENGTH OF 400. FEET.

SCS RUNOFF CURVE NUMBER	=	96.30	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.612	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	12.458	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	3.782	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	898.806	INCHES
TOTAL INITIAL WATER	=	898.806	INCHES
TOTAL SUBSURFACE INFLOW	=	0.04	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM Temple TX

STATION LATITUDE	=	31.00 DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	56
END OF GROWING SEASON (JULIAN DATE)	=	336
EVAPORATIVE ZONE DEPTH	=	22.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	10.30 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	64.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	68.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR TEMPLE TEXAS

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.94	2.57	1.97	3.56	4.65	2.94
1.75	2.50	3.51	3.30	2.69	2.37

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR TEMPLE TEXAS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.60	50.30	57.70	66.70	73.50	80.80
84.60	84.50	78.70	69.00	56.90	49.70

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR TEMPLE TEXAS AND STATION LATITUDE = 31.00 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.80	2.29	1.88	3.42	3.48	3.29
	1.75	2.92	3.01	4.02	2.53	2.04
STD. DEVIATIONS	1.35	1.35	1.07	2.20	2.42	1.79
	2.03	2.40	2.13	2.43	1.94	1.20
RUNOFF						
TOTALS	0.400	0.598	0.458	1.291	1.373	1.270
	0.725	1.143	1.065	1.852	0.866	0.537
STD. DEVIATIONS	0.491	0.568	0.485	1.272	1.480	1.027
	1.071	1.304	1.036	1.593	1.012	0.513
EVAPOTRANSPIRATION						
TOTALS	1.357	1.577	1.983	2.682	2.525	2.017
	1.218	1.619	1.797	1.622	1.199	1.184
STD. DEVIATIONS	0.427	0.549	0.745	0.858	1.092	0.929
	1.184	0.912	1.061	0.758	0.400	0.386
SUBSURFACE INFLOW INTO LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED FROM LAYER 4						
TOTALS	0.0337	0.0372	0.0150	0.0044	0.0069	0.0033
	0.0035	0.0034	0.0034	0.0035	0.0034	0.0099
STD. DEVIATIONS	0.1208	0.0866	0.0284	0.0015	0.0089	0.0002
	0.0005	0.0001	0.0002	0.0001	0.0002	0.0343
PERCOLATION/LEAKAGE THROUGH LAYER 6						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 5

AVERAGES	0.0021	0.0025	0.0009	0.0003	0.0004	0.0002
	0.0002	0.0002	0.0002	0.0002	0.0002	0.0006
STD. DEVIATIONS	0.0074	0.0058	0.0017	0.0001	0.0005	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0021

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	32.43	(6.086)	117728.2	100.00
RUNOFF	11.578	(3.7408)	42028.24	35.699
EVAPOTRANSPIRATION	20.782	(2.9569)	75437.36	64.078
SUBSURFACE INFLOW INTO LAYER 4	0.00000		0.000	0.00000
LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.12760	(0.19526)	463.200	0.39345
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000	(0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 5	0.001	(0.001)		
CHANGE IN WATER STORAGE	-0.015	(1.1260)	-55.35	-0.047

PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	4.65	16879.500
RUNOFF	3.672	13328.3271
DRAINAGE COLLECTED FROM LAYER 4	0.05261	190.96300
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00004
AVERAGE HEAD ON TOP OF LAYER 5	0.099	
MAXIMUM HEAD ON TOP OF LAYER 5	0.192	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	7.8 FEET	

SNOW WATER	1.50	5446.1431

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3448
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1719

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	4.2044	0.3504
2	874.0299	0.2913
3	9.8640	0.4110
4	0.0022	0.0109
5	0.0000	0.0000
6	10.2480	0.4270
SNOW WATER	0.000	

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**                                                                  **
**                                                                  **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE        **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)        **
**                   DEVELOPED BY ENVIRONMENTAL LABORATORY          **
**                     USAE WATERWAYS EXPERIMENT STATION            **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY       **
**                                                                  **
**                                                                  **
**********************************************************************
**********************************************************************

PRECIPITATION DATA FILE:    C:\T200m\Reqk\TLGFWC.D4
TEMPERATURE DATA FILE:      C:\T200m\Reqk\TLGFWC.D7
SOLAR RADIATION DATA FILE:  C:\T200m\Reqk\TLGFWC.D13
EVAPOTRANSPIRATION DATA:    C:\T200m\Reqk\TLGFWC.D11
SOIL AND DESIGN DATA FILE:  C:\T200m\Reqk\TLGFWC.D10
OUTPUT DATA FILE:           C:\T200m\Reqk\TLGFWC.OUT

TIME:  19:26     DATE:  11/30/2015

**********************************************************************

     TITLE:  Temple Expansion: Final condition with cover, 0.8% grade

**********************************************************************

     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
            COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

                              LAYER  1
                              --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                      MATERIAL TEXTURE NUMBER  25
     THICKNESS                    =     18.00   INCHES
     POROSITY                     =      0.4370 VOL/VOL
     FIELD CAPACITY               =      0.3730 VOL/VOL
     WILTING POINT                =      0.2660 VOL/VOL
     INITIAL SOIL WATER CONTENT   =      0.3485 VOL/VOL
     EFFECTIVE SAT. HYD. COND.    =  0.359999990000E-05 CM/SEC
   NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
            FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.

                              LAYER  2
                              --------

                  TYPE 2 - LATERAL DRAINAGE LAYER
                      MATERIAL TEXTURE NUMBER   0
     THICKNESS                    =      0.20   INCHES
     POROSITY                     =      0.8500 VOL/VOL
     FIELD CAPACITY               =      0.0100 VOL/VOL
     WILTING POINT                =      0.0050 VOL/VOL
     INITIAL SOIL WATER CONTENT   =      0.0710 VOL/VOL
     EFFECTIVE SAT. HYD. COND.    =   2.09999990000     CM/SEC
     SLOPE                        =      4.00   PERCENT
     DRAINAGE LENGTH              =    400.0    FEET

                              LAYER  3
                              --------

                  TYPE 4 - FLEXIBLE MEMBRANE LINER
                      MATERIAL TEXTURE NUMBER  36
     THICKNESS                    =      0.04   INCHES
     POROSITY                     =      0.0000 VOL/VOL
     FIELD CAPACITY               =      0.0000 VOL/VOL
     WILTING POINT                =      0.0000 VOL/VOL
     INITIAL SOIL WATER CONTENT   =      0.0000 VOL/VOL
     EFFECTIVE SAT. HYD. COND.    =  0.399999993000E-12 CM/SEC
     FML PINHOLE DENSITY          =      1.00   HOLES/ACRE
     FML INSTALLATION DEFECTS     =      1.00   HOLES/ACRE
     FML PLACEMENT QUALITY        =  3 - GOOD

                              LAYER  4
                              --------

                  TYPE 3 - BARRIER SOIL LINER
                      MATERIAL TEXTURE NUMBER   0
     THICKNESS                    =     18.00   INCHES
     POROSITY                     =      0.4750 VOL/VOL
     FIELD CAPACITY               =      0.3780 VOL/VOL
     WILTING POINT                =      0.2650 VOL/VOL
     INITIAL SOIL WATER CONTENT   =      0.4750 VOL/VOL
     EFFECTIVE SAT. HYD. COND.    =  0.989999971000E-03 CM/SEC

                              LAYER  5
                              --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                      MATERIAL TEXTURE NUMBER  14
     THICKNESS                    =     12.00   INCHES
     POROSITY                     =      0.4790 VOL/VOL
     FIELD CAPACITY               =      0.3710 VOL/VOL
     WILTING POINT                =      0.2510 VOL/VOL
     INITIAL SOIL WATER CONTENT   =      0.3710 VOL/VOL
     EFFECTIVE SAT. HYD. COND.    =  0.249999994000E-04 CM/SEC

                              LAYER  6
                              --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                      MATERIAL TEXTURE NUMBER  18
     THICKNESS                    =   3000.00   INCHES
     POROSITY                     =      0.6710 VOL/VOL
     FIELD CAPACITY               =      0.2920 VOL/VOL
     WILTING POINT                =      0.0770 VOL/VOL
```

INITIAL SOIL WATER CONTENT = 0.2920 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.100000005000E-02 CM/SEC

LAYER 7

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4520	VOL/VOL
FIELD CAPACITY	=	0.4110	VOL/VOL
WILTING POINT	=	0.3110	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4110	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999975000E-05	CM/SEC

LAYER 8

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.20	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1693	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.600000005000E-02	CM/SEC
SLOPE	=	0.80	PERCENT
DRAINAGE LENGTH	=	240.0	FEET
SUBSURFACE INFLOW	=	0.04	INCHES/YR

LAYER 9

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	1.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 10

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #25 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 4.% AND A SLOPE LENGTH OF 400. FEET.

SCS RUNOFF CURVE NUMBER	=	90.20	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	6.273	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	7.866	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	4.788	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	915.435	INCHES
TOTAL INITIAL WATER	=	915.435	INCHES
TOTAL SUBSURFACE INFLOW	=	0.04	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
Temple TX

STATION LATITUDE	=	31.00 DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	56
END OF GROWING SEASON (JULIAN DATE)	=	336
EVAPORATIVE ZONE DEPTH	=	18.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	10.30 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	64.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	68.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR TEMPLE TEXAS

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.94	2.57	1.97	3.56	4.65	2.94
1.75	2.50	3.51	3.30	2.69	2.37

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR TEMPLE TEXAS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC

46.60	50.30	57.70	66.70	73.50	80.80
84.60	84.50	78.70	69.00	56.90	49.70

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR TEMPLE TEXAS
AND STATION LATITUDE = 31.00 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.80	2.29	1.88	3.42	3.48	3.29
	1.75	2.92	3.01	4.02	2.53	2.04
STD. DEVIATIONS	1.35	1.35	1.07	2.20	2.42	1.79
	2.03	2.40	2.13	2.43	1.94	1.20
RUNOFF						
TOTALS	0.395	0.618	0.498	1.446	1.622	1.495
	0.837	1.303	1.245	2.148	0.933	0.554
STD. DEVIATIONS	0.551	0.629	0.568	1.418	1.713	1.224
	1.238	1.461	1.228	1.837	1.158	0.564
EVAPOTRANSPIRATION						
TOTALS	1.254	1.450	1.773	2.554	2.018	1.760
	1.060	1.501	1.646	1.603	1.246	1.233
STD. DEVIATIONS	0.528	0.666	0.644	0.867	0.937	0.870
	1.030	0.908	1.012	0.696	0.464	0.381
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.0511	0.0756	0.0460	0.0041	0.0018	0.0001
	0.0000	0.0001	0.0001	0.0001	0.0002	0.0745
STD. DEVIATIONS	0.1598	0.1564	0.1403	0.0084	0.0052	0.0002
	0.0001	0.0003	0.0001	0.0001	0.0003	0.2050
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
STD. DEVIATIONS	0.0002	0.0002	0.0001	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002
SUBSURFACE INFLOW INTO LAYER 8						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED FROM LAYER 8						
TOTALS	0.0032	0.0030	0.0033	0.0032	0.0033	0.0032
	0.0033	0.0033	0.0032	0.0033	0.0032	0.0033
STD. DEVIATIONS	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003
	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
PERCOLATION/LEAKAGE THROUGH LAYER 10						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3						
AVERAGES	0.0014	0.0022	0.0012	0.0001	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0020
STD. DEVIATIONS	0.0043	0.0046	0.0038	0.0002	0.0001	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0056
DAILY AVERAGE HEAD ON TOP OF LAYER 9						
AVERAGES	0.0922	0.0924	0.0927	0.0928	0.0930	0.0931
	0.0933	0.0934	0.0935	0.0937	0.0938	0.0939
STD. DEVIATIONS	0.0126	0.0121	0.0116	0.0111	0.0106	0.0102
	0.0098	0.0094	0.0090	0.0087	0.0083	0.0080

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	32.43	(6.086)	117728.2	100.00
RUNOFF	13.094	(4.4509)	47531.30	40.374
EVAPOTRANSPIRATION	19.098	(2.6937)	69325.19	58.886
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.25355	(0.35613)	920.375	0.78178
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00026	(0.00035)	0.945	0.00080
AVERAGE HEAD ON TOP OF LAYER 3	0.001	(0.001)		
SUBSURFACE INFLOW INTO LAYER 8	0.00000		0.000	0.00000
LATERAL DRAINAGE COLLECTED FROM LAYER 8	0.03858	(0.00419)	140.035	0.11895

P5 18 of 30

PERCOLATION/LEAKAGE THROUGH LAYER 10	0.00004	(0.00000)	0.158	0.00013
AVERAGE HEAD ON TOP OF LAYER 9	0.093	(0.010)		
CHANGE IN WATER STORAGE	-0.012	(0.8816)	-43.60	-0.037

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	4.65	16879.500
RUNOFF	4.158	15094.6611
DRAINAGE COLLECTED FROM LAYER 2	0.11486	416.94321
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000102	0.37046
AVERAGE HEAD ON TOP OF LAYER 3	0.097	
MAXIMUM HEAD ON TOP OF LAYER 3	0.193	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
DRAINAGE COLLECTED FROM LAYER 8	0.00011	0.40571
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.000000	0.00046
AVERAGE HEAD ON TOP OF LAYER 9	0.099	
MAXIMUM HEAD ON TOP OF LAYER 9	0.191	
LOCATION OF MAXIMUM HEAD IN LAYER 8 (DISTANCE FROM DRAIN)	7.8 FEET	
SNOW WATER	1.50	5446.1431

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4270
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.2660

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	5.8750	0.3264
2	0.0020	0.0100
3	0.0000	0.0000
4	8.5500	0.4750
5	4.4520	0.3710
6	876.0001	0.2920
7	9.8640	0.4110
8	0.0838	0.4190
9	0.0000	0.0000
10	10.2480	0.4270
SNOW WATER	0.000	

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**                                                                  **
**                                                                  **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE        **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)        **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY           **
**                    USAE WATERWAYS EXPERIMENT STATION             **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY      **
**                                                                  **
**                                                                  **
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PRECIPITATION DATA FILE:    C:\HELP3\Reqk\TLGIR.D4
TEMPERATURE DATA FILE:      C:\HELP3\Reqk\TLGIR.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\Reqk\TLGIR.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\Reqk\TLGIR.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\Reqk\TLGIR.D10
OUTPUT DATA FILE:           C:\HELP3\Reqk\TLGIR.OUT

TIME:  13:17     DATE:  11/ 8/2016

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     TITLE:  Temple Expansion: Intermediate Condition with recirculation

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

                              LAYER  1
                              --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER  14
  THICKNESS                    =     12.00   INCHES
  POROSITY                     =      0.4790 VOL/VOL
  FIELD CAPACITY               =      0.3710 VOL/VOL
  WILTING POINT                =      0.2510 VOL/VOL
  INITIAL SOIL WATER CONTENT   =      0.2938 VOL/VOL
  EFFECTIVE SAT. HYD. COND.    =  0.249999994000E-04 CM/SEC


                              LAYER  2
                              --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER  18
  THICKNESS                    =   1200.00   INCHES
  POROSITY                     =      0.6710 VOL/VOL
  FIELD CAPACITY               =      0.2920 VOL/VOL
  WILTING POINT                =      0.0770 VOL/VOL
  INITIAL SOIL WATER CONTENT   =      0.2934 VOL/VOL
  EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC
NOTE:  100.00 PERCENT OF THE DRAINAGE COLLECTED FROM LAYER # 4
         IS RECIRCULATED INTO THIS LAYER.


                              LAYER  3
                              --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER   0
  THICKNESS                    =     24.00   INCHES
  POROSITY                     =      0.4520 VOL/VOL
  FIELD CAPACITY               =      0.4110 VOL/VOL
  WILTING POINT                =      0.3110 VOL/VOL
  INITIAL SOIL WATER CONTENT   =      0.4199 VOL/VOL
  EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-05 CM/SEC


                              LAYER  4
                              --------

               TYPE 2 - LATERAL DRAINAGE LAYER
                   MATERIAL TEXTURE NUMBER   0
  THICKNESS                    =      0.20   INCHES
  POROSITY                     =      0.8500 VOL/VOL
  FIELD CAPACITY               =      0.0100 VOL/VOL
  WILTING POINT                =      0.0050 VOL/VOL
  INITIAL SOIL WATER CONTENT   =      0.0666 VOL/VOL
  EFFECTIVE SAT. HYD. COND.    =   8.00000000000     CM/SEC
  SLOPE                        =      0.80   PERCENT
  DRAINAGE LENGTH              =    240.0    FEET
  SUBSURFACE INFLOW            =      0.04   INCHES/YR
NOTE:  100.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS
         LAYER IS RECIRCULATED INTO LAYER #  2.


                              LAYER  5
                              --------

               TYPE 4 - FLEXIBLE MEMBRANE LINER
                   MATERIAL TEXTURE NUMBER  35
  THICKNESS                    =      0.06   INCHES
  POROSITY                     =      0.0000 VOL/VOL
  FIELD CAPACITY               =      0.0000 VOL/VOL
  WILTING POINT                =      0.0000 VOL/VOL
  INITIAL SOIL WATER CONTENT   =      0.0000 VOL/VOL
  EFFECTIVE SAT. HYD. COND.    =  0.199999996000E-12 CM/SEC
  FML PINHOLE DENSITY          =      1.00   HOLES/ACRE
  FML INSTALLATION DEFECTS     =      1.00   HOLES/ACRE
  FML PLACEMENT QUALITY        =  3 - GOOD


                              LAYER  6
                              --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER  16
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THICKNESS	=	24.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #14 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 1.% AND A SLOPE LENGTH OF 240. FEET.

SCS RUNOFF CURVE NUMBER	=	96.30	
FRACTION OF AREA ALLOWING RUNOFF	=	75.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.783	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.790	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.510	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	375.902	INCHES
TOTAL INITIAL WATER	=	375.902	INCHES
TOTAL SUBSURFACE INFLOW	=	0.04	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM Temple TX

STATION LATITUDE	=	31.00	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	56	
END OF GROWING SEASON (JULIAN DATE)	=	336	
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	10.30	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	64.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	68.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR TEMPLE TEXAS

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.94	2.57	1.97	3.56	4.65	2.94
1.75	2.50	3.51	3.30	2.69	2.37

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR TEMPLE TEXAS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.60	50.30	57.70	66.70	73.50	80.80
84.60	84.50	78.70	69.00	56.90	49.70

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR TEMPLE TEXAS AND STATION LATITUDE = 31.00 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 10

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.17	2.37	1.95	3.89	2.71	3.21
	1.93	3.37	2.51	3.97	2.24	2.26
STD. DEVIATIONS	0.79	1.41	1.19	2.50	1.85	1.68
	2.06	3.04	1.50	2.92	2.00	1.02
RUNOFF						
TOTALS	0.098	0.532	0.354	1.501	0.742	1.212
	0.815	1.234	0.743	1.614	0.595	0.559
STD. DEVIATIONS	0.099	0.529	0.429	1.364	0.713	0.810
	1.147	1.516	0.725	1.652	0.903	0.462
EVAPOTRANSPIRATION						
TOTALS	1.128	1.630	1.761	2.105	1.929	1.830
	1.304	1.578	1.525	2.179	1.459	1.552
STD. DEVIATIONS	0.606	0.983	1.095	1.143	1.257	0.887
	1.161	1.101	0.815	0.986	0.702	0.599
LATERAL DRAINAGE RECIRCULATED INTO LAYER 2						
TOTALS	1.9518	1.7157	1.8494	1.8589	1.8822	1.8247
	1.8838	1.9620	1.8047	1.7973	1.9756	1.7834
STD. DEVIATIONS	0.3090	0.2112	0.3544	0.2604	0.1612	0.2730
	0.2480	0.2313	0.3127	0.2440	0.3676	0.2347
SUBSURFACE INFLOW INTO LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED FROM LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE RECIRCULATED FROM LAYER 4						

TOTALS	1.9518	1.7157	1.8494	1.8589	1.8822	1.8247
	1.8838	1.9620	1.8047	1.7973	1.9756	1.7834
STD. DEVIATIONS	0.3090	0.2112	0.3544	0.2604	0.1612	0.2730
	0.2480	0.2313	0.3127	0.2440	0.3676	0.2347

PERCOLATION/LEAKAGE THROUGH LAYER 6

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 5

AVERAGES	0.0417	0.0402	0.0395	0.0410	0.0402	0.0402
	0.0402	0.0419	0.0398	0.0384	0.0436	0.0381
STD. DEVIATIONS	0.0066	0.0048	0.0076	0.0057	0.0034	0.0060
	0.0053	0.0049	0.0069	0.0052	0.0081	0.0050

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 10

	INCHES		CU. FEET	PERCENT
PRECIPITATION	31.60	(6.065)	114708.0	100.00
RUNOFF	9.998	(3.5087)	36293.07	31.640
EVAPOTRANSPIRATION	19.979	(2.9620)	72523.55	63.224
DRAINAGE RECIRCULATED INTO LAYER 2	22.28954	(2.62699)	80911.031	70.53651
SUBSURFACE INFLOW INTO LAYER 4	0.00000		0.000	0.00000
LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.00000	(0.00000)	0.000	0.00000
DRAINAGE RECIRCULATED FROM LAYER 4	22.28954	(2.62699)	80911.031	70.53651
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00002	(0.00000)	0.077	0.00007
AVERAGE HEAD ON TOP OF LAYER 5	0.040	(0.005)		
CHANGE IN WATER STORAGE	1.652	(1.0351)	5997.76	5.229

PEAK DAILY VALUES FOR YEARS 1 THROUGH 10

	(INCHES)	(CU. FT.)
PRECIPITATION	4.22	15318.600
RUNOFF	3.129	11356.9883
DRAINAGE RECIRCULATED INTO LAYER 2	0.15044	546.09473
DRAINAGE COLLECTED FROM LAYER 4	0.00000	0.00000
DRAINAGE RECIRCULATED FROM LAYER 4	0.15044	546.09473
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00046
AVERAGE HEAD ON TOP OF LAYER 5	0.100	
MAXIMUM HEAD ON TOP OF LAYER 5	0.193	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	7.8 FEET	
SNOW WATER	0.65	2360.6431

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4448

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.2510

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

FINAL WATER STORAGE AT END OF YEAR 10

LAYER	(INCHES)	(VOL/VOL)
1	3.4020	0.2835
2	368.2359	0.3069
3	10.4654	0.4361
4	0.0739	0.3694
5	0.0000	0.0000
6	10.2480	0.4270
SNOW WATER	0.000	

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**                                                                  **
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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE        **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)        **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY           **
**                    USAE WATERWAYS EXPERIMENT STATION             **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY      **
**                                                                  **
**                                                                  **
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PRECIPITATION DATA FILE:     C:\HELP3\Reqk\TLGFR.D4
TEMPERATURE DATA FILE:       C:\HELP3\Reqk\TLGFR.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\Reqk\TLGFR.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\Reqk\TLGFR.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\Reqk\TLGFR.D10
OUTPUT DATA FILE:            C:\HELP3\Reqk\TLGFR.OUT


TIME:  15:18     DATE:  11/ 4/2016


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     TITLE:  Temple Expansion: Final Condition with recirculation

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                              LAYER  1
                              --------

                TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER  14
          THICKNESS                    =     12.00   INCHES
          POROSITY                     =      0.4790 VOL/VOL
          FIELD CAPACITY               =      0.3710 VOL/VOL
          WILTING POINT                =      0.2510 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.3141 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.249999994000E-04 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                              LAYER  2
                              --------

                TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER  18
          THICKNESS                    =   3000.00   INCHES
          POROSITY                     =      0.6710 VOL/VOL
          FIELD CAPACITY               =      0.2920 VOL/VOL
          WILTING POINT                =      0.0770 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.2917 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC
          SUBSURFACE INFLOW            =      2.00   INCHES/YR
        NOTE:  75.00 PERCENT OF THE DRAINAGE COLLECTED FROM LAYER # 4
                IS RECIRCULATED INTO THIS LAYER.


                              LAYER  3
                              --------

                TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER   0
          THICKNESS                    =     24.00   INCHES
          POROSITY                     =      0.4520 VOL/VOL
          FIELD CAPACITY               =      0.4110 VOL/VOL
          WILTING POINT                =      0.3110 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.4119 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-05 CM/SEC


                              LAYER  4
                              --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                    MATERIAL TEXTURE NUMBER   0
          THICKNESS                    =      0.20   INCHES
          POROSITY                     =      0.8500 VOL/VOL
          FIELD CAPACITY               =      0.0100 VOL/VOL
          WILTING POINT                =      0.0050 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.1519 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =   3.50000000000      CM/SEC
          SLOPE                        =      0.80   PERCENT
          DRAINAGE LENGTH              =    240.0    FEET
          SUBSURFACE INFLOW            =      0.04   INCHES/YR
        NOTE:  75.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS
                LAYER IS RECIRCULATED INTO LAYER #  2.


                              LAYER  5
                              --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                    MATERIAL TEXTURE NUMBER  35
          THICKNESS                    =      0.06   INCHES
          POROSITY                     =      0.0000 VOL/VOL
          FIELD CAPACITY               =      0.0000 VOL/VOL
          WILTING POINT                =      0.0000 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.0000 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.199999996000E-12 CM/SEC
          FML PINHOLE DENSITY          =      0.00   HOLES/ACRE
          FML INSTALLATION DEFECTS     =      0.00   HOLES/ACRE
          FML PLACEMENT QUALITY        =  4 - POOR


                              LAYER  6
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TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #14 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 3.% AND A SLOPE LENGTH OF 400. FEET.

SCS RUNOFF CURVE NUMBER	=	96.30	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.648	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	12.458	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	3.782	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	898.891	INCHES
TOTAL INITIAL WATER	=	898.891	INCHES
TOTAL SUBSURFACE INFLOW	=	2.04	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
Temple TX

STATION LATITUDE	=	31.00	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	56	
END OF GROWING SEASON (JULIAN DATE)	=	336	
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	10.30	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	64.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	68.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR TEMPLE TEXAS

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.94	2.57	1.97	3.56	4.65	2.94
1.75	2.50	3.51	3.30	2.69	2.37

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR TEMPLE TEXAS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.60	50.30	57.70	66.70	73.50	80.80
84.60	84.50	78.70	69.00	56.90	49.70

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR TEMPLE TEXAS
AND STATION LATITUDE = 31.00 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.80	2.29	1.88	3.42	3.48	3.29
	1.75	2.92	3.01	4.02	2.53	2.04
STD. DEVIATIONS	1.35	1.35	1.07	2.20	2.42	1.79
	2.03	2.40	2.13	2.43	1.94	1.20
RUNOFF						
TOTALS	0.400	0.596	0.458	1.290	1.373	1.269
	0.724	1.143	1.065	1.851	0.865	0.537
STD. DEVIATIONS	0.491	0.569	0.483	1.273	1.480	1.027
	1.069	1.307	1.036	1.592	1.011	0.512
EVAPOTRANSPIRATION						
TOTALS	1.353	1.576	1.993	2.681	2.500	2.017
	1.217	1.630	1.794	1.635	1.204	1.184
STD. DEVIATIONS	0.430	0.539	0.725	0.854	1.099	0.924
	1.187	0.917	1.065	0.766	0.403	0.386
SUBSURFACE INFLOW INTO LAYER 2						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE RECIRCULATED INTO LAYER 2						
TOTALS	0.5310	0.5073	0.5863	0.5487	0.5721	0.5474
	0.5420	0.5294	0.5056	0.5184	0.5007	0.5174
STD. DEVIATIONS	0.0569	0.0993	0.1698	0.1184	0.0936	0.0692
	0.0379	0.0210	0.0116	0.0072	0.0062	0.0098
SUBSURFACE INFLOW INTO LAYER 4						

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.1770	0.1691	0.1954	0.1829	0.1907	0.1825
	0.1807	0.1765	0.1685	0.1728	0.1669	0.1725
STD. DEVIATIONS	0.0190	0.0331	0.0566	0.0395	0.0312	0.0231
	0.0126	0.0070	0.0039	0.0024	0.0021	0.0033

LATERAL DRAINAGE RECIRCULATED FROM LAYER 4

TOTALS	0.5310	0.5073	0.5863	0.5487	0.5721	0.5474
	0.5420	0.5294	0.5056	0.5184	0.5007	0.5174
STD. DEVIATIONS	0.0569	0.0993	0.1698	0.1184	0.0936	0.0692
	0.0379	0.0210	0.0116	0.0072	0.0062	0.0098

PERCOLATION/LEAKAGE THROUGH LAYER 6

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 5

AVERAGES	0.0345	0.0362	0.0381	0.0369	0.0372	0.0368
	0.0353	0.0344	0.0340	0.0337	0.0336	0.0336
STD. DEVIATIONS	0.0037	0.0072	0.0110	0.0080	0.0061	0.0047
	0.0025	0.0014	0.0008	0.0005	0.0004	0.0006

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	32.43 (6.086)	117728.2	100.00
RUNOFF	11.572 (3.7454)	42006.30	35.681
EVAPOTRANSPIRATION	20.783 (2.9256)	75442.73	64.082
SUBSURFACE INFLOW INTO LAYER 2	0.00000	0.000	0.00000
DRAINAGE RECIRCULATED INTO LAYER 2	6.40630 (0.63644)	23254.857	19.75301
SUBSURFACE INFLOW INTO LAYER 4	0.00000	0.000	0.00000
LATERAL DRAINAGE COLLECTED FROM LAYER 4	2.13543 (0.21214)	7751.620	6.58434
DRAINAGE RECIRCULATED FROM LAYER 4	6.40630 (0.63644)	23254.857	19.75301
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000 (0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 5	0.035 (0.004)		
CHANGE IN WATER STORAGE	-0.017 (1.1173)	-62.54	-0.053

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	4.65	16879.500
RUNOFF	3.672	13328.3271
DRAINAGE RECIRCULATED INTO LAYER 2	0.05116	185.70552
DRAINAGE COLLECTED FROM LAYER 4	0.01705	61.90184
DRAINAGE RECIRCULATED FROM LAYER 4	0.05116	185.70552
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00004
AVERAGE HEAD ON TOP OF LAYER 5	0.103	
MAXIMUM HEAD ON TOP OF LAYER 5	0.199	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	8.1 FEET	
SNOW WATER	1.50	5446.1431

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3406

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1719

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	4.2002	0.3500
2	874.0143	0.2913
3	9.8817	0.4117
4	0.0301	0.1503
5	0.0000	0.0000
6	10.2480	0.4270
SNOW WATER	0.000	

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**                                                                  **
**                                                                  **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE        **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)        **
**                   DEVELOPED BY ENVIRONMENTAL LABORATORY          **
**                     USAE WATERWAYS EXPERIMENT STATION            **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY      **
**                                                                  **
**                                                                  **
**********************************************************************
**********************************************************************


PRECIPITATION DATA FILE:     C:\HELP3\Reqk\TLGFWCR.D4
TEMPERATURE DATA FILE:       C:\HELP3\Reqk\TLGFWCR.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\Reqk\TLGFWCR.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\Reqk\TLGFWCR.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\Reqk\TLGFWCR.D10
OUTPUT DATA FILE:            C:\HELP3\Reqk\TLGFWCR.OUT


TIME:  16:25     DATE:  11/ 4/2016


**********************************************************************

     TITLE:  Temple Expansion: Final condition with cover, with recirculation

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                              LAYER  1
                              --------

                TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER  25
          THICKNESS                    =     18.00   INCHES
          POROSITY                     =      0.4370 VOL/VOL
          FIELD CAPACITY               =      0.3730 VOL/VOL
          WILTING POINT                =      0.2660 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.3485 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.3599999990000E-05 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                              LAYER  2
                              --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
          THICKNESS                    =      0.20   INCHES
          POROSITY                     =      0.8500 VOL/VOL
          FIELD CAPACITY               =      0.0100 VOL/VOL
          WILTING POINT                =      0.0050 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.0710 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =   2.09999990000     CM/SEC
          SLOPE                        =      4.00   PERCENT
          DRAINAGE LENGTH              =    400.0    FEET


                              LAYER  3
                              --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  36
          THICKNESS                    =      0.04   INCHES
          POROSITY                     =      0.0000 VOL/VOL
          FIELD CAPACITY               =      0.0000 VOL/VOL
          WILTING POINT                =      0.0000 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.0000 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.399999993000E-12 CM/SEC
          FML PINHOLE DENSITY          =      1.00   HOLES/ACRE
          FML INSTALLATION DEFECTS     =      1.00   HOLES/ACRE
          FML PLACEMENT QUALITY        =  3 - GOOD


                              LAYER  4
                              --------

                TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER   0
          THICKNESS                    =     18.00   INCHES
          POROSITY                     =      0.4750 VOL/VOL
          FIELD CAPACITY               =      0.3780 VOL/VOL
          WILTING POINT                =      0.2650 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.4750 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.989999971000E-03 CM/SEC


                              LAYER  5
                              --------

                TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER  14
          THICKNESS                    =     12.00   INCHES
          POROSITY                     =      0.4790 VOL/VOL
          FIELD CAPACITY               =      0.3710 VOL/VOL
          WILTING POINT                =      0.2510 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.3710 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.249999994000E-04 CM/SEC


                              LAYER  6
                              --------

                TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER  18
          THICKNESS                    =   3000.00   INCHES
          POROSITY                     =      0.6710 VOL/VOL
          FIELD CAPACITY               =      0.2920 VOL/VOL
```

WILTING POINT	=	0.0770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2920	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC
SUBSURFACE INFLOW	=	2.00	INCHES/YR

NOTE: 80.00 PERCENT OF THE DRAINAGE COLLECTED FROM LAYER # 8 IS RECIRCULATED INTO THIS LAYER.

LAYER 7

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4520	VOL/VOL
FIELD CAPACITY	=	0.4110	VOL/VOL
WILTING POINT	=	0.3110	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4149	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999975000E-05	CM/SEC

LAYER 8

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.20	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4229	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	1.50000000000	CM/SEC
SLOPE	=	0.80	PERCENT
DRAINAGE LENGTH	=	240.0	FEET
SUBSURFACE INFLOW	=	0.04	INCHES/YR

NOTE: 80.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS LAYER IS RECIRCULATED INTO LAYER # 6.

LAYER 9

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	1.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 10

TYPE 3 - BARRIER SOIL LINER

MATERIAL TEXTURE NUMBER 16

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #25 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 4.% AND A SLOPE LENGTH OF 400. FEET.

SCS RUNOFF CURVE NUMBER	=	90.20	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	6.273	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	7.866	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	4.788	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	915.580	INCHES
TOTAL INITIAL WATER	=	915.580	INCHES
TOTAL SUBSURFACE INFLOW	=	2.04	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
Temple TX

STATION LATITUDE	=	31.00 DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	56
END OF GROWING SEASON (JULIAN DATE)	=	336
EVAPORATIVE ZONE DEPTH	=	18.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	10.30 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	64.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	68.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR TEMPLE TEXAS

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.94	2.57	1.97	3.56	4.65	2.94
1.75	2.50	3.51	3.30	2.69	2.37

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING

COEFFICIENTS FOR TEMPLE TEXAS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.60	50.30	57.70	66.70	73.50	80.80
84.60	84.50	78.70	69.00	56.90	49.70

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR TEMPLE TEXAS
AND STATION LATITUDE = 31.00 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.80	2.29	1.88	3.42	3.48	3.29
	1.75	2.92	3.01	4.02	2.53	2.04
STD. DEVIATIONS	1.35	1.35	1.07	2.20	2.42	1.79
	2.03	2.40	2.13	2.43	1.94	1.20
RUNOFF						
TOTALS	0.395	0.618	0.498	1.446	1.622	1.495
	0.837	1.303	1.245	2.148	0.933	0.554
STD. DEVIATIONS	0.551	0.629	0.568	1.418	1.713	1.224
	1.238	1.461	1.228	1.837	1.158	0.564
EVAPOTRANSPIRATION						
TOTALS	1.254	1.450	1.773	2.554	2.018	1.760
	1.060	1.501	1.646	1.603	1.246	1.233
STD. DEVIATIONS	0.528	0.666	0.644	0.867	0.937	0.870
	1.030	0.908	1.012	0.696	0.464	0.381
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.0511	0.0756	0.0460	0.0041	0.0018	0.0001
	0.0000	0.0001	0.0001	0.0001	0.0002	0.0745
STD. DEVIATIONS	0.1598	0.1564	0.1403	0.0084	0.0052	0.0002
	0.0001	0.0003	0.0001	0.0001	0.0003	0.2050
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
STD. DEVIATIONS	0.0002	0.0002	0.0001	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002
SUBSURFACE INFLOW INTO LAYER 6						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE RECIRCULATED INTO LAYER 6						
TOTALS	0.6931	0.6313	0.6932	0.6708	0.6931	0.6707
	0.6931	0.6931	0.6707	0.6930	0.6707	0.6931
STD. DEVIATIONS	0.0003	0.0097	0.0004	0.0003	0.0000	0.0000
	0.0003	0.0002	0.0000	0.0000	0.0000	0.0005
SUBSURFACE INFLOW INTO LAYER 8						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED FROM LAYER 8						
TOTALS	0.1733	0.1578	0.1733	0.1677	0.1733	0.1677
	0.1733	0.1733	0.1677	0.1733	0.1677	0.1733
STD. DEVIATIONS	0.0001	0.0024	0.0001	0.0001	0.0000	0.0000
	0.0001	0.0001	0.0000	0.0000	0.0000	0.0001
LATERAL DRAINAGE RECIRCULATED FROM LAYER 8						
TOTALS	0.6931	0.6313	0.6932	0.6708	0.6931	0.6707
	0.6931	0.6931	0.6707	0.6930	0.6707	0.6931
STD. DEVIATIONS	0.0003	0.0097	0.0004	0.0003	0.0000	0.0000
	0.0003	0.0002	0.0000	0.0000	0.0000	0.0005
PERCOLATION/LEAKAGE THROUGH LAYER 10						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3						
AVERAGES	0.0014	0.0022	0.0012	0.0001	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0020
STD. DEVIATIONS	0.0043	0.0046	0.0038	0.0002	0.0001	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0056
DAILY AVERAGE HEAD ON TOP OF LAYER 9						
AVERAGES	0.0986	0.0986	0.0986	0.0986	0.0986	0.0986
	0.0986	0.0986	0.0986	0.0986	0.0986	0.0986
STD. DEVIATIONS	0.0001	0.0000	0.0000	0.0001	0.0000	0.0001
	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	32.43 (6.086)	117728.2	100.00
RUNOFF	13.094 (4.4509)	47531.30	40.374
EVAPOTRANSPIRATION	19.098 (2.6937)	69325.19	58.886
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.25355 (0.35613)	920.375	0.78178
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00026 (0.00035)	0.945	0.00080
AVERAGE HEAD ON TOP OF LAYER 3	0.001 (0.001)		
SUBSURFACE INFLOW INTO LAYER 6	0.00000	0.000	0.00000
DRAINAGE RECIRCULATED INTO LAYER 6	8.16596 (0.01034)	29642.422	25.17870
SUBSURFACE INFLOW INTO LAYER 8	0.00000	0.000	0.00000
LATERAL DRAINAGE COLLECTED FROM LAYER 8	2.04149 (0.00259)	7410.605	6.29467
DRAINAGE RECIRCULATED FROM LAYER 8	8.16596 (0.01034)	29642.422	25.17870
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.00005 (0.00000)	0.167	0.00014
AVERAGE HEAD ON TOP OF LAYER 9	0.099 (0.000)		
CHANGE IN WATER STORAGE	-0.014 (0.8820)	-49.56	-0.042

PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	4.65	16879.500
RUNOFF	4.158	15094.6611
DRAINAGE COLLECTED FROM LAYER 2	0.11486	416.94321
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000102	0.37046
AVERAGE HEAD ON TOP OF LAYER 3	0.097	
MAXIMUM HEAD ON TOP OF LAYER 3	0.193	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
DRAINAGE RECIRCULATED INTO LAYER 6	0.02240	81.32686
DRAINAGE COLLECTED FROM LAYER 8	0.00560	20.33171
DRAINAGE RECIRCULATED FROM LAYER 8	0.02240	81.32686
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.000000	0.00046
AVERAGE HEAD ON TOP OF LAYER 9	0.099	
MAXIMUM HEAD ON TOP OF LAYER 9	0.191	
LOCATION OF MAXIMUM HEAD IN LAYER 8 (DISTANCE FROM DRAIN)	7.8 FEET	
SNOW WATER	1.50	5446.1431
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4270	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.2660	

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	5.8750	0.3264
2	0.0020	0.0100
3	0.0000	0.0000
4	8.5500	0.4750
5	4.4520	0.3710
6	876.0001	0.2920
7	9.9587	0.4149
8	0.0848	0.4241
9	0.0000	0.0000
10	10.2480	0.4270
SNOW WATER	0.000	

APPENDIX III-3F

LINER QUALITY CONTROL PLAN

PART III, ATTACHMENT 3, APPENDIX F
LINER QUALITY CONTROL PLAN

Temple Recycling & Disposal Facility

Temple, Bell County, Texas

TCEQ Permit MSW-692B

GOLDER ASSOCIATES INC.
Professional Engineering Firm
Registration Number F-2578

INTENDED FOR PERMITTING PURPOSES ONLY

Owner/Site Operator/Permittee:

City of Temple

City of Temple
201 N. Main
Temple, Texas 76501

Operator:

WASTE MANAGEMENT

Waste Management of Texas
9708 Giles Lane
Austin, Texas 78781

Submitted By:

Golder Associates Inc.
500 Century Plaza Drive, Suite 190
Houston, TX 77073 USA
Professional Engineering Firm Registration Number F-2578

Submitted: June 2016
Revised: December 2016

Project No. 1400336

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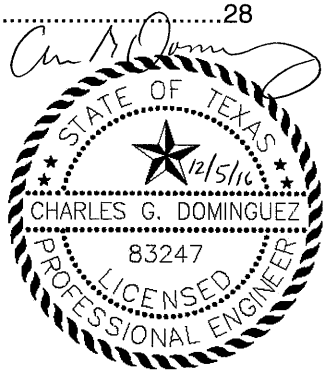

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INTENDED FOR PERMITTING PURPOSES ONLY

1.0 PURPOSE

1.1 Purpose and Scope

This Liner Quality Control Plan (LQCP) has been prepared in accordance with 30 TAC §330.339. This LQCP establishes the procedures for construction, testing, and documentation of the liner and leachate collection system for Temple Recycling and Disposal Facility.

This LQCP was developed to address the construction and quality control testing of components of the liner and leachate collection system in compliance with the Subtitle D requirements. Construction and testing of all liner and leachate collection systems components must be according to this LQCP.

A copy of a current version of this LQCP must be maintained on-site at all times with the Site Operating Record. The LQCP shall be available for reference by the Texas Commission on Environmental Quality's (TCEQ's) inspector and construction and testing personnel. Revisions to this LQCP shall receive written approval from the TCEQ before implementation.

The liner system for the existing and proposed disposal cells will consist of a composite system comprised of (from the bottom up):

- 2 feet of compacted soil with a hydraulic conductivity of 1 x 10^{-7} cm/sec or less
- 60-mil high-density polyethylene (HDPE) geomembrane liner
- Granular or geosynthetic drainage layers at the base of the landfill
- Geotextiles for liner protection and fines filtration and drainage on slopes
- 2 feet of protective cover soil

One recompacted clay lined cell (referred to herein as the pre-Subtitle D cell) was developed in the southeast corner of Tract 3. This cell has a 3-foot thick compacted clay liner with no leachate collection layer and will be lined with an overliner system described in the Overliner System Quality Control Plan (Appendix III-3H).

1.2 General Responsibilities

The owner/operator is responsible for fully implementing this LQCP. It is the owner/operator's responsibility to ensure that adequate and approved disposal space is available at all times and to arrange for the construction of new cells as the need arises. The site manager (SM) or designated alternate shall be responsible for contracting a qualified Professional of Record (POR) prior to initiating liner and leachate collection system construction.

Each phase of the soil and liner evaluation shall be conducted by or under the supervision of the POR. The POR shall be an independent third party professional engineer (PE) licensed in the State of Texas with experience in civil or geotechnical engineering and soils testing. A qualified construction quality assurance (CQA) monitor performing daily quality assurance/quality control (QA/QC) observation and testing shall be under the direct supervision of the POR. The POR or his/her qualified representative(s) shall provide full-time monitoring.

2.0 SOIL LINER EVALUATION

This section outlines generally acceptable construction practices and specifications and the minimum quality control testing requirements for soil liners.

2.1 Pre-construction Material Evaluation

The first step in constructing a soil liner is to pre-qualify the soil materials that are selected for liner construction. Soil liner material may be obtained from in situ soil strata that will be excavated as the liner is constructed or from a select borrow source. Representative samples from either source shall be subject to the minimum pre-construction testing program shown in Table III-3F-1.

TABLE III-3F-1: Soil Liner Materials Pre-Construction Testing Schedule

TEST	METHOD USED	FREQUENCY(1)
Soil Classification	ASTM D2487	1 per soil type
Particle-Size Analysis	ASTM D422 or D1140	1 per soil type
Atterberg Limits	ASTM D4318	1 per soil type
Hydraulic Conductivity(2)	ASTM D5084(3)	1 per soil type
Standard Proctor Test	ASTM D698	1 per soil type
Moisture Content	ASTM D2216	1 per soil type

Notes:

1. If either the liquid limit (LL) or plasticity index (PI) varies by more than 10 points from other samples, the soil is considered a different soil type.
2. Conduct this test on a remolded sample that is compacted at or less than 95% of the maximum dry density and at the optimum moisture content as determined from the standard Proctor test. If pre-construction samples are compacted at higher or lower densities and/or respective moisture contents, then these values will govern for field control. Pre-construction tests should represent the "worst-case" condition in the field concerning hydraulic conductivity results.
3. Testing procedures in Appendix VII of the US Army Corps of Engineers Manual EM 1110-2-1906, November 30, 1970, Laboratory Soils Testing, may be used as an alternative method. Permeability tests will be conducted using tap water or 0.05N calcium sulfate solution as the permeant fluid. Distilled or deionized water is not acceptable.

Where soil types vary substantially and are not segregated, representative blends of those soil types anticipated to be utilized for soil liner construction should also be sampled and tested. The material tested shall comply with the following minimum material specifications:

- Plasticity Index ≥ 15
- Liquid Limit ≥ 30
- Percent Passing No. 200 Sieve ≥ 30
- Particle Size ≤ 1 inch
- Hydraulic Conductivity ≤ 1×10^{-7} cm/sec

The Proctor moisture-density curves shall be developed for each type of soil determined suitable as liner material and shall be used during the construction phase as a performance reference for compaction and

moisture control. Rocks and stones in soil for liner construction shall be limited to no more than one inch in diameter and no more than 10% by weight.

The POR should consider the potential adverse effects on and/or inconsistencies of results due to laboratory drying procedures, as some materials may exhibit variation in results for Proctor and Atterberg limits tests. Samples should not be oven-dried nor dried back more than 2 to 3 percent below the lowest anticipated moisture content needed to develop the Proctor moisture-density relationship. The zero air voids line shall be computed and included along with the Proctor curves, indicating the specific gravity value used.

Pre-construction samples to be run for hydraulic conductivity testing shall be molded at or less than the optimum moisture content and at or less than 95 percent of the maximum dry density according to the standard Proctor test (ASTM D698). These points should represent reasonable worst-case conditions for hydraulic conductivity results on appropriately compacted soils. If higher moisture contents or dry densities are used for the hydraulic conductivity tests, then the higher values will be used for field control during placement. However, if lower moisture or density values are used and confirmed to achieve acceptable hydraulic conductivities, field control will still be based on the minimum compaction requirements in Section 2.2.

As a general rule, a minimum of one series of pre-construction tests should be performed for every 15,000 to 20,000 cubic yards of soil to be used in liner construction, unless soil types are limited and easily distinguished. As soil is usually made available subsequent to excavation during liner construction, additional pre-construction samples should be taken and tests performed when soils vary or as soon as the initial pre-construction test results appear inappropriate or questionable. If and when the same borrow source is utilized for the soil supply of more than one liner area, results from previous tests may be used to supplement the pre-construction data.

2.2 Soil Liner Construction Specifications and Practices

The soil liner shall be constructed in accordance with the requirements included in this section.. Also, certain construction practices shall be utilized as described herein when appropriate.

2.2.1 Liner Subgrade Preparation

Subgrade surfaces for both the bottom and the sideslope of waste disposal areas to receive constructed soil liners shall be prepared to ensure a stable foundation and to facilitate bonding of the soil liner to the subgrade material. Upon achieving the design subgrade level, zones of soft or unsuitable soils and deleterious material shall be excavated and removed and replaced with appropriate general fill or soil liner material. Free shallow groundwater or excess soil moisture shall be removed by providing drainage and/or aeration.

The exposed subgrade should be proof-rolled, processed and recompacted, or overexcavated and replaced, as necessary. The POR shall determine sufficient stability based on observation of acceptable deflection, pumping, and strength of the subgrade material. The subgrade lines and grades shall be determined by instrument survey methods prior to subsequent soil liner construction.

The prepared subgrade shall be tied into the first soil liner lift in a manner deemed suitable by the POR, such that the integrity of the first lift will be maintained.

2.2.2 Work Area Selection and Sizing

Work areas for soil liner construction should be selected, sized, and sequenced so that work on each lift can begin and be completed in the same day. The area worked at any one time should be of such size that placement, processing, and compaction will be uniform, with minimal variation caused by weather conditions. It is critical that completed lifts be tested and covered with the next loose lift before that completed lift dries out in the sun or becomes damaged by heavy precipitation. Furthermore, the selection of size and shape of work areas shall be consistent, so that uniform construction techniques and equipment can be selected. Adequate numbers of quality control personnel will be provided to suit the pace of construction so proper monitoring and documentation is performed.

2.2.3 Lift Placement and Processing

Reduction of soil clods, uniform moisture distribution, and consistent placement thickness are key elements to achieving uniform compaction of soil liners. Soil liner material shall be placed in loose lifts, generally not exceeding 8 inches after spreading and leveling and/or processing, with the expectation that the finished lift, following compaction, will be about 6 inches or less. In no case will the loose lift thickness, after spreading and leveling, be greater than the length of the compactor feet. The intent of limiting the loose thickness is to achieve good interlift bonding and to minimize bridging or layering effects.

The loose lift of soil shall be mechanically processed, either in-place or in a separate processing area, to break down the original soil structure and to reduce clod size. Additional processing, if necessary, will be used to blend variable soil types within the loose lift and incorporate additional water. The goal of processing is to yield a relatively uniform mass of soil that is devoid of original structure that may contribute to excess hydraulic conductivity. Processing may be achieved by discing, grading, compacting, or pulverizing. Pneumatic-tired or tracked equipment will not generally be acceptable to provide processing action, although this equipment may be used to pull the other acceptable implements.

Moisture adjustment may be required, particularly during dry seasons, and reasonable practices shall be used to distribute added water uniformly within the lift. Care shall be taken to prevent over-watering and ponding of water within the loose lift, as this excess water is difficult to redistribute. Drying back of overly wet soils during processing can result in clods having dry, crusting surfaces, which may not bond together

adequately. If such drying is allowed, then additional effort will be necessary to assure even moisture distribution and hydration. Hydration times shall be evaluated and determined if acceptable by the POR.

2.2.4 Minimum Compaction Requirements

Processed loose lifts shall be leveled prior to compaction to provide uniform compaction effort over the lift. Each lift shall be compacted to the moisture and density requirements established for the project and as set forth in the provisions of this LQCP. The lifts shall be compacted to at least 95 percent of the maximum dry density with a corresponding moisture content at or up to 5 percent above optimum determined by standard Proctor test results (ASTM D698) conducted on similar representative material. The above criteria shall be utilized, unless pre-construction hydraulic conductivity tests were performed at higher or lower densities or moisture contents, in which case these density and moisture values will be used as field compaction minimums. The soil liner density must be expressed as a percentage of the maximum dry density and at the corresponding optimum moisture content as discussed in this section.

In the event that subsequent laboratory testing of samples from an area of constructed liner indicate an alternate moisture density curve is appropriate for the soil type, the CQA monitor will switch to the appropriate curve as necessary. It is recognized that laboratory data becomes available often several days after construction of an area of clay liner. If the laboratory data indicates that the area constructed using the incorrect moisture-density curve meets the permeability requirements for a constructed clay liner (i.e., less than or equal to 1×10^{-7} cm/sec), the area will be considered acceptable as clay liner.

Soil liners shall not be compacted with a bulldozer or any track-mobilized equipment unless it is used to pull a footed roller; however, this practice is not encouraged. All soil liners shall be compacted with a pad-footed or prong-footed roller only. Bulldozers, pneumatic rollers or scrapers, and flat-wheeled rollers will not be permitted for compaction.

Construction survey control should be conducted routinely during lift placement to verify that loose and finished lifts are of the proper thickness to ensure uniform compaction.

2.2.5 Lift Bonding and Liner Tie-In

Interlift bonding shall be accomplished prior to placing the subsequent loose lift. Compactors shall be of sufficient weight and foot length to penetrate the current lift when loose and provide bonding to the previous lift.

When lifts of the soil liner are not constructed continuously, a vertical construction joint may occur. To remove the vertical construction joint(s), the edge of the adjoining liner section shall be cut back or flattened to permit offsetting the tie-in for subsequent lifts as shown on Figure III-3F-1. For each 6-inch lift, the edge should be cut back at least 2.5 feet or graded to a maximum slope of 5H:1V, and then the corresponding adjoining lift should be placed against the existing finished lift. The new loose lift and at least 2 feet of the

adjoining existing lift will be processed together, and then recompacted, so that the existing liner edge is tied to new construction without superimposed vertical construction joints. This tie-in procedure shall be repeated lift-by-lift until all corresponding adjacent lifts are constructed to the required elevation. The cut back edge of the existing liner may be done all at once or one lift at a time.

2.3 Construction Monitoring and Conformance Testing

Quality assurance of recompacted soil liners shall consist of monitoring the work as soil liner construction proceeds and laboratory and field testing to assure that liner material conformance and construction performance specifications are achieved.

2.3.1 Monitoring and Observations

Full-time quality assurance monitoring and testing will be performed during the course of soil liner construction. The work will be performed by a POR described in Section 1.2, or by a CQA monitor working under the general supervision of the POR. The CQA monitor will be on-site at all times when liner construction is ongoing, so that all relevant activities can be observed and documented. The POR will visit the site periodically as construction progress warrants. Such visits will be frequent enough so that the POR is fully knowledgeable of the construction methods and performance, so that the POR can determine that quality control monitoring and testing activities are adequate to meet the terms and intent of this LQCP.

Visual observation shall include, but not be limited to, the following:

- Moisture content and distribution, particle size, and other physical properties of the soil during processing, placement, and compaction.
- Type and level of compactive effort, including roller type and weight, drum size, foot length and face area, and number of passes.
- Action of compaction equipment on soil surface (i.e., foot penetration, rolling, pumping, or shearing).
- Maximum clod size and breakdown of soil structure.
- Method of bonding lifts together and making liner tie-ins.
- Stones or other inclusions, which may damage overlying geosynthetics components or adversely affect compaction, lift bonding, and in-place testing/sampling.
- Areas where damage due to excess moisture, insufficient moisture, or freezing may have occurred.

2.3.2 Construction Testing

During soil liner construction, the minimum testing and sampling program presented in Table III-3F-2 shall be conducted to determine that adequate compaction and material conformance are being achieved.

TABLE III-3F-2: Soil Liner Construction Testing Schedule

TEST	METHOD	PARALLEL LIFTS MINIMUM FREQUENCY(1)(5)(6)	HORIZONTAL LIFTS MINIMUM FREQUENCY(2)(5)(6)
Field Moisture/ Density Test	ASTM D6938, D2937, or D1556	1 per 8,000 ft^2, 3 minimum, per 6-inch lift	1 per 100 linear feet per 12-inch height of clay berm
Percent Finer Than No. 200 Sieve	ASTM D1140 or D422	1 per 100,000 ft^2, 1 minimum, per 6-inch lift	1 per 2,000 lineal feet per 12 inches of clay berm (horizontal lifts)(4)
Atterberg Limits	ASTM D4318	1 per 100,000 ft^2, 1 minimum, per 6-inch lift	1 per 2,000 lineal feet per 12-inches of clay berm (horizontal lifts) (4)
Hydraulic Conductivity(3)	ASTM D5084	1 per 100,000 ft^2, 1 minimum, per 6-inch lift	1 per 2,000 lineal feet per 12-inches of clay berm (horizontal lifts) (4)

Notes:

1. For bottom liner and sidewall liner placed parallel to the slope.
2. For clay berm constructed with horizontal lifts.
3. Testing procedures in Appendix VII of the US Army Corps of Engineers Manual EM 1110-2-1906, November 30, 1970, Laboratory Soils Testing, may be used as an alternative method. Permeability tests will be conducted using tap water or 0.05N calcium sulfate solution as the permeant fluid. Distilled or deionized water is not acceptable.
4. For tall, but lengthwise short sections constructed with horizontal lifts, the frequency of tests may be great. Owner may consult with the TCEQ on a case-by-case basis prior to construction for approval to reduce the frequency.
5. A voluntary increase in the number of any tests performed does not in turn require a commensurate increase in the other testing requirements to meet the above program.
6. A minimum of one of each of the designated tests must be conducted for each lift of liner regardless of surface area.

Typically, field moisture-density tests will be performed using a nuclear density gage (ASTM D6938). Other acceptable test methods include the Sand Cone Method (ASTM D1556) or Drive Cylinder Test (ASTM D2937). Questions concerning the accuracy of any single field moisture-density test shall be addressed by retesting in the same general location. Periodic checks using the various test methods may be performed to verify the field moisture-density test results. Alternatively, field moisture-density checks may be performed using laboratory measurements of tube samples obtained adjacent to the field test locations.

The percent finer than No. 200 Sieve, Atterberg Limits, and hydraulic conductivity tests will be performed on samples generally obtained with a thin-walled tube sampler. If more material is needed, the extra material can be obtained from cuttings at the same location. These construction test samples will be obtained from the recently completed lift, taken one lift at a time, so that sample penetrations only go through one lift and do not penetrate from one lift into the next. Undisturbed samples will generally be sent to the geotechnical laboratory in the sampling tube, which will be properly sealed to preserve the moisture content and integrity of the sample.

2.3.3 Failure Repairs

Sections of compacted soils liner that do not pass either the density or moisture requirements in the field shall be reworked and retested until the section in question does pass. All field density results shall be reported in the Soil and Liner Evaluation Report, whether they indicate passing or failing values.

In the event of a failed moisture-density test, additional tests will be performed between the failed test and the nearest adjacent passing test locations. If those additional tests pass, then the area between the failed test and the additional passing tests will be reworked and retested until passing. If the additional tests fail, then additional tests will be performed halfway between the initial additional tests and the adjacent passing tests to further define the failing area. This procedure will be repeated until the failing area is defined, reworked, and retested with passing results.

2.3.4 Clay Liner Perforations

When taking field densities and undisturbed samples, all holes dug or created in the liner for density probes or samples must be backfilled with bentonite or a bentonite-rich soil material. This backfill will be tamped in the hole to remove pockets of air or loose soil, and to assure a tight compact seal.

2.3.5 Liner Thickness Verification

Soil liner thickness verification shall be determined by instrument survey method only; no test probes that create holes will be allowed. The verification points for record purposes shall be on a grid not exceeding 5,000 square feet per grid. If the area under evaluation is less than 5,000 square feet, a minimum of two grid points is required for verification. The selected grid shall be the same for both beginning and finished elevations of the soil liner, so that minimum thicknesses can be calculated and verified.

2.3.6 Post-Construction Care of Soil Liner

The integrity of the soil liner shall be maintained by moistening to prevent the material from desiccating. Conversely, the soil liner shall be kept free of standing water by adequately pumping after rainfall events. Damage caused by rain shall be repaired, and if the lift must be reworked, as determined by the POR, then appropriate retesting (including field moisture-density and permeability tests) shall be performed.

3.0 GEOMEMBRANE LINER EVALUATION

This section presents general procedures, quality control testing requirements, and construction specifications for geomembrane liner construction. Unless otherwise designed, the composite liner system will generally include the following components above the minimum 2-foot thick compacted soil liner:

- 60-mil high density polyethylene (HDPE) geomembrane
- A geosynthetic drainage layer composed of a geonet and filter geotextile (or equivalent geocomposite)
- 2-foot protective cover

Chimney drains will be provided in the protective cover to allow leachate to readily drain to the leachate collection system. The geomembrane and the geocomposite drainage layer may be replaced with an alternate material that incorporates both components (e.g., Super Gripnet® by Agru America) provided material equivalency in terms of barrier and flow characteristic is demonstrated.

3.1 Pre-installation Material Evaluation

3.1.1 Manufacturer's Quality Control Certificates

Prior to the installation of any geomembrane, the manufacturer or installer shall provide the POR with quality control certificates signed by a responsible party employed by the manufacturer. Each quality control certificate shall include roll identification numbers, testing procedures, and results of quality control tests. The quality control tests shall be performed in the manufacturing plant using the test methods and frequencies listed in the most recent version of the Geosynthetic Research Institute (GRI) test method GM13. The owner may require more frequent testing at his/her discretion.

The POR shall review the test results prior to accepting the geomembrane to assure that the certified minimum properties meet the minimum values for smooth and textured geomembranes, as determined by the most recent GRI test method GM13, "Test Methods, Test Properties and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes," included in Appendix III-3F-1. The owner may require more frequent testing at his/her discretion.

The rolls delivered to the site shall be inventoried, recording the manufacturer's name and product identification, and the roll thickness, number, and dimensions. Manufacturer's certificates should be cross-referenced to rolls delivered on-site.

Resumes of the installer's supervisor(s) or Master Seamer(s) shall be obtained to verify that adequate seaming experience will be utilized on the project. The installer's supervisor or Master Seamer shall have had experience totaling a minimum of 2,000,000 square feet of geomembrane installation.

Upon delivery of geosynthetic materials, storage and handling procedures shall also be documented. Rolls of geosynthetic materials shall be handled and stored in such a way as not to damage the material. As a general rule, rolls of geosynthetic materials should not be stacked more than four rolls high.

In addition to the manufacturer's quality control certificates, samples of the geomembrane will be obtained either at the manufacturing facility or upon delivery to the site for conformance testing. The test samples shall be obtained for conformance testing in accordance with the testing schedule shown in Table III-3F-3. Conformance testing shall be provided by a third party.

The POR shall review the test results to ensure that they meet the values presented in Table III-3F-3. The POR shall compare measured shear strength values to those used in the stability analyses included in Appendix III-3C. If the measured interface shear strengths are less than the values used in the analyses, the stability of the liner system shall be reassessed and revised calculations shall be included in the GLER.

TABLE III-3F-3: Geomembrane Conformance Test Schedule

TEST	METHOD[1]	FREQUENCY
Thickness (laboratory measurement)	ASTM D5199 (Smooth) or ASTM D5994 (Textured)	Not less than 1 test per 100,000 ft^2 with not less than 1 per resin lot
Density	ASTM D1505 or D792	
Carbon black content[5]	ASTM D4218	
Carbon black dispersion	ASTM D5596	
Tensile properties	ASTM D6693, Type IV	
Direct shear[2][3][4]	ASTM D5321	Per geomembrane/adjoining material interface

Notes:
1. Updated ASTM or GRI methods may be implemented based on a review by the POR.
2. Soak interface and apply normal stresses of 200, 1000, and 5000 psf for at least one hour prior to shearing at a displacement rate of 0.04 in/min.
3. The POR shall confirm that the interface shear strengths exceed the values used in the stability calculations presented in Appendix III-3C. If the measured interface shear strengths are less than the values used in the analyses, the stability of the liner system shall be reassessed and revised calculations shall be included in the GLER.
4. Test results from materials used during one construction event may be used in subsequent events provided the materials used are the same and approved by the POR.
5. Other methods such as D1603 (tube furnace) or D6370 (TGA) are acceptable if an appropriate correlation to D4218 (muffle furnace) can be established.

3.2 Installation Procedures

3.2.1 Geomembrane Liner Subgrade Preparation and Acceptance

Prior to geomembrane installation over a soil liner, the top of the soil liner shall be checked for irregularities, protrusions, sharp stones, stones larger than 3/8 inch in size, loose soil, and abrupt changes in grade. The soil liner surface shall be prepared by rolling with a smooth-drum roller to minimize the roughness and to press down protruding soil or rock particles prior to geomembrane deployment. Loose rocks and/or dry soil

particles that could damage the geomembrane shall be removed. Excessive voids or dimples shall be filled in with a soil-bentonite mixture. The surface shall not exhibit excessive desiccation prior to geomembrane deployment. The geomembrane subgrade acceptance shall be documented.

3.2.2 Anchor Trench Construction

The anchor trench shall be constructed according to the project plans and specifications, and the excavation and backfilling operations shall be documented. If the anchor trench is excavated in a clay material susceptible to desiccation, the amount of anchor trench open at any time should be minimized. The inside edge of the trench shall be rounded so as to avoid stresses from sharp bends in the geomembrane. Excessive amounts of loose soil shall not be allowed underneath the geomembrane in the anchor trench, and the anchor trench shall be adequately drained to prevent ponding or softening of adjacent soils while the trench is open. The anchor trench shall be backfilled and compacted according to the project plans and specifications; however, backfilling shall be performed, at a minimum, with ordinary compaction as deemed suitable by the POR. The anchor trench backfill is compacted to at least 90% of the maximum dry density as determined by the moisture/density compaction relationship.

3.2.3 Geomembrane Deployment

The geomembrane shall be installed in direct and uniform contact with the compacted soil liner. The geomembrane shall not be placed during inclement weather, such as high winds or rain.

Geomembrane seaming should generally not take place when ambient temperatures are below 32 degrees Fahrenheit (°F), unless preheating is used. For extrusion welding, preheating will be required if the temperature is below 32°F. For fusion welding, preheating may be waived if the installer demonstrates that quality welds may be obtained without preheating. Seaming shall not be permitted at ambient temperatures above 104°F, unless the installer can demonstrate that seam quality is not compromised.

In general, only low ground pressure rubber-tired support equipment approved by the POR may be allowed on the geomembrane. If the POR observes any potential damage done to the liner by the support equipment, use of the equipment will cease and the damage will be repaired. Personnel working on the geomembrane shall not smoke, wear damaging shoes, or engage in any other activity likely to damage the geomembrane. Only those sections that are to be placed and seamed in one day should be unrolled. Panels left unseamed should be anchored with sandbags or other suitable weights. In general, seams should be oriented parallel to the line of maximum slope (i.e., oriented up and down, not across the slope). In corners and odd-shaped geometric locations, the number of field seams should be minimized.

Panels should be overlapped, as recommended by the manufacturer, as appropriate for the type of seam welding to be performed; however, overlapping shall be no less than 2 inches. Field seaming shall only be performed by the method(s) approved by the manufacturer, either by extrusion welding or double-tracked fusion welding. No seaming shall take place without the installer's supervisor or Master Seamer and CQA

monitor being present. Fishmouths, or wrinkles at the seam overlap, shall be cut along the ridge of the wrinkle to achieve a flat overlap. The cut shall be seamed and/or patched. Seams shall extend to the outside edge of panels placed in the anchor trench.

Panel layout and field seams shall be given an identification code, mapped, and logged to record relevant installation information. Inspection and testing records shall be logged as well as repair and retest data.

3.3 Installation Monitoring and Testing

3.3.1 Trial Seams

Each day prior to commencing field seaming, trial seams shall be made on pieces of geomembrane material to verify that conditions are adequate for production seaming. Trial seams shall be made at the beginning of each seaming period and shift (generally, at least twice each day) for each combination of production seaming machine and operator to be used that day. The trial test seam shall be at least 3 feet long by 1 foot wide (after seaming) with the seam centered lengthwise. Four 1-inch wide specimens shall be die-cut from the trial seam sample. Two specimens shall be tested in the field for shear and two for peel (test both inner and outer welds for dual track fusion welding) and shall be compared to the minimum seam strength requirements specified in the most current version of the GRI Test Method GM19. The current versions of the GRI test methods are included in Appendix III-3F-1.

If any of the trial seam specimens fail, the entire trial seam operation shall be repeated. If an additional specimen fails during the second trial seam, the seaming machine and seamer shall not be used for seaming until the deficiencies are corrected and two consecutive successful trial seams are achieved. Additional trial seams shall be performed if frequent field seaming problems are experienced or if power to the seaming machines is interrupted sufficiently long to require rewarming. Additional trial seams shall be made at each occurrence of significantly different environmental conditions, including, but not limited to, temperature, humidity, and dust, and after any machine is turned off for more than 30 minutes.

3.3.2 Non-Destructive Testing

Continuous, non-destructive testing shall be performed on all seams by the installer. All leaks must be isolated and repaired by following the procedures described in this LQCP.

> Air Pressure Testing – ASTM D5820. The ends of the air channel of the dual-track fusion weld must be sealed and pressured to approximately 30 pounds per square inch (psi), if possible. The air pump must then be shut off and the air pressure observed after 2 minutes. A loss of less than 3 psi is acceptable if it is determined that the air channel is not blocked between the sealed ends. A loss greater or equal to 3 psi indicates the presence of a seam leak that must then be isolated and repaired by following the procedures described in this LQCP. The POR or his/her qualified representative must observe and record all pressure gauge readings.
>
> Vacuum-Box Testing – ASTM D5641. Apply a vacuum of approximately 4 to 8 psi to all extrusion welded seams that can be tested in this manner. The seam must be observed for

leaks for at least 10 seconds while subjected to this vacuum. The POR or his/her qualified representative must observe 100% of this testing.

Other Testing. Other non-destructive testing must have prior written approval from the TCEQ.

3.3.3 Destructive Seam Testing

Destructive samples shall be taken at a minimum frequency of one test location, selected randomly, within each 500 linear feet of seam length, inclusive of both primary longitudinal and cross seams, cap strips, and repairs 20 square feet or larger. Each test sample should be of sufficient length and 12 inches wide with the seam located in the middle. Test specimens, approximately 1 inch wide, shall be cut from both ends of the sample for field testing (peel and shear). The remaining sample should be cut into three parts (one for quality assurance laboratory testing, one for installer quality control laboratory testing, and one for archive storage to be maintained at a location selected by the owner).

The field tests shall be conducted on a certified calibrated tensiometer capable of maintaining a constant extension rate of 2 inches per minute. If one of the field test specimens from the ends of the destructive sample fails, then the seam will be considered to have failed, and repairs shall be initiated as described below. If both specimens pass, then a sample for laboratory testing will be sent to the quality assurance laboratory for testing in both peel and shear. Seam strengths for HDPE geomembranes shall meet the minimum values specified in the most current version of the GRI Test Method GM19 "Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes".

Destructive test results for both field and laboratory tests shall include qualitative data, including the location of the failure and locus-of-break code, as described in ASTM D6392. Peel tests on double-tracked fusion welds shall be performed on both inside and outside tracks of the weld. Seam break classifications for extrusion and fusion welds are shown on Figures III-3F-2 and III-3F-3, respectively.

At a minimum, a destructive test must be done for each welding machine used for seaming or repairs. A sufficient amount of the seam must be removed to conduct field testing, independent laboratory testing, and archiving of enough material to retest the seam when necessary. Destructive seam testing locations shall be cap-stripped and the cap completely seamed by extrusion welding to the geomembrane. Capped sections shall be non-destructively tested. Additional destructive test samples may be taken if deemed necessary by the POR or his/her qualified representative.

Weld Acceptance Criteria: For HDPE seams (both smooth and textured), the minimum passing criteria for destructive seam testing are described in the GRI Test Method GM19. The POR must use the most current version of GM19 when evaluating welded seams.

Seam Failure Delineation: When a sample fails a destructive test, the installer shall trace the welding path to an intermediate location at least 10 feet in each direction, or a distance determined by the POR, from the point of the failed test and take 1-inch wide specimens for an additional set of field tests. If these additional samples pass the tests, then two laboratory destructive samples shall be taken adjacent to the intermediate locations or at locations determined by the POR or his/her representative. If these laboratory samples pass the tests,

then the seam shall be repaired between these locations. If either sample fails, then the process shall be repeated to establish a zone where the seam should be repaired. All acceptable repaired seams shall be bounded by two locations from which samples passing laboratory destructive tests have been taken.

Seam Failure Repairs: Any portion of the geomembrane exhibiting a flaw or failing a destructive or non-destructive test shall be repaired. Repair methods may include spot welding (extrusion) for minor flaws and punctures; patches for larger holes and tears; capping for large lengths of failed seams or panel damage; and extrusion welding of outer flap to repair an inadequate fusion seam (less than 100-feet cumulative length) that has an exposed edge.

For any repair method, the following provisions shall be satisfied:

- Surfaces of the geomembrane that are to be repaired using extrusion methods shall be ground no more than one hour prior to the repair
- All surfaces shall be clean and dry at the time of repair
- Patches or caps shall extend at least 6 inches beyond the edge of the defect, and all corners of patches shall be rounded with a radius of approximately 3 inches
- All repairs shall be non-destructively tested, as previously described
- All seaming equipment, personnel, and operation procedures used in repair work shall meet the same requirements as for new seaming operations

The POR or his/her qualified representative shall observe all non-destructive testing of repairs and shall record the number of each repair, type, date, and test outcome. Repairs that pass the non-destructive tests shall be taken as an indication of an adequate repair. Repairs more than 150 feet long shall also be required to have a destructive test performed. Repairs that fail the initial retest shall be redone and retested until a passing test results. All work and testing of repairs shall be fully documented in a repair log.

When placing overlying material on the geomembrane, effort must be made to minimize wrinkle development. If possible, cover should be placed during the coolest weather available. Small wrinkles should be isolated and covered as quickly as possible to prevent their growth. In no case shall the geomembrane be allowed to fold over on itself.

4.0 LEACHATE COLLECTION SYSTEM

4.1 Leachate Collection System and Drainage Materials

Leachate collection and associated leachate removal systems will be constructed of materials that are chemically resistant to the leachate expected to be generated; of sufficient strength and thickness to prevent collapse under the pressures exerted by overlying wastes, waste cover materials, and by any equipment used at the landfill; and designed and operated to function through the scheduled closure and post-closure period of the landfill.

The leachate collection trenches and sumps shall be constructed in conjunction with liner construction. All soil testing and evaluation of either in situ soil or constructed soil liners and all geomembrane testing shall be completed prior to installing the leachate collection system on the area under evaluation. The locations of the trenches and sumps and design details are shown on the Figures III-3-2 through III-3-5 in Attachment 3 to the SDP. The installation of the leachate collection system and protective cover system will have continuous inspection by the POR or his/her qualified representative(s). Quality assurance monitoring shall consist of measuring the dimensions of the excavated trenches and sumps, and documenting that the pipe, geotextile filters, bedding materials and drainage layers have been placed in accordance with the design details. All data and observations regarding construction of the leachate collection system shall be documented in the Geomembrane Liner Evaluation Report (GLER).

Materials selected for use in the leachate collection system and drainage layers shall be verified by the POR to comply with this LQCP.

4.1.1 Geocomposite Drainage Layer

Geosynthetic drainage material shall conform to the material and performance properties specified in Table III-3F-4. Manufacturers' certificates of material and performance characteristics shall be obtained and documented at the minimum frequency shown on Table III-3F-4, with not less than one per resin lot. Geosynthetic drainage material conformance testing will consist of transmissivity testing on each material type using the test set-up described in Table III-3F-4.

The drainage layer for the leachate collection system will consist of a geosynthetic drainage layer over both the floor and sideslopes of the landfill cells. On the floor, the drainage layer shall consist of a geonet with a nonwoven geotextile heat-bonded or placed on the topside. On the sideslopes, the geosynthetic drainage layer shall consist of a geonet with a nonwoven geotextile heat-bonded to both sides. The geosynthetic drainage layer shall be anchored in an anchor trench at the crest of the sideslopes.

Geotextile panels placed in the leachate collection system shall be overlapped and either heat-bonded or field sewn. Only low ground pressure rubber-tired support equipment approved by the POR may be allowed on the

geotextile. Personnel working on the geotextile shall not smoke, wear damaging shoes, or engage in any activity that damages the geotextile, or underlying geosynthetics.

TABLE III-3F-4: Geosynthetic Drainage Layer Specifications(1)

GEOCOMPOSITE

Property	Qualifier	Unit	Value	Test Method	Frequency
Transmissivity	Min.	m^2/sec	8.42×10^{-4} – Cell Floor 3.9×10^{-5} – Sideslopes	ASTM D4716(2)	200,000 sf
Ply Adhesion	Min.	lb/in	0.5	ASTM D7005	200,000 sf

GEONET CORE

Property	Qualifier	Unit	Value	Test Method	Frequency
Thickness	Min.	mils	200	ASTM D5199	200,000 sf
Density (black resin)	Min.	g/cm^3	0.940	ASTM D1505	200,000 sf
Carbon Black Content	Range	%	2 to 3	ASTM D4218	200,000 sf

GEOTEXTILE

Property	Qualifier	Unit	Value	Test Method	Frequency
Mass per Unit Area	MARV	oz/yd^2	6	ASTM D5261	200,000 sf
AOS		US Sieve (mm)	70 (0.210)	ASTM D4751	540,000 sf

Notes:
1. See Appendix III-3E-1 and Appendix III-3D-2 for design calculations for the geocomposite on the floor and sideslope, respectively. These calculations shall be referenced to determine the suitability of the alternate materials.
2. For the single-sided geocomposite (for use on the cell floor), the transmissivity shall be measured at a minimum gradient of 0.1 under a minimum normal pressure of 10,000 psf with a minimum seating period of 1 hour. For the double-sided geocomposite (for use on the sideslopes), the transmissivity shall be measured at a minimum gradient of 0.33 under a minimum normal pressure of 10,000 psf with a minimum seating period of 1 hour.

4.1.2 Filter Geotextile

The leachate drainage aggregate that is placed in the collection trenches and sumps shall be wrapped in a geotextile filter fabric. The geotextile shall have the minimum properties listed in Table III-3F-5.

Table III-3F-5: Nonwoven Filter Geotextile Specifications

Property	Qualifier	Unit	Value	Test Method	Frequency
Mass per Unit Area	MARV	oz/yd^2	7.5	ASTM D5261	100,000 sf
AOS		US Sieve (mm)	80 (0.15)	ASTM D4751	550,000 sf
Puncture Resistance		lb	550	ASTM D6241	550,000 sf
Grab Tensile Strength		lb	205	ASTM D4632	100,000 sf

4.1.3 Leachate Pipe

The leachate piping includes perforated collection trench pipes and solid sideslope riser pipes. The leachate piping shall have the minimum SDR rating and perforation schedule shown on the plans and specifications.

4.1.4 Drainage Material

Granular drainage materials, to be used in the underdrains, along the leachate collection lines, and in the sumps, shall be selected to meet the performance requirements specified in the Site Development Plan (SDP). At least one set of pre-construction tests shall be conducted for each drainage medium from each proposed source. Pre-construction tests shall include a complete grain-size analysis, including minus No. 200 Sieve (ASTM D422) and calcium carbonate content (ASTM D3042 modified to use hydrochloric acid with a pH of 5 or the J&L method). If a separate source is used exclusively for the underdrain, the calcium carbonate testing may be omitted for that source. The grain-size analysis will be used to determine if the material is compatible with the perforations in the leachate collection pipes and if the material is expected to achieve a minimum permeability of 1×10^{-2} cm/sec. The measured calcium carbonate content must not exceed 15 percent.

Granular drainage materials selected for use shall be tested at regular intervals for conformance during construction. Minimum testing frequency shall include one grain-size analysis for every 3,000 cubic yards, or portion thereof, for each material being used.

4.2 Protective Cover Material

Protective cover materials shall be free of deleterious materials that could puncture the synthetic lining system. The protective cover material shall be selected and placed so as not to harm the geomembrane or other geosynthetic layers. The installation of the leachate collection system and protective cover system will have continuous inspection by the POR or his/her qualified representative(s).

It is anticipated that the on-site soils will have a hydraulic conductivity less than 1×10^{-4} cm/sec. Therefore, chimney drains, constructed directly on top of the geosynthetic leachate collection drainage laterals, will be included.

Visual observations shall be made to verify that no deleterious materials are present in the protective cover that could damage the lining and leachate collection systems or impede their performance as designed.

Alternate protective cover material, such as shredded tire chips, may only be used when overlying a protective layer of sufficient puncture resistance to prevent penetration of steel belting fragments or other deleterious materials through the geosynthetic drainage layers or geomembrane. Prior to use of an alternate protective cover material, written approval will be obtained from the TCEQ.

Protective cover does not require compaction control; however, it should be stable for construction and disposal traffic. Care shall be exercised in placement so as not to shift, wrinkle, or damage the underlying geosynthetic layers, and the placement methods shall be documented. Protective cover placement should be conducted at the coolest part of the day to minimize the development of wrinkles in the geosynthetic materials.

The protective cover shall be placed such that the top surface, while spreading, is at least 2 feet above the geosynthetic layers at all times unless low ground pressure dozers are used (i.e., track pressure less than 5 psi). A greater thickness shall be maintained to support loaded hauling trucks and trailers and for turning areas. Drivers shall proceed with caution when on the overlying soil and prevent spinning of tires, quick stops, or sharp turns.

Protective cover shall generally be placed in an upslope direction for sidewalls. Where the top few feet of sidewall (typically less than 5 feet vertically) is to be protected by a different soil type, such as clay for tying in the final cover soil liner, this material may be placed from the top, provided adequate care is taken to protect the geosynthetic liner components.

The final thickness of the protective cover shall be a minimum 24 inches above a geosynthetic drainage layer. The required thickness of protective cover shall be verified by survey methods on an established grid system with not less than one verification point per 5,000 square feet of surface area.

5.0 SPECIAL CONDITIONS – EXCAVATIONS BELOW THE SEASONAL HIGH GROUNDWATER TABLE

5.1 Introduction

This section of the LQCP addresses the issue of cell construction below the seasonal high groundwater table and provides information pertaining to site-specific conditions, analysis and design methods, construction methods, and documentation/reporting procedures to be considered during development of future disposal cells at the facility.

In landfill excavation areas that have been identified as extending below the seasonal high water table, the liner system and the waste placed above the liner system will provide ballast (weight) to protect the liner system from uplift forces from groundwater. Soil or a soil/waste combination may also be used to ballast the liner system.

In accordance with 30 TAC §330.337(e), prior to excavating any unit below the seasonal high water table, the owner/operator is required to perform a preliminary foundation evaluation and provide that evaluation to TCEQ for review and approval. The foundation evaluation must consider stability, settlement, and constructability. This evaluation has been performed as part of this permit amendment application and is provided in Part III, Attachment 3, Waste Management Unit Design Report. Section 5.8 of this LQCP addresses additional measures to be implemented to verify the integrity of lining systems constructed below the seasonal high water table.

The stability of the liner systems against uplift is considered for two cases: 1) short-term, i.e., during construction and filling operations; and 2) long-term, i.e., after filling and into post-closure. Short-term stability against uplift of the liner system will be provided by an active underdrain system. Long-term stability against uplift of the sidewall and floor liner systems is provided by the weight of the protective cover, waste material, and cover system components, collectively referred to as ballast.

5.2 Site Characterization

The site stratigraphy consists of three distinct strata, namely (in order from ground surface down):

- Stratum I: Stiff to hard, dark brown to tan, low plasticity clay, with high plasticity clay with organic content comprising the top of the stratum in some areas. The thickness of Stratum I ranges from 0 to 28 feet.
- Stratum II: Weathered, extremely weak to weak, tan and light gray, with orange mottling, claystone. The top of Stratum II was found between approximately elevation 517 and 601 feet, with a thickness ranging between 0 and 49 feet. The average top of the layer is approximately at elevation 563 feet.
- Stratum III: Slightly weathered to fresh (unweathered), massive, weak to strong, light gray claystone. The top of Stratum III was found between approximately elevation 506 and 565 feet. The average top of the stratum is approximately 533 feet. The bottom of this stratum was not identified.

5.3 Seasonal High Groundwater Table

Site monitor well records were reviewed and used to determine the historical seasonal high groundwater table for the site. Figure III-3F-4 presents the seasonal high groundwater table elevations. A list of the monitor wells and readings used in developing this figure is presented in Appendix III-3F-2.

For each new increment of liner construction, the POR shall reevaluate the seasonal high groundwater table for the area being evaluated as part of the Soil Liner Evaluation Report (SLER) submittal. The specific information to be included in the SLER is:

- A description of the seasonal high groundwater table established in the SDP or previous SLER, as applicable
- A summary of the groundwater data collected since the development of the SDP or previous SLER, as applicable
- An evaluation of whether the seasonal high groundwater table must be adjusted upward on the basis of these data
- An analysis of the changes required in the groundwater drains or ballast requirements as a result of the revised seasonal high groundwater table

The most recent seasonal high water table data will be included in the SLER submitted for each excavation area.

5.4 Short-Term Excavation Stability

Measures will be taken to protect the liner and leachate collection system during construction below the seasonal high groundwater table. One or more of the following methods are allowed by 30 TAC §330.337 to provide short-term protection.

1. Providing calculations satisfactory to the executive director that the weight of the liner systems, including any ballast, is sufficient to offset by a factor of 1.2 any otherwise unbalanced upward or inward hydrostatic forces on the liner
2. Incorporating an active or passive dewatering system in the design to reduce upward or inward hydrostatic forces on the liner by a factor of 1.2 and by providing calculations satisfactory to the executive director that the dewatering system will perform to adequately reduce those forces
3. Providing evidence satisfactory to the executive director that the soil surrounding the landfill is so poorly permeable that groundwater cannot move sufficiently to exert force that would damage the liner
4. Providing evidence that the seasonal high water table is below the deepest planned excavation

Excavations below the water table can result in bottom or slope instability or excessive groundwater influx that may make construction of the liner system difficult. During excavation, control of groundwater can be accomplished by temporarily lowering the groundwater level. Since soil will be excavated gradually for use as daily cover or compacted clay liner material, the cell excavation will take place over a fairly long time period. Therefore, in areas where excessive seepage is encountered, the seepage will be directed away

from the cell or into sumps using ditches, and the excavation activities will be moved while the groundwater is allowed to drain. If this approach is not effective or practical, other means, such as well-points may be used to lower the surrounding groundwater table.

Once the design base grades are reached, groundwater will be controlled by installing toe drains and a geocomposite underdrain along the sideslopes. Additional toe drains or geocomposite drains may be installed in areas of significant seepage to control water during liner system construction.

The toe drains will consist of a 2-foot wide by 2-foot deep trench with a 4-inch ADS N-12 dual wall corrugated HDPE (or equal) perforated pipe surrounded by drainage material, wrapped with filter geotextile. The geosynthetic underdrain layer will consist of a double-sided geocomposite (i.e., a geonet with a filter geotextile on both sides).

Groundwater will be removed from below the liner system via an underdrain sump constructed immediately beneath the leachate collection sump. The location of the underdrain sumps is shown on Figure III-3F-5. Underdrain details are shown on Figure III-3F-6. Pumps sized to accommodate the designed flows from the underdrain system will be installed within a riser pipe with controls to allow automatic operation. The underdrain sump riser pipe shall exit the cell in such a manner so as not to penetrate the composite liner system within the planned limits of the waste disposal.

The system will prevent excessive pressure head from developing beneath the liner system during construction and filling operations. The geocomposite and toe drains have been sized to accommodate the anticipated inflow of groundwater into the excavation and deliver it to the sump where it will be pumped out of the cell. The geocomposite will be double-sided (i.e., a geonet with a filter geotextile on both sides) with a minimum transmissivity of 1×10^{-4} m^2/sec (measured at a minimum gradient of 0.25). The system will be operated until adequate ballast is achieved and approval is obtained from the TCEQ to deactivate and abandon the system.

Calculations for the future landfill cell underdrains for the Temple Recycling and Disposal Facility are included in the Appendix III-3F-3.

5.5 Long-Term Excavation Stability

As described previously, it is anticipated that portions of the liner system will be founded below the seasonal high groundwater table. Calculations have been prepared to demonstrate that long-term excavation stability will be provided by the weight (ballast) of the leachate collection system, the protective cover, and waste, assuming seasonal high groundwater potentiometric levels. The ballast counteracting the hydrostatic forces resulting from this high groundwater include the soil materials from the leachate collection system components, the protective cover, waste above the liner and leachate collection system, and the soil

materials from the interim cover. The weight of the geosynthetic components of the leachate collection system and any geosynthetic components of the interim cover will be considered negligible.

5.6 Ballast Thickness Calculations

The required ballast thickness will be calculated using the following procedures:

1. Determine the hydrostatic uplift pressure, *P*, acting on the base of the bottom leachate collection system and the sidewall leachate collection system from the assumed seasonal high groundwater table, and the resistance provided by the ballast:

   A. Bottom Leachate Collection System

   Determine the maximum hydrostatic uplift pressure, *P*, acting on the geomembrane component of the liner system using the unit weight of water, γ_w, times the vertical distance from the base of the leachate collection system to the seasonal high water table, H_{wt}.

   $$P = \gamma_w H_{wt}$$

   The resisting pressure, *R*, provided by the ballast is equal to the sum of the unit weights of each ballast component, γ_i, times their respective vertical thickness, T_i, as shown in the following equation:

   $$R = \Sigma(\gamma T_i)$$

   B. Sidewall Leachate Collection System

   Determine the normal uplift pressure, P_N, acting at a location on the base of the sidewall leachate collection system using the unit weight of water times the vertical distance from the location on the sidewall to the seasonal high piezometric level.

   $$P_N = \gamma_w H_{wt}$$

   The resisting pressure, R_N, provided by the ballast is equal to the normal component of the sum of the unit weights of each ballast component, γ_i, times their respective vertical thickness, T_i, as shown in the following equation:

   $$R_N = \Sigma(\gamma T_i)\cos^2\beta$$

   Where β is the angle between the sidewall liner and horizontal.

2. The equations for *R* and *P* are solved for equilibrium to find the thickness of ballast required to counteract the calculated water pressure.

   The safety factors indicated in the regulations, either 1.2 or 1.5 depending on the type and configuration of ballast used, are incorporated into the above referenced equations by multiplying by the appropriate factor. If only soil ballast is used, a factor of 1.2 is used in the equation, and if some combination of soil layers and waste is used as ballast, a factor of 1.5 is used.

   $$1.2P = R \qquad or \qquad 1.5P = R$$

When the equations for R and P are input, the required waste thickness, and/or required ballast thickness, is then determined. The equations can be solved for any location within or near an excavation where the piezometric profile is known or can be estimated.

Example waste for ballast calculations are presented in Appendix III-3F-4. Figures III-3F-7 through III-3F-9 show the locations of the points analyzed and the seasonal high groundwater table. In each SLER, waste for ballast calculations will be provided to determine the minimum amount of waste needed, if any, to offset the hydrostatic uplift from the seasonal high water table.

5.7 Slope Stability of Sidewall Liners

The calculations described above evaluate the factor of safety of the landfill liner system against uplift in the direction normal to the liner system. On the sidewalls, these normal hydrostatic pressures also decrease the resistance to translational sliding along the bottom of the liner system. For this reason, the stability of the sidewall liners may be of concern.

As described previously, where encountered, groundwater will be collected within drains constructed below the liner system. All drains placed below the liner system will be maintained and operated until sufficient ballast is in place to resist the uplift pressures below the liner system. The groundwater control measures will prevent the buildup of hydrostatic pressures at the base of the liner system. It is therefore concluded that the stability of the sidewall liner systems has been adequately addressed.

5.8 Observations and Documentation

5.8.1 Verification During Construction

The POR shall verify that the dewatering and ballast meets the established criteria and that uplift of the liner and leachate collection system did not occur during construction. The verification shall be documented in the Ballast Evaluation Report (BER), which will be submitted to the TCEQ for approval.

5.8.2 Construction Observations

The POR shall observe the liner subgrade, liner, and leachate collection system materials for the presence of groundwater seepage during construction to verify the subgrade is suitable for liner system construction.

The entire subgrade shall be observed during excavation, and the occurrence of the following shall be noted:

- Groundwater seepage within the subgrade
- Softening of the subgrade surface resulting from groundwater seepage
- Softness or sheen in the secondary features resulting from groundwater seepage

In each SLER, observations and subgrade evaluations performed by the POR will be presented to verify that the subgrade soils are suitable for liner system construction.

5.8.3 Water Table Observation

The landfill groundwater monitoring system near the construction area will be monitored during excavation below the seasonal high water table. If the observations indicate the groundwater level is different than the previously determined seasonal high water table, the design seasonal high water table will be adjusted upward and the ballast calculations will be revised accordingly.

5.9 Reporting

If an underdrain is required below the liner system, once protective cover, waste, and soil cover materials have been placed in accordance with ballast calculations, a BER will be completed and filed with the TCEQ documenting that sufficient ballast has been placed in the cell to offset the hydrostatic uplift forces that may exist below the leachate collection system. The underdrain must remain operational and pumped (if necessary) until approval of the BER is received from the TCEQ. The following information will be included, as applicable, with the BER.

1. A summary of in-place density measurements will be presented verifying that the weight of the leachate collection system, protective cover, ballast (if any), and cover required as ballast complied with the calculations.
2. The top of protective cover will be surveyed after installation to assure that the liner and leachate collection system did not undergo uplift prior to waste placement.
3. Water level measurements obtained from appropriate site piezometer and monitor wells near each excavation area will be presented verifying that the groundwater levels do not exceed the design seasonal high water table. If the observed water levels exceed the design seasonal high water level, the ballast calculations will be adjusted accordingly.
4. A TCEQ Waste-as-Ballast Placement Record form completed by the landfill manager or designated representative will be presented confirming that the waste material in the first 5 feet of waste was free of brush and large bulky items, daily operations of the pressure relief/underdrain system (if required) were completed, and a wheeled trash compactor having a minimum weight of 40,000 pounds was used to place waste.

The BER will be signed and sealed by the POR, signed by the site operator, and submitted to the TCEQ for approval. If no response is received, either oral or written, within 14 days after receipt at the TCEQ, then the reports will be considered approved.

6.0 MARKING AND IDENTIFYING EVALUATED AREAS

In accordance with 30 TAC Section §330.143(b)(1) and (6), markers shall be placed so that all areas for which SLER and GLER have been submitted and approved by the TCEQ are readily identifiable. Such markers are to provide site workers with immediate knowledge of the extent of approved disposal areas and shall be placed in accordance with the Site Operating Plan.

Markers shall be metal, wooden, or recycled posts and shall extend at least 6 feet above ground level. Markers shall not be obscured by vegetation and shall be placed so that they are not destroyed during operations. Sufficient intermediate markers shall be installed to show the required boundary. Lost markers shall be promptly replaced. Limits of the evaluated area shall be referenced to the site grid system. Markers shall not be placed inside the evaluated area. Markers shall be color coded in accordance with 30 TAC §330.143(b)(1). Markers shall be red in color.

7.0 DOCUMENTATION AND REPORTING

7.1 Liner Evaluation Reports

Upon completion of all required liner construction and evaluation, the POR shall prepare and submit in triplicate the SLER and the GLER to the TCEQ for review and approval. Multiple submittals of the reports or documentation during the project may be made, if they may facilitate TCEQ's review of the project.

The SLER and the GLER shall be signed and sealed by the POR performing the evaluation and counter-signed by the site operator or his/her authorized representative. The area covered by this LQCP shall not be used for the receipt of solid waste until written acceptance of the SLER or GLER document(s) is received from the TCEQ. If no response, either written or verbal, is received within 14 days, the SLER or GLER shall be considered accepted and the owner or operator may continue facility construction or operations.

The construction documentation provided in the SLER or GLER will contain a narrative describing the conduct of work and testing programs required by the LQCP, "as-built" or record drawings, and appendices of field and laboratory data. Because the volume of data for these projects can be quite large, the documents may be divided for ease of review. The preferred document format for larger reports will include the SLER, its narrative, as-built drawings, and summaries of test results in a single volume; the GLER, its narrative, as-built drawings, and summaries of test results in a second volume.

The construction documentation report will contain or discuss the following information at a minimum:

For soil liners:

- Pre-construction soil test results
- Summary of construction material conformance tests results
- Summary of field moisture-density control test methods and results
- Summary of hydraulic conductivity test results
- Soil liner construction practices for floor and sidewall sections
- Placement and processing methods
- Observations of soil conditions prior to and after compaction, including soil structure, clod size, and presence of inclusions
- Compaction methods, equipment type, compactor weight and foot length, and number of passes
- Lift tie-in and bonding observations
- Repair of failed and damaged lifts
- Any and all deviations from the permitted design
- Liner thickness verification
- Post-construction care of soil liner
- Laboratory worksheets for hydraulic conductivity tests

- Sample calculations for hydraulic conductivity tests

For geomembrane liners:

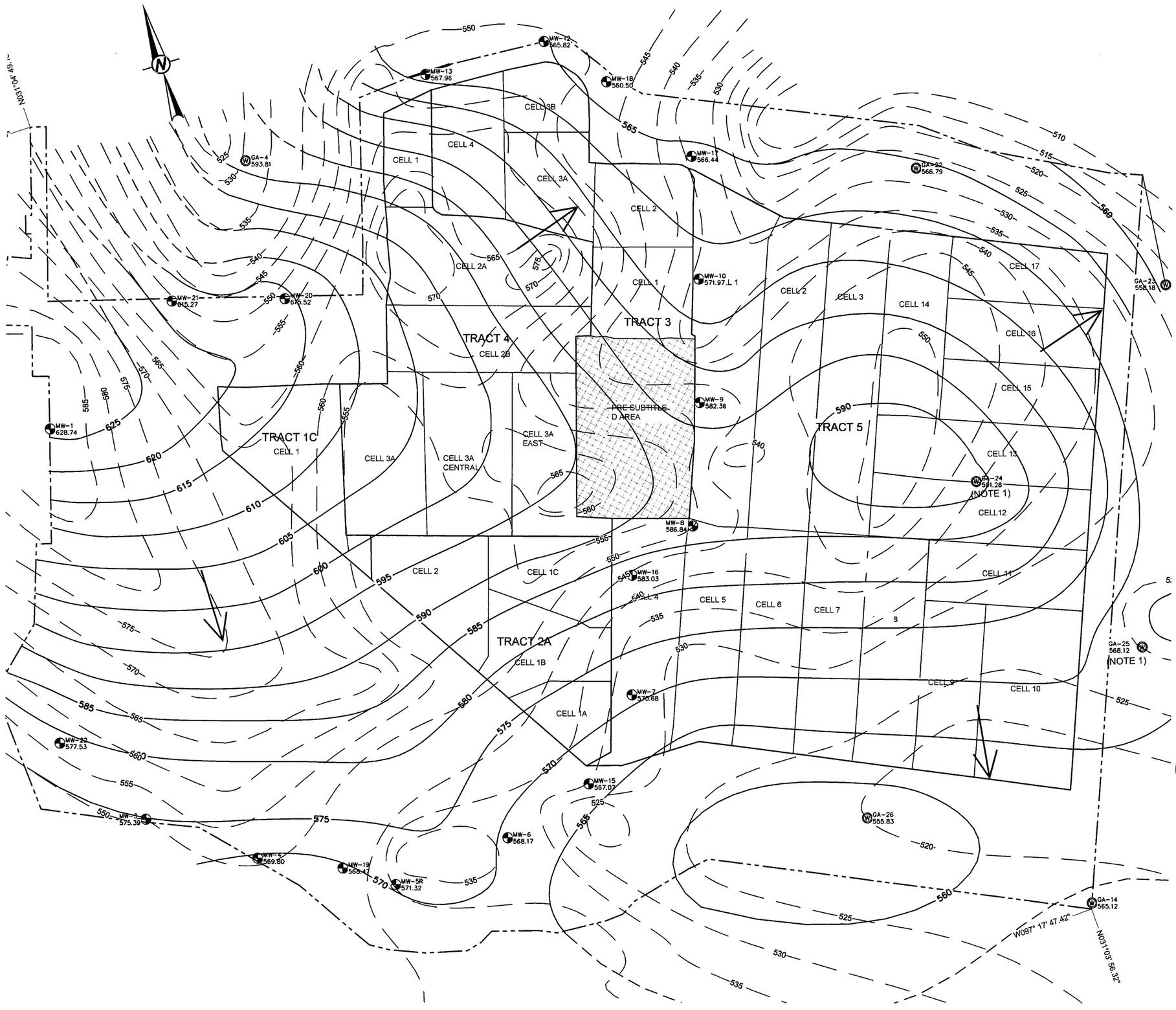
- Roll shipment and receipt information
- Manufacturer's quality control certificates and results
- Storage and handling information
- Conformance test sampling and test results
- Seamer's names and resumes of experience and qualifications
- Subgrade acceptance
- Anchor trench preparation and backfilling
- Panel deployment, identification, and placement
- Seam preparation, orientation, and identification
- Equipment placed or operated on geomembrane
- 100 percent visual inspection for defects, damage, etc.
- Trial seam tests for each combination of seaming equipment and personnel
- Seaming methods, times, temperature, and equipment shutdowns and startups
- Continuous 100 percent non-destructive seam testing, methods, criteria, and results
- Destructive testing methods, criteria, and results
- Repairs, including preparation and procedures, failure delineation, patch size and shape, and retesting
- Material properties and placement of drainage materials and protective cover
- Confirmation of the interface friction angle for the geomembrane/adjoin material interface and a recalculation of the factor of safety, if needed.

The report shall also include pertinent record drawings including:

- Phase layout plan
- Location of the subject cell with SLER/GLER markers
- Previous filled and active areas
- As-built geomembrane panel layout drawings showing location of destructive test samples, patches, and repairs
- As-built drawings showing elevations of protective cover to confirm its thickness

7.2 Interim Status Report

An Interim Status Report (ISR) should be provided to the TCEQ for portions of a liner system that remain uncovered with waste for more than six months from the date that the protective cover was applied, and the area shall be reevaluated by a POR.



LEGEND

- PERMIT BOUNDARY
- 550 — GROUNDWATER ELEVATION CONTOURS (FT-MSL)
- INFERRED GROUNDWATER ELEVATION CONTOURS (FT-MSL)
- CELL BOUNDARIES
- 545 — WEATHERED/UNWEATHERED INTERFACE ELEVATIONS (FT-MSL)
- PRE SUBTITLE D CELL BOUNDARY
- MW-1 500.00 — EXISTING MONITORING WELL AND GROUNDWATER ELEVATION (FT-MSL)
- GA-2 500.00 — PIEZOMETER AND GROUNDWATER ELEVATION (FT-MSL)
- CELL 1 — CELL DESIGNATION

NOTES

1. THE HIGHEST MEASURED GROUNDWATER CONTOURS WERE CREATED USING THE HIGHEST MEASURED HISTORICAL GROUNDWATER LEVELS AND DO NOT REPRESENT AN OBSERVED POTENTIOMETRIC SURFACE.

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Professional Engineering Firm
Registration Number F-2578

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STATE OF TEXAS
CHARLES G. DOMINGUEZ
83247
LICENSED PROFESSIONAL ENGINEER
11/5/16

1	2016-12	RESPONSE TO 1ST NOD PRM	TNB	MX
0	2016-06-10	INITIAL SUBMITTAL	AGM	TNB

CLIENT: CITY OF TEMPLE

CONSULTANT: Golder Associates
HOUSTON
500 CENTURY PLAZA DR., SUITE 190
HOUSTON, TX 77073
USA
(281) 821-6868

PROJECT: PERMIT AMENDMENT APPLICATION MSW 692B
TEMPLE RECYCLING AND DISPOSAL FACILITY
BELL COUNTY, TEXAS

TITLE: SEASONAL HIGH GROUNDWATER TABLE

REV. 0 | 4 of 9 | FIGU III-3F-

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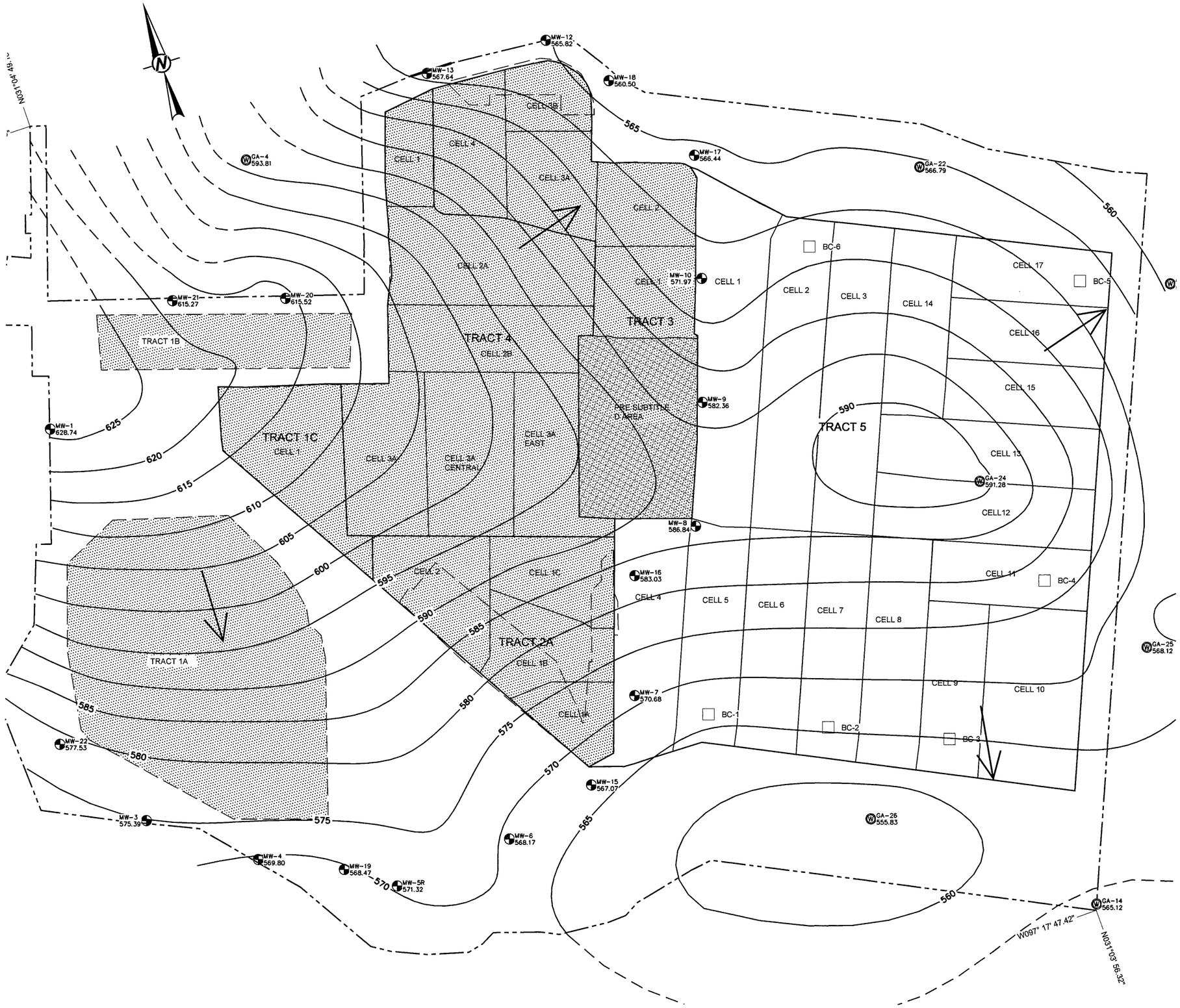

LEGEND

- PERMIT BOUNDARY
- 550 — GROUNDWATER ELEVATION CONTOURS (FT-MSL)
- INFERRED GROUNDWATER ELEVATION CONTOURS (FT-MSL)
- CELL BOUNDARIES
- PRE SUBTITLE D CELL BOUNDARY
- MW-1 500.00 — EXISTING MONITORING WELLAND GROUNDWATER ELEVATION (FT-MSL)
- GA-2 500.00 — PIEZOMETERS AND GROUNDWATER ELEVATION (FT-MSL)
- CELL 1 — CELL DESIGNATION
- BC-4 — BALLAST CALCULATION POINT

NOTES

1. THE GROUNDWATER ELEVATION FROM GA-24 OMITTED FROM GROUNDWATER ELEVATION CONTOURS BECAUSE THE READING WAS ANOMOLOUSLY HIGH AND REPRESENTS ISSUES WITH PIEZOMETER CONSTRUCTION.

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STATE OF TEXAS
5/5/16
CHARLES G. DOMINGUEZ
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REV.	DATE	DESCRIPTION	BY	CHK
1	2016-12	RESPONSE TO 1ST NOD PRM	TNB	MX
0	2016-06-10	INITIAL SUBMITTAL	AGM	TNB

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PROJECT: PERMIT AMENDMENT APPLICATION MSW 692B
TEMPLE RECYCLING AND DISPOSAL FACILITY
BELL COUNTY, TEXAS

TITLE: SEASONAL HIGH POTENTIOMETRIC SURFACE WITH BALLAST CALCULATION POINTS

REV. 0 | 7 of 9 | FIGU III-3F-

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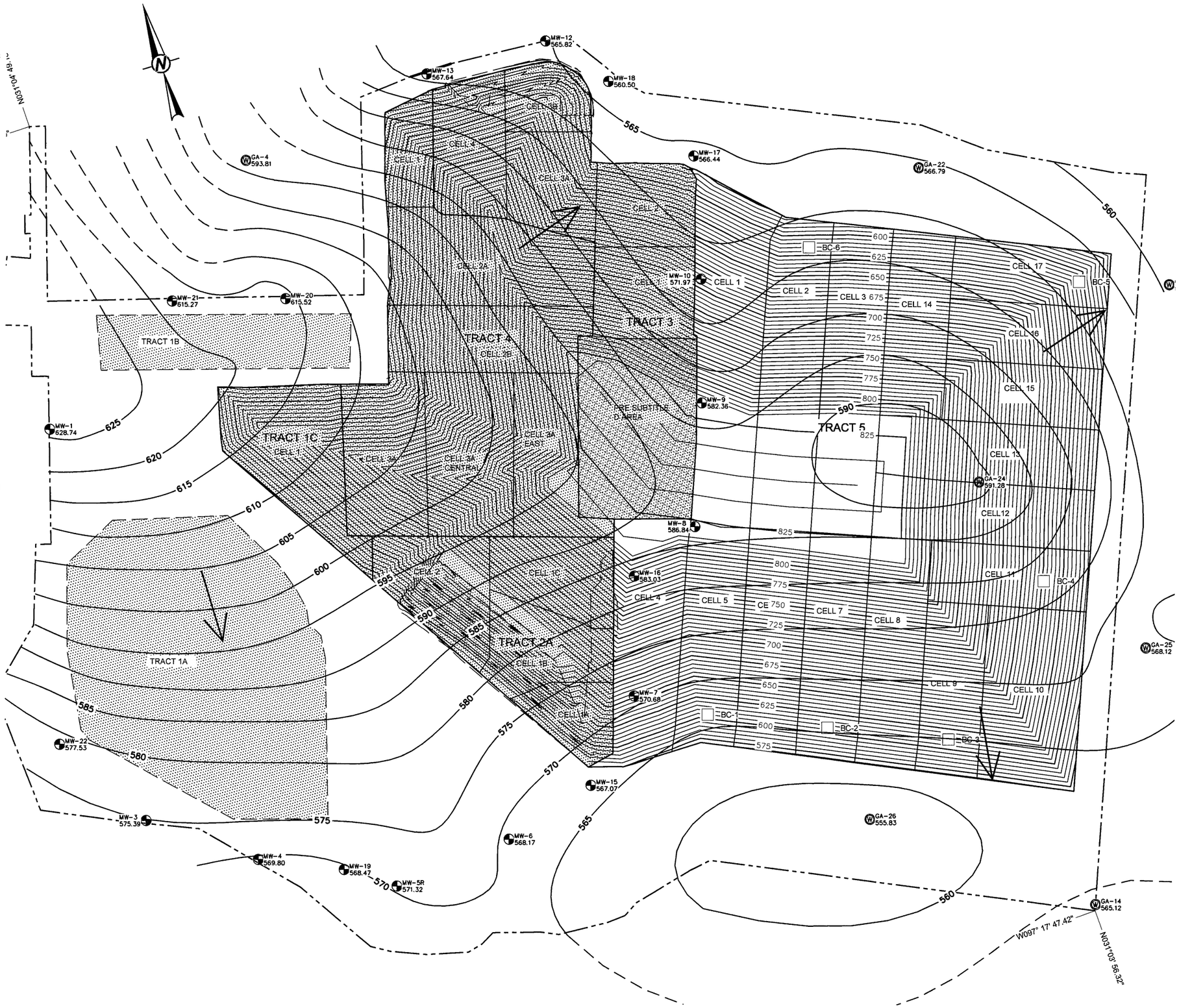

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LEGEND

	PERMIT BOUNDARY
600	GROUNDWATER ELEVATION CONTOURS (FT-MSL)
	INFERRED GROUNDWATER ELEVATION CONTOURS (FT-MSL)
700	FINAL COVER MAJOR CONTOURS
	FINAL COVER MINOR CONTOURS
	CELL BOUNDARIES
	PRE SUBTITLE D CELL BOUNDARY
MW-1 500.00	EXISTING MONITORING WELL & ELEV.AND GROUNDWATER ELEVATION (FT-MSL)
GA-2 500.00	PIEZOMETERS & ELEVATIONAND GROUNDWATER ELEVATION (FT-MSL)
CELL 1	CELL DESIGNATION
BC-4	BALLAST CALCULATION POINT

NOTES

1. THE GROUNDWATER ELEVATION FROM GA-24 OMITTED FROM GROUNDWATER ELEVATION CONTOURS BECAUSE THE READING WAS ANOMOLOUSLY HIGH AND REPRESENTS ISSUES WITH PIEZOMETER CONSTRUCTION.

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REV	DATE	DESCRIPTION	BY	CHK
1	2016-12	RESPONSE TO 1ST NOD PRM	TNB	MX
0	2016-06-10	INITIAL SUBMITTAL	AGM	TNB

CLIENT: CITY OF TEMPLE

CONSULTANT: Golder Associates
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(281) 821-6868

PROJECT: PERMIT AMENDMENT APPLICATION MSW 692B
TEMPLE RECYCLING AND DISPOSAL FACILITY
BELL COUNTY, TEXAS

TITLE: SEASONAL HIGH POTENTIOMETRIC SURFACE WITH FINAL COVER AND BALLAST CALCULATION POINTS

REV. 0

8 of 9

FIGU III-3F-

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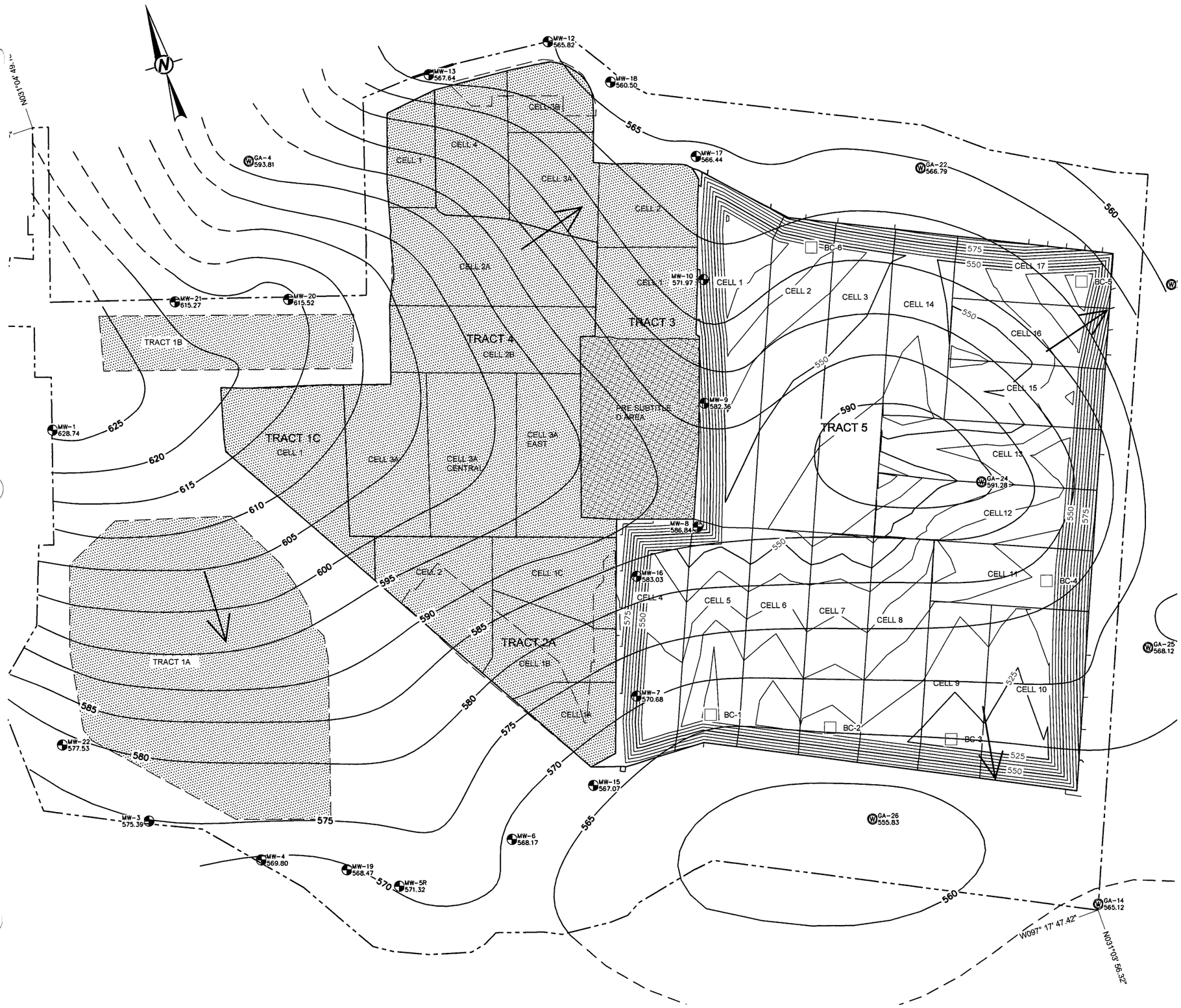

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LEGEND

- PERMIT BOUNDARY
- 600 — GROUNDWATER ELEVATION CONTOURS (FT-MSL)
- INFERRED GROUNDWATER ELEVATION CONTOURS (FT-MSL)
- 550 — EXCAVATION MAJOR CONTOURS
- EXCAVATION MINOR CONTOURS
- CELL BOUNDARIES
- PRE SUBTITLE D CELL BOUNDARY
- MW-1 500.00 — EXISTING MONITORING WELL AND GROUNDWATER ELEVATION (FT-MSL)
- GA-2 500.00 — PIEZOMETERS & ELEVATION AND GROUNDWATER ELEVATION (FT-MSL)
- CELL 1 — CELL DESIGNATION
- BC-4 — BALLAST CALCULATION POINT

NOTES

1. THE GROUNDWATER ELEVATION FROM GA-24 OMITTED FROM GROUNDWATER ELEVATION CONTOURS BECAUSE THE READING WAS ANOMOLOUSLY HIGH AND REPRESENTS ISSUES WITH PIEZOMETER CONSTRUCTION.

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REV	DATE	DESCRIPTION	BY	CHK
1	2016-12	RESPONSE TO 1ST NOD PRM	TNB	MX	CGD
0	2016-06-10	INITIAL SUBMITTAL	AGM	TNB	JBF	CGD

CITY OF TEMPLE

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Golder Associates

PERMIT AMENDMENT APPLICATION MSW 692B
TEMPLE RECYCLING AND DISPOSAL FACILITY
BELL COUNTY, TEXAS

SEASONAL HIGH POTENTIOMETRIC SURFACE WITH EXCAVATION SURFACE AND BALLAST CALCULATION POINTS

APPLICATION SECTION

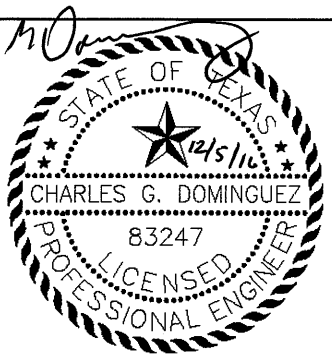
REV 0 | 9 of 9 | FIGURE III-3F-

APPENDIX III-3F-3A

UNDERDRAIN SEEPAGE CALCULATION

UNDERDRAIN SEEPAGE CALCULATION

Made By: AGM
Checked by:JBF
Reviewed by: CDG



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1.0 OBJECTIVE

Use finite element analyses to model seepage and estimate the potential water pressure buildup beneath the Temple Recycling and Disposal Facility (TRDF) expansion area liner system. Design the underdrain system to limit build-up of water pressure under the worst-case seepage conditions.

2.0 METHOD

2.1 Site Conditions

The subsurface stratigraphy of the site includes three units, Stratum I, II, and III. These units are comprised of: stiff to hard, low to high plasticity clays (Stratum I); weathered, extremely weak to weak claystone (Stratum II); and slightly weathered to fresh, weak to strong claystone (Stratum III). Based upon an evaluation of the soil boring and groundwater data from site investigations, there is a preferential flow pathway for groundwater at and above the Stratum II/III interface because Stratum III is not hydraulically connected to Stratum II and acts as the local aquaclude dividing the upper water bearing unit from lower aquifers. The Stratum II thickness below the Proposed Tract 5 area of the landfill floor varies from 0 to 8 ft with an average thickness of 4 ft. Stratum II thickness below the Tract 1C Cell 1 varies from 0 to 3 ft.

2.2 Finite Element Analysis Methodology

Two generalized stratigraphies were modeled using a finite element program (SEEP/W): (i) 4 ft thick Stratum II underlying the liner system on the cell floor, and (ii) 8 ft thick Stratum II underlying the liner system on the cell floor. Each model was run with varying boundary conditions to compare the effect the hydraulic head varying in distance from the sideslope excavation.

3.0 CALCULATIONS

3.1 Soil Parameters

Permeability parameters were determined by measuring the hydraulic conductivity of the soils with a flexible wall permeameter (ASTM Test Method D5084). Details on TRDF's soil stratum properties are available in the Geology Report in Part III, Attachment 4.

Stratum Number	Horizontal Permeability, K_x (cm/s)	Horizontal Permeability, K_x (ft/s)	Vertical Permeability, K_y (cm/s)	Vertical Permeability, K_y (ft/s)	K_y/K_x Ratio
I	3.91E-08	1.28E-09	1.10E-07	3.61E-09	2.820
II	9.10E-07	2.98E-08	1.57E-08	5.15E-10	0.017
III	2.29E-09	7.51E-11	1.69E-08	5.55E-10	7.390

3.2 Critical Cross Sections

The critical cross-section will occur along the portion of the TRDF with the thickest layer of Stratum II underlying the Compacted Clay Liner (CCL). The thickest layer of Stratum II underlying the CCL is 8 ft, but does not extend evenly along the entire length of the TRDF floor. Two SEEP/W simplified configurations were modeled, assuming that the Stratum II layer is a consistent thickness. These critical cross sections have 4-ft and 8-ft thick Stratum II layers underlying the TRDF floor, conservatively representing the average and worst-case conditions, respectively.

3.3 Boundary Conditions

3.3.1 Sideslope Underdrain and Compacted Clay Liner (CCL)

A geocomposite underdrain layer will be placed along the sideslope to intercept, collect, and transmit groundwater to the toe of the slope. The sideslope underdrain was modeled as a seepage face; i.e. a free draining surface with no positive pore pressures. The CCL was modeled as an impenetrable boundary.

3.3.2 Total Head

A total head boundary was set to represent hydrostatic groundwater conditions 8 ft below existing grade (at el. 560 ft). The average depth of the water level below existing grade is 10 ft in Tract 5 and 11 ft in Tract 1C. Setting the total head boundary to represent 8 ft below existing grade creates a conservative analysis. The horizontal distance from the excavation slope crest to the total head boundary varies from 30 to 80 ft. This variation was introduced to identify the effect of the horizontal distance of the total head boundary from the excavation slope.

3.3.3 Toe Drain

The toe drain was modeled as a sink (a node assigned P=0). A sink models a condition in which all water seeping into it is removed before creating a presure condition.

4.0 RESULTS

Two geometry configurations were used in the SEEP/W analyses: (i) 4-ft Stratum II thickness, and (ii) 8-ft Stratum II thickness. Each configuration was modeled with the constant head boundary 80 ft from the excavation crest as well as 30 ft from the excavation crest. Section 4.1 presents the groundwater flows that may occur along the excavated slope, at the toe, and combined flow into the toe drain for both configurations. Section 4.2 plots the pore-water pressure along the TRDF expansion floor for the four geometry and boundary condition combinations. Section 4.3 presents the SEEP/W output figures.

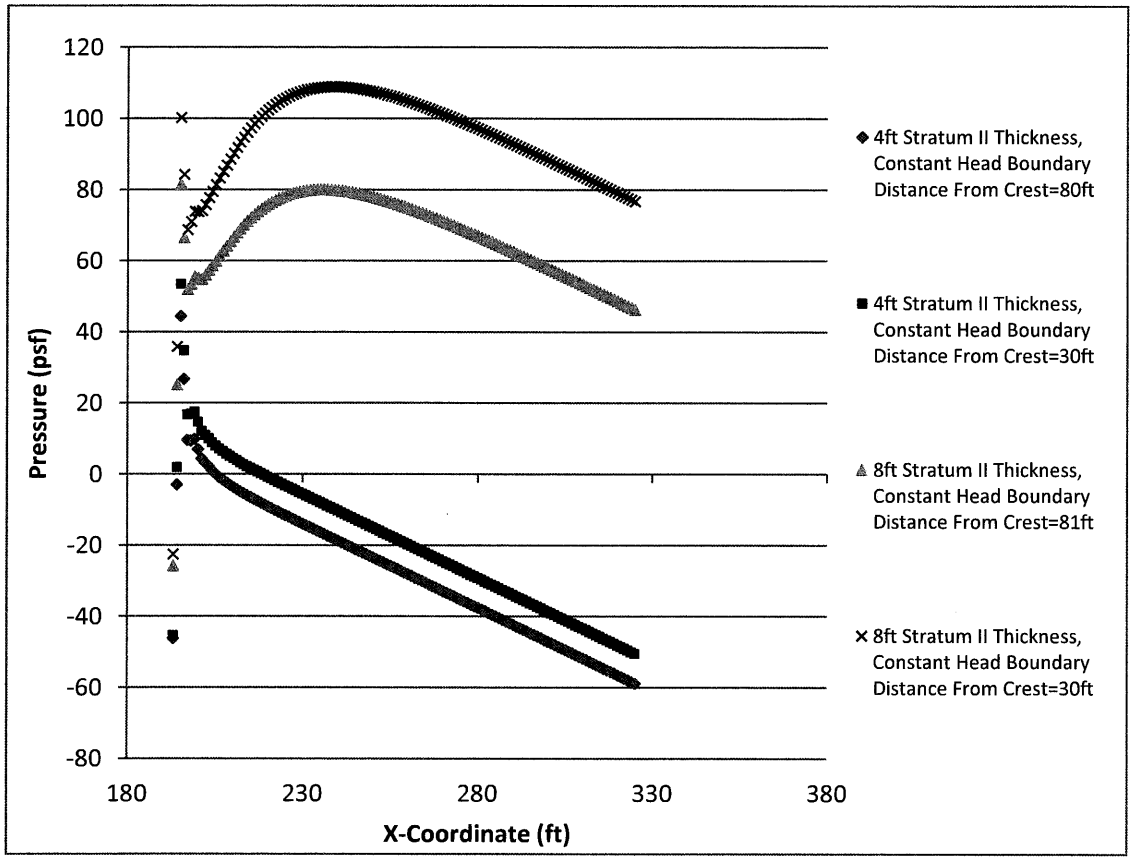
4.1 Groundwater Flow Summary

Flows along the slope and at the toe were determined using SEEP/W.

Total flow into the toe drain is the sum of flows into the sideslope and at the toe.

Stratum II Thickness	Constant Head Boundary Distance From Crest = 80 ft.			Constant Head Boundary Distance From Crest = 30 ft.		
	Along Slope	At Toe	Total Flow into Toe Drain	Along Slope	At Toe	Total Flow into Toe Drain
	Flow (ft^3/sec/ft)					
4 ft.	3.62E-08	1.50E-08	5.12E-08	5.65E-08	1.63E-08	7.28E-08
8 ft.	3.91E-08	2.37E-08	6.28E-08	6.11E-08	2.68E-08	8.78E-08

4.2 Pore-Water Pressures Along TRDF expansion floor



Maximum Pore Pressure = 109 psf

Off-Setting Ballast Pressure = 210 psf (2 ft of Protective Cover @ 105 pcf)

FS = 1.93 > 1.2 OKAY

5.0 CONCLUSION

The maximum calculated steady-state flow of groundwater occurs when when the constant head boundary is 30 ft from the crest of the excavation with an 8 ft thick Stratum II. The flow at the toe is 2.68 E-08 ft^3/sec/ft, along the ecavated slope is 6.11 E-08 ft^3/sec/ft, and the total maximum calculated steady-state flow into the toe drain is 8.78 E-08 ft^3/sec/ft.

The maximum pore-water pressure along the floor is 109 psf, occuring 46 ft horizontally away from the toe drain when assuming an 8 ft thick layer of Stratum II underlying the CCL. These pressures are believed to be conservative and can be offset over the short-term by the 2-ft thick protective cover layer with a factor of safety greater than 1.2 and later by overlying waste with a factor of safety greater than 1.5.

The average depth of Stratum II after excavation in Tract 1C Cell 1 is 3 ft with, on average, lower head values than those in Tract 5. Considering the similarity of material properties, Stratum II thickness, average head, and smaller size,Tract 1C Cell 1 pressures are expected to be less than those determined in the Tract 5 analysis.

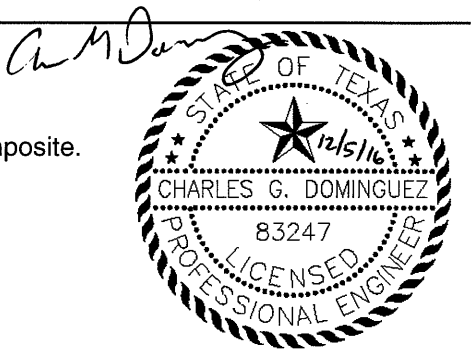
Based on the selected foundation soil parameters, cross-section geometry, and assumptions discussed above, the maximum calculated steady-state flow of groundwater into the underdrain geocomposite and the toe drain will not exceed the capacity of the system. The underdrain pipe sizing calculation is included in Appendix III-3F-3b and the underdrain geocomposite transmissivity calculation is included in Appendix III-3F-3c.

APPENDIX III-3F-3C

UNDERDRAIN GEOCOMPOSITE CALCULATION

UNDERDRAIN GEOCOMPOSITE CALCULATION

Made By: JBF
Checked by: MX
Reviewed by: CGD



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1.0 OBJECTIVE

Determine the required transmissivity of the sideslope underdrain geocomposite.

2.0 GIVEN

Maximum groundwater flow along entire sideslope = 6.11E-08 ft^3/sec per unit width (maximum total flow along slope - See Appendix III-3F-3a)

3.0 METHOD

Determine the required transmissivity of the sideslope underdrain geocomposite layer after applying reduction factors and a factor of safety.

$$\theta_{measured\text{-}req} = FS\Pi(RF)q_hL/(\sin\beta)$$ (Ref. 1)

$\theta_{measured\text{-}req}$ = required transmissivity of geosynthetic drainage layer measured in laboratory
Test Conditions: i = 0.33
Normal Stress = 10,000 psf
Boundary Cond'ns = steel plates
Test Time = 15 minutes
FS = factor of safety = 1.5 (short-term cond'ns)
RF = reduction factors (see below) -- (short-term cond'ns)
$\Pi(RF)$ = product of all reduction factors
q_h = rate of liquid supply per unit area ($m^3/s/m^2$ or m/s)
L = length of geocomposite in direction of flow (m)
q_hL = 6.11E-08 ft^3/sec (this value represents the total flow along the entire sideslop, which is computed in SEEP/W, IN App. III-3F-3a)
β = slope angle

Reduction Factor	Description	Value (Ref. 1)
RF_{in} =	Reduction Factor for intrusion of geotextile into geonet	1.2
RF_{cr} =	Reduction Factor for creep	1.0
RF_{cc} =	Reduction Factor for chemical clogging of geotextile and/or geonet	1.1
RF_{bc} =	Reduction Factor for biological clogging of geotextile and/or geonet	1.1
	$\Pi(RF)$ =	1.5

4.0 CALCULATION

I) Transmissivity for maximum flow

$$\theta_{measured\text{-}req} = 3.9E\text{-}07 \text{ ft}^3\text{/s-ft} = 3.6E\text{-}08 \text{ m}^3\text{/s-m}$$

II) Typical transmissivity values for double-sided 200-mil geonet geocomposites under low normal loads are in the 10^{-4} m^3/s-m range; roughly 3 orders of magnitude greater than required.

5.0 CONCLUSION

A standard 200-mil, double-sided geocomposite underdrain layer will have flow capacity adequate to prevent the development of hydrostatic pressure below the clay liner on the sideslopes.

6.0 REFERENCES

1. Giroud, J.P, Zornberg, J.G., and Zhao, A., "Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers", Geosynthetics International, Vol. 7, Nos. 4-6, 2000.

APPENDIX III-3F-4

BALLAST CALCULATIONS

BALLAST CALCULATIONS

Made By: AGM
Checked by: JBF
Reviewed by: CGD

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Professional Engineering Firm
Registration Number F-2578

INTENDED FOR PERMITTING PURPOSES ONLY

1.0 OBJECTIVE

Provide example ballast calculations in accordance with the section on Special Conditions-Excavations Below the Seasonal High Groundwater Table of the Liner Quality Control Plan (LQCP) for the Temple Recycling and Disposal Facility (TRDF). This LQCP incorporates methods that will be used to maintain the integrity of liner systems during construction below the seasonal high water table.

2.0 APPROACH

Example ballast thickness calculations have been performed per the outlined in the Ballast Thickness Calculations section of the LQCP. calculations have been performed for various points within worst-case conditions where the difference between the seasonal high potentiometric surface and the design basegrade is the greatest. The cells examined include Tract 5 Cell 5, Tract 5 Cell 7, Tract 5 Cell 9, Tract 5 Cell 11, Tract 5 Cell 17, and Tract 5 Cell 2. A total of six (6) points were selected for the calculation, as shown in Figures III-3F-7 through III-3F-9. All points are located along the toe of sideslopes where the ballast required to offset the hydrostatic pressure is the greatest.

Three figures are attached. All three figures contain the seasonal high potentiometric surface, existing monitoring wells, 2015 piezometers, and locations of the existing and proposed cells. Figure III-3F-7 presents the detailed locations of TRDF's existing and proposed cells, Figure III-3F-8 presents the entire facility's proposed final cover grades, and Figure III-3F-9 presents the TRDF expansion area excavation grades.

The factor of safety against hydrostatic uplift is defined as the sum of the resisting forces provided by the overlying materials including protective soil cover, solid waste, and final cover, divided by the hydrostatic uplift forces acting at the base of the geomembrane liner. As described in the LQCP, a factor of safety of 1.5 is required when waste is being applied as the ballast material.

3.0 CALCULATIONS

The points selected, as well as final cover and subgrade grades and seasonal high groundwater contours, are shown on Figures III-3F-7 through III-3F-9. Each ballast calculation point selected is labeled 'BC-#' in the figures. The calculations for Points BC-1 through BC-6 were performed per the methods outlined in the Ballast Thickness Calculations section of the LQCP, and the resulting factors of safety are presented in Table 1 below.

Table 1: Ballast Calculation

Point	Final Cover Elev	FC Thickness	FC Unit Weight	FC Offset Ballast	Waste Elev	Waste Thickness	Waste Unit Weight	Waste Offset Ballast	PC Elev	PC Thickness	PC Unit Weight	PC Offset Ballast	GW Elev[1]	GM Elev	Sum Ballast Offset	Hydrostatic Force	Factor of Safety
BC-1	605	3.0	115	311	602	69	44	2762	533	2.0	115	207	566	531	3279	2184	1.5
BC-2	607	3.0	115	311	604	74	44	2944	531	2.0	115	207	565	529	3462	2303	1.5
BC-3	613	3.0	115	311	610	85	44	3397	525	2.0	115	207	565	523	3915	2608	1.5
BC-4	648	3.0	115	311	645	109	44	4349	536	2.0	115	207	578	534	4866	2746	1.8
BC-5	608	3.0	115	311	605	70	44	2786	535	2.0	115	207	568	533	3304	2172	1.5
BC-6	617	3.0	115	311	614	75	44	2979	540	2.0	115	207	571	538	3496	2062	1.7

NOTES
[1] Based on Seasonal High Potentiometric Surface.
[2] Design elevations are approximate and should be confirmed during cell construction.

Table 2: Summary of of Ballast Calculation Results

Point	Long-Term Factor of Safety at Final Covered Condition	Thickness of Waste (ft) Required to Achieve FS = 1.5
BC-1	1.5	*
BC-2	1.5	*
BC-3	1.5	*
BC-4	1.8	97.9
BC-5	1.5	*
BC-6	1.7	72.2

* Final buildout waste thickness is required.

4.0 CONCLUSION

Review of the results indicates the ballasting is adequate for the proposed design.

APPENDIX III-3G-4

LEACHATE COLLECTION SYSTEM OVERLINER DRAINAGE LAYOUT

LEACHATE COLLECTION SYSTEM OVERLINER DRAINAGE LAYOUT

Made By: VK
Checked by: JBF / MX
Reviewed by: CGD

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1.0 OBJECTIVE

I) Determine the required transmissivity of the overliner drainage layer (double-sided geocomposite) based on critical case conditions.

II) Based on published data, determine the geocomposite drainage layer type that will meet the required transmissivity.

2.0 GIVEN

The critical case overliner slope is a composite slope consisting of the following : (i) a 15% slope of length (L_{up} - upstream) = 270 ft.

and (ii) a 33% slope of length (L_{down} - downstream) = 85 ft.

The permeability of the protective cover, K_{prot} = 1.0E-05 cm/s (same as HELP model)

3.0 METHOD

Determine the required transmissivity of the overliner drainage layer after applying reduction factors and a factor of safety.

$$\theta_{\text{measured -req, downstream}} = FS\Pi(RF)q_h(L_{up} + L_{down})/(\sin\beta_{down}) \text{ (Ref. 2)}$$

$$\theta_{\text{measured -req, upstream}} = FS\Pi(RF)q_h(L_{up})/(\sin\beta_{up}) \text{ (Ref. 2)}$$

$\theta_{\text{measured -req}}$ = required transmissivity of geocomposite drainage layer measured in laboratory
Test Conditions: i = 0.33
Normal Stress = 10,000 psf
Boundary Cond'ns = steel plates
Test Time = 15 minutes
FS = factor of safety (see Table 1)
RF = reduction factors (see Table 1)
$\Pi(RF)$ = product of all reduction factors
q_h = rate of liquid supply expressed per unit surface area measured horizontally.

L = length of geocomposite in direction of flow
β = slope angle

Based on the above equations and the given slopes of the upstream and downstream sections, the required transmissivity on the upstream slope will be higher. Hence, the upstream section represents the critical case.

The required transmissivity is calculated for the following conditions:

(i) exposed condition - consists of saturated protective cover overlying the drainage layer. Under this condition the gradient = 1.0 and q_h is equal to the hydraulic conductivity of the protective cover soil $q_h = 1.0 \times 10^{-5}$ cm/dec = 0.340 in/day.

(ii) open condition
(iii) intermediate condition
(iv) final condition prior to final cover placement
(v) final condition with final cover

} (Refer Appendix III-3E-1 for explanation of conditions ii-v)

4.0 CALCULATION

Table 1 Required Transmissivity for Overliner Upstream Slope Section (Critical Case)

Condition	q_h (in/day)(1)	θ_{design} (m^2/sec)	RF_{cr}	RF_{cc} (2)	RF_{bc} (2)	RF_{in} (2)	FS	$\theta_{required}$ (m^2/sec)
Exposed	0.340	5.5E-05	1	1	1.1	1.1	1.5	1.19E-04
Open	0.278	4.5E-05	1	1.2	1.1	1.1	2	1.82E-04
Intermediate	0.152	2.4E-05	2	1.7	1.3	1.1	3	2.67E-04
Final - no cover	0.053	8.5E-06	2	2	2	1.2	4	3.27E-04
Final	1.1E-04	1.8E-08	2	2	2	1.2	4	6.79E-07

(1) All values except the exposed condition (explained in Section 3.0) are obtained from Appendix III-3E-1
(2) Reduction factors are based on Ref. 1

I) The required transmissivity ($\theta_{required}$) (i.e. the transmissivity required during QC and conformance testing) was determined to be **3.7×10^{-4} m^2/sec.**

II) Typical transmissivity values for double-sided 200-mil geonet geocomposites are in the 10^{-4} m^2/sec range and are expected to meet the required transmissivity for the overliver system.

5.0 CONCLUSION

A standard 200-mil, double-sided geocomposite drainage layer will have flow capacity adequate to prevent the development of hydrostatic pressure below the protective cover on the overliner slopes. As per the Liner Quality Control Plan (Appendix III-3F), construction performance testing will be performed to verify that the geocomposite selected for construction has adequate transmissivity to meet the design requirement.

6.0 REFERENCES

1. Giroud, J.P, Zornberg, J.G., and Zhao, A., "Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers", Geosynthetics International, Vol. 7, Nos. 4-6, 2000.
2 Giroud, J.P, Zornberg, J.G., and Zhao, A., "Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers Comprising Two Different Slopes", Geosynthetics International, Vol. 7, Nos. 4-6, 2000.

APPENDIX III-3H

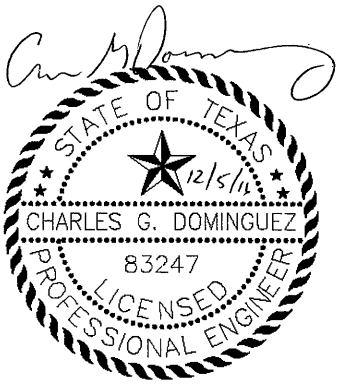
OVERLINER SYSTEM QUALITY CONTROL PLAN

PART III, ATTACHMENT 3, APPENDIX H
OVERLINER SYSTEM
QUALITY CONTROL PLAN

Temple Recycling & Disposal Facility

Temple, Bell County, Texas

TCEQ Permit MSW-692B



Owner/Site Operator/Permittee:

City of Temple
201 N. Main
Temple, Texas 76501

GOLDER ASSOCIATES INC.
Professional Engineering Firm
Registration Number F-2578

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Operator:

WASTE MANAGEMENT

Waste Management of Texas
9708 Giles Lane
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Submitted By:

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Submitted: June 2016
Revised: December 2016

Project No. 1400336

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1.0 PURPOSE

1.1 Purpose and Scope

This Overliner Quality Control Plan (OQCP) has been prepared in accordance with 30 TAC §330.339. This OQCP establishes the procedures for the construction, testing, and documentation of the liner and leachate collection system components of the overliner for Temple Recycling and Disposal Facility.

A copy of a current version of this OQCP must be maintained on-site at all times with the Site Operating Record. The OQCP shall be available for reference by the Texas Commission on Environmental Quality's (TCEQ's) inspector and construction and testing personnel. Revisions to this OQCP shall receive written approval from the TCEQ before implementation.

The proposed liner and leachate collection system for the overliner area consists of (from the bottom up):

- Geosynthetic clay liner (GCL)
- 60-mil linear low-density polyethylene (LLDPE) geomembrane liner, textured on both sides
- Double-sided geocomposite drainage layer
- 2-foot protective cover soil

1.2 General Responsibilities

The owner/operator is responsible for fully implementing this OQCP. The site manager (SM) or designated alternate shall be responsible for contracting a qualified Professional of Record (POR) prior to overliner liner and leachate collection system construction.

Each phase of the overliner system evaluation shall be conducted by or under the supervision of the POR. The POR shall be an independent third party professional engineer (PE) licensed in the State of Texas with experience in civil or geotechnical engineering and soils testing. A qualified construction quality assurance (CQA) monitor performing daily quality assurance/quality control (QA/QC) observation and testing shall be under the direct supervision of the POR. The POR or his/her qualified representative(s) shall provide full-time monitoring.

2.0 OVERLINER SYSTEM SUBGRADE PREPARATION

This section outlines the activities prior to placement of the overliner system, which will consist of preloading and subgrade preparation.

2.1 Preloading

In order to mitigate some of the effects of settlement within the underlying pre-Subtitle D waste, the area of the overliner will be preloaded with a minimum of 20 feet of soil. The fill will compress the upper portions of the existing waste and collapse near surface voids.

The preloading fill will consist of any soil material. The soil will be dumped and shaped with a dozer or other equipment. No compaction is necessary.

The site will record the location of the preload soil and confirm that it remains in place for at least 3 months. If desired, the preloading can be achieved with a "rolling stockpile," i.e., the preloading may be accomplished incrementally using the same soil. Once the preloading duration is reached, the material can be "rolled" to the adjacent section.

The POR will review the site records and confirm that the entire overliner area has been preloaded.

2.1.1 Overliner Subgrade Preparation

Following removal of the preloading soil, the subgrade surface for the overliner system shall be prepared to ensure a stable foundation. Upon achieving the design subgrade level, zones of soft or unsuitable soils and deleterious material shall be excavated and removed or covered with appropriate general fill. The POR shall determine sufficient stability.

The subgrade lines and grades shall be determined by survey methods prior to subsequent overliner construction.

3.0 GEOSYNTHETIC CLAY LINER EVALUATION

This section presents general procedures, quality control testing requirements, and installation procedures for geosynthetic clay liner (GCL) construction. The GCL approved for use at the site consists of sodium bentonite encapsulated between two geotextile layers, needle-punched or stitched-bonded together.

3.1 Pre-Installation Material Evaluation

3.1.1 Manufacturer's Quality Control Certificates

Prior to the installation of the GCL, the manufacturer or installer shall provide the POR with quality control certificates signed by a responsible party employed by the manufacturer. Each quality control certificate shall include roll identification numbers, testing procedures, and results of quality control tests. The quality control tests shall be performed in accordance with project-specific testing methods and subject to the minimum testing frequency shown in Table III-3H-1. The owner may require more frequent testing at his discretion.

The quality control testing may be performed in the manufacturing plant. The POR shall review the test results prior to accepting the GCL to ensure that the certified minimum properties meet the values presented in Table III-3H-1.

In addition to the manufacturer's quality control certificates, samples of rolls of GCL will be obtained for conformance testing. The samples shall be tested by an independent third party laboratory in accordance with Table III-3H-2.

The POR shall review the test results to ensure that they meet the values presented in Table III-3H-1. The POR shall compare measured shear strength values to those used in the stability analyses included in Appendix III-3G-5. If the measured interface shear strength is less than the values used in the analyses, the stability of the liner system shall be reassessed and revised calculations shall be included in the GCL Evaluation Report (GCLER).

In order to prevent premature hydration, the GCL rolls shall be shipped in plastic wrapping that shall remain intact until material installation. Upon delivery of the GCL, storage and handling procedures shall be documented. The rolls will be stacked, stored, and handled in accordance with ASTM D 5888 or manufacturer's recommendations.

Table III-3H-1: GCL QC Submittal Frequency & Material Specifications

Bentonite					
Property	**Qualifier**	**Unit**	**Value**	**Test Method[1]**	**Frequency**
Fluid Loss	max.	ml	18	ASTM D5891	1 per 50 tons or every truck or railcar
Free Swell	min.	ml	24	ASTM D5890	
Geotextile					
Property	**Qualifier**	**Unit**	**Value**	**Test Method[1]**	**Frequency**
Mass per Unit Area	—	g/cc	—	ASTM D5261	1 per 200,000 ft^2
Tensile Properties:	—	lb	—	ASTM D4632	
GCL Product					
Property	**Qualifier**	**Unit**	**Value**	**Test Method[1]**	**Frequency**
Bentonite Mass	min.	lb/ft^2	0.8	ASTM D5993	1 per 40,000 ft^2
Bentonite Moisture Content	—	%	—	ASTM D5993	
Grab Tensile Strength	—	lb	—	ASTM D6768	1 per 200,000 ft^2
Hydraulic Flux	max.	m^3/m^2-s	1 x 10^{-8}	ASTM D5887	1 per week for each production line[2]

Notes:
1. Updated methods may be implemented based on a review by the POR.
2. Report last 20 test values, ending on production date of supplied GCL.
3. For those properties that do not indicate a value, the GCL material must meet the manufacturer's minimum specification

Table III-3H-2: GCL Conformance Test Schedule

TEST	**METHOD[1]**	**FREQUENCY**
Bentonite Mass/Unit Area	ASTM D5993	Not less than 1 test per 100,000 ft^2
Hydraulic Flux	ASTM D5887	
Direct Shear[2][3][4]	ASTM D6243	1 test per GCL/adjoining material

Notes:
1. Updated methods may be implemented based on a review by the POR.
2. Direct shear testing shall be performed on the subgrade/GCL/geomembrane sandwich. Soak interface and apply normal stresses of 100, 200, and 400 psf for at least 1 hour prior to shearing at a displacement rate of 0.04 in/min.
3. The testing results shall be compared to the values used in the overliner system stability analyses included in the Appendix III-3G-5. If the measured interface shear strength is less than the values used in the analyses, the stability of the liner system shall be reassessed and revised calculations shall be included in the GCLER.
4. Test results from materials used during one construction event may be used in subsequent events provided the materials used are the same and approved by the POR.

3.2 Installation Procedures

3.2.1 GCL Subgrade Preparation

Surfaces to be lined should be smooth and free of all rocks greater than 0.75-inch diameter (or as recommended by the manufacturer, if less than 0.75 inches), sharp/angular objects, sticks, roots, or debris of any kind. The surface should provide a firm, unyielding foundation for the GCL with no sudden, sharp, or abrupt changes or break in grade. The subgrade surface shall be prepared by rolling with a smooth-drum roller to minimize the roughness and press down protruding soil or rock particles prior to GCL deployment. Loose rocks and/or dry soil particles that could damage the GCL shall be removed. Excessive voids or dimples shall be filled with soil.

Standing water or excessive moisture on the subgrade will not be allowed. The subgrade shall be maintained in a smooth, uniform, and drained condition.

3.2.2 Anchor Trench Construction

The anchor trench shall be constructed according to the project plans and specifications, and the excavation and backfilling operations shall be documented. If the anchor trench is excavated in a clay material susceptible to desiccation, the amount of anchor trench open at any time should be minimized. The inside edge of the trench shall be rounded so as to avoid stresses from sharp bends in the GCL. The GCL will not be placed into the anchor trench on top of any rocks greater than 0.75-inch diameter, sharp/angular objects, sticks, roots, or debris of any kind. The anchor trench shall be adequately drained to prevent ponding or hydration of the GCL while the trench is open. The anchor trench shall be backfilled and compacted according to the project plans and specifications; however, backfilling shall be performed, at a minimum, with ordinary compaction as deemed suitable by the POR.

3.2.3 GCL Deployment

Equipment used to deploy GCL must not cause excessive rutting of the subgrade. Deployed GCL panels should contain no folds or excessive slack. Installation personnel must not smoke or wear damaging shoes on GCL. GCL should not be placed during excessive winds. In general, only low ground pressure rubber-tired support equipment approved by the POR may be allowed on the GCL. If the POR observes any potential damage done to the liner by the support equipment, use of the equipment will cease and the damage will be repaired. Generators, gasoline or solvent cans, tools, or supplies must not be stored directly on the GCL.

Panels should be overlapped and seamed, as recommended by the manufacturer. End-to-end seams on sideslopes should be kept to a minimum. If end-to-end seams are necessary (i.e., if the GCL roll lengths are insufficient to cover the entire slope length), a minimum overlap of 5 feet will be required. Alternatively, seams may be glued, as recommended by the manufacturer. In addition, end-to-end seams may be placed only in the lower half of the slope and must be staggered.

GCL deployment shall be limited to the amount that can be covered with the overlying geomembrane liner the same day. GCL deployment shall not be undertaken during precipitation or when there is an impending threat of precipitation.

Following deployment, the CQA monitor shall visually examine the entire surface of the GCL for even bentonite distribution, thin spots, or other panel defects. All defects will be recorded and repaired in accordance with this OQCP. The QA/QC representative shall also verify the following:

- Proper overlap during deployment
- Seams between GCL panels are constructed per manufacturer's recommendations
- Defects are patched and overlapped properly
- The bentonite has not become excessively hydrated

Excessively hydrated GCL shall be removed and replaced with new material. Geomembrane shall not be placed on hydrated GCL.

GCL panels shall be given an identification code, mapped, and logged to record relevant installation information.

3.2.4 GCL Repairs

Torn or otherwise damaged geosynthetic facing must be patched with the same type of geosynthetic. The geosynthetic patch must extend at least 12 inches beyond the damaged area and must be heat bonded, or otherwise attached to the main GCL to avoid shifting during placement of overlying geosynthetics. If the GCL damage includes loss of bentonite, the patch must consist of full GCL extending at least 12 inches beyond the damaged area. Lapping procedures must be the same as specified for original laps of GCL panels.

3.2.5 GCL Protection

The overlying geosynthetics and soil layers shall be deployed in such a manner as to ensure that the GCL is not damaged. Textured geomembranes shall not be dragged across previously installed GCL. A smooth rubsheet shall be placed between the GCL and textured geomembrane to prevent damage. The rubsheet will be removed when the geomembrane is in position. Other methods may be employed at the POR's discretion.

To avoid local bentonite displacement, and the possible impact on the hydraulic performance of a GCL, the protective cover soil of suitable thickness should be placed over the geomembrane and geocomposite overlying the GCL as soon as practicable following completion of the geomembrane and leachate collection system construction.

4.0 GEOMEMBRANE LINER EVALUATION

This section presents general procedures, quality control testing requirements, and construction specifications for geomembrane liner construction. Unless otherwise designed, the composite liner system will generally include the following components above the geosynthetic clay liner:

The proposed liner and leachate collection system for the overliner area consists of, from top to bottom:

- 60-mil linear low-density polyethylene (LLDPE) geomembrane liner, textured on both sides
- A geocomposite drainage layer composed of a geonet and filter geotextiles heat-bonded to both sides
- 2-foot protective cover soil

The geomembrane and the geocomposite drainage layer may be replaced with an alternate material that incorporates both components (e.g., Super Gripnet® by Agru America) provided material equivalency in terms of barrier and flow characteristic is demonstrated.

4.1 Pre-installation Material Evaluation

4.1.1 Manufacturer's Quality Control Certificates

Prior to the installation of any geomembrane, the manufacturer or installer shall provide the POR with quality control certificates signed by a responsible party employed by the manufacturer. Each quality control certificate shall include roll identification numbers, testing procedures, and results of quality control tests. The quality control tests shall be performed in the manufacturing plant using the test methods and frequencies listed in the most recent version of the Geosynthetic Research Institute (GRI) test method GM17. The owner may require more frequent testing at his/her discretion.

The POR shall review the test results prior to accepting the geomembrane to assure that the certified minimum properties meet the minimum values for smooth and textured geomembranes as determined by the most recent GRI test method GM17, "Test Methods, Test Properties and Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes," included in Appendix III-3H-1. The owner may require more frequent testing at his/her discretion.

The rolls delivered to the site shall be inventoried, recording the manufacturer's name and product identification, and the roll thickness, number, and dimensions. Manufacturer's certificates should be cross-referenced to rolls delivered on-site.

Resumes of the installer's supervisor(s) or Master Seamer(s) shall be obtained to verify that adequate seaming experience will be utilized on the project. The installer's supervisor or Master Seamer shall have had experience totaling a minimum of 2,000,000 square feet of geomembrane installation.

Upon delivery of geosynthetic materials, storage and handling procedures shall also be documented. Rolls of geosynthetic materials shall be handled and stored in such a way as not to damage the material. As a general rule, rolls of geosynthetic materials should not be stacked more than four rolls high.

In addition to the manufacturer's quality control certificates, samples of the geomembrane will be obtained either at the manufacturing facility or upon delivery to the site for conformance testing. The test samples shall be obtained for conformance testing in accordance with the testing schedule shown in Table III-3H-3.

Table III-3H-3: Geomembrane Conformance Test Schedule

TEST	METHOD[1]	FREQUENCY
Thickness (laboratory measurement)	ASTM D5994 (Textured)	Not less than 1 test per 100,000 ft^2 with not less than one per resin lot
Density	ASTM D1505 or D792	
Carbon black content[2]	ASTM D4218	
Carbon black dispersion	ASTM D5596	
Tensile properties	ASTM D6693, Type IV	

Notes:
1. Updated ASTM or GRI methods may be implemented based on a review by the POR.
2. Other methods such as D1603 (tube furnace) or D6370 (TGA) are acceptable if an appropriate correlation to D4218 (muffle furnace) can be established.

4.2 Installation Procedures

4.2.1 Geomembrane Deployment

The geomembrane shall be installed in direct and uniform contact with the GCL. The geomembrane shall not be placed during inclement weather such as high winds or rain.

Geomembrane seaming should generally not take place when ambient temperatures are below 32 degrees Fahrenheit (°F), unless preheating is used. For extrusion welding, preheating will be required if the temperature is below 32°F. For fusion welding, preheating may be waived if the installer demonstrates that quality welds may be obtained without preheating. Seaming shall not be permitted at ambient temperatures above 104°F, unless the installer can demonstrate that seam quality is not compromised.

In general, only low ground pressure rubber-tired support equipment approved by the POR may be allowed on the geomembrane. If the POR observes any potential damage done to the liner by the support equipment, use of the equipment will cease and the damage will be repaired. Personnel working on the geomembrane shall not smoke, wear damaging shoes, or engage in any other activity likely to damage the geomembrane. Only those sections that are to be placed and seamed in one day should be unrolled. Panels left unseamed should be anchored with sandbags or other suitable weights. In general, seams should be oriented parallel to the line of maximum slope (i.e., oriented up and down, not across the slope). In corners and odd-shaped geometric locations, the number of field seams should be minimized.

Panels should be overlapped as recommended by the manufacturer as appropriate for the type of seam welding to be performed; however, overlapping shall be no less than 2 inches. Field seaming shall only be performed by the method or methods approved by the manufacturer, either by extrusion welding or double-tracked fusion welding. No seaming shall take place without the installer's supervisor or Master Seamer and CQA monitor being present. Fishmouths or wrinkles at the seam overlap shall be cut along the ridge of the wrinkle in order to achieve a flat overlap. The cut shall be seamed and/or patched. Seams shall extend to the outside edge of panels placed in the anchor trench.

Panel layout and field seams shall be given an identification code, mapped, and logged to record relevant installation information. Inspection and testing records shall be logged as well as repair and retest data.

4.3 Installation Monitoring and Testing

4.3.1 Trial Seams

Each day prior to commencing field seaming, trial seams shall be made on pieces of geomembrane material to verify that conditions are adequate for production seaming. Trial seams shall be made at the beginning of each seaming period and shift (generally, at least twice each day) for each combination of production seaming machine and operator to be used that day. The trial test seam shall be at least 3 feet long by 1 foot wide (after seaming) with the seam centered lengthwise. Four 1-inch wide specimens shall be die-cut from the trial seam sample. Two specimens shall be tested in the field for shear and two for peel (test both inner and outer welds for dual track fusion welding) and shall be compared to the minimum seam strength requirements specified in the most current version of the GRI Test Method GM19. The current versions of the GRI test methods are included in Appendix III-3H-1.

If any of the trial seam specimens fail, the entire trial seam operation shall be repeated. If an additional specimen fails during the second trial seam, the seaming machine and seamer shall not be used for seaming until the deficiencies are corrected and two consecutive successful trial seams are achieved. Additional trial seams shall be made at each occurrence of significantly different environmental conditions, including, but not limited to, temperature, humidity, and dust, and after any machine is turned off for more than 30 minutes.

4.3.2 Non-Destructive Testing

Continuous, non-destructive testing shall be performed on all seams by the installer. All leaks must be isolated and repaired by following the procedures described in this OQCP.

> Air Pressure Testing – ASTM D5820. The ends of the air channel of the dual-track fusion weld must be sealed and pressured to approximately 30 pounds per square inch (psi), if possible. The air pump must then be shut off and the air pressure observed after 2 minutes. A loss of less than 3 psi is acceptable if it is determined that the air channel is not blocked between the sealed ends. A loss greater or equal to 3 psi indicates the presence of a seam leak that must

then be isolated and repaired by following the procedures described in this OQCP. The POR or his/her qualified representative must observe and record all pressure gauge readings.

Vacuum-Box Testing – ASTM D5641. Apply a vacuum of approximately 4 to 8 psi to all extrusion welded seams that can be tested in this manner. The seam must be observed for leaks for at least 10 seconds while subjected to this vacuum. The POR or his/her qualified representative must observe 100 percent of this testing.

Other Testing. Other non-destructive testing must have prior written approval from the TCEQ.

4.3.3 Destructive Seam Testing

Destructive samples shall be taken at a minimum frequency of one test location, selected randomly, within each 500 linear feet of seam length, inclusive of both primary longitudinal and cross seams, cap strips, and repairs 20 square feet or larger. Each test sample should be of sufficient length and 12 inches wide with the seam located in the middle. Test specimens, approximately 1 inch wide, shall be cut from both ends of the sample for field testing (peel and shear). The remaining sample should be cut into three parts (one for quality assurance laboratory testing, one for installer quality control laboratory testing, and one for archive storage to be maintained at a location selected by the owner).

The field tests shall be conducted on a certified calibrated tensiometer capable of maintaining a constant extension rate of 2 inches per minute. If one of the field test specimens from the ends of the destructive sample fails, then the seam will be considered to have failed, and repairs shall be initiated as described below. If both specimens pass, then a sample for laboratory testing will be sent to the quality assurance laboratory for testing in both peel and shear. Seam strengths for linear low-density polyethylene (LLDPE) geomembranes shall meet the minimum values specified the most current version of the GRI Test Method GM19 (included in Appendix III-3H-1).

Destructive test results for both field and laboratory tests shall include qualitative data, including the location of the failure and locus-of-break code, as described in ASTM D6392. Peel tests on double-tracked fusion welds shall be performed on both inside and outside tracks of the weld. Seam break classifications for extrusion and fusion welds are shown on Figures III-3H-1 and III-3H-2, respectively.

At a minimum, a destructive test must be done for each welding machine used for seaming or repairs. A sufficient amount of the seam must be removed to conduct field testing, independent laboratory testing, and archiving of enough material to retest the seam when necessary. Destructive seam testing locations shall be cap-stripped and the cap completely seamed by extrusion welding to the geomembrane. Capped sections shall be non-destructively tested. Additional destructive test samples may be taken if deemed necessary by the POR or his/her qualified representative.

Weld Acceptance Criteria: For LLDPE seams (both smooth and textured), the minimum passing criteria for destructive seam testing are described in the GRI Test Method GM19. The POR must use the most current version of GM19 when evaluating welded seams.

Seam Failure Delineation: When a sample fails a destructive test, the installer shall trace the welding path to an intermediate location at least 10 feet in each direction, or a distance determined by the POR, from the point of the failed test and take 1-inch wide specimens for an additional set of field tests. If these additional samples pass the tests, then two laboratory destructive samples shall be taken adjacent to the intermediate locations or at locations determined by the POR or his/her representative. If these laboratory samples pass the tests, then the seam shall be repaired between these locations. If either sample fails, then the process shall be repeated to establish a zone where the seam should be repaired. All acceptable repaired seams shall be bounded by two locations from which samples passing laboratory destructive tests have been taken.

Seam Failure Repairs: Any portion of the geomembrane exhibiting a flaw or failing a destructive or non-destructive test shall be repaired. Repair methods may include spot welding (extrusion) for minor flaws and punctures; patches for larger holes and tears; capping for large lengths of failed seams or panel damage; and extrusion welding of outer flap to repair an inadequate fusion seam (less than 100-feet cumulative length) that has an exposed edge.

For any repair method, the following provision shall be satisfied:

- Surfaces of the geomembrane that are to be repaired using extrusion methods shall be ground no more than one hour prior to the repair
- All surfaces shall be clean and dry at the time of repair
- Patches or caps shall extend at least 6 inches beyond the edge of the defect, and all corners of patches shall be rounded with a radius of approximately 3 inches
- All repairs shall be non-destructively tested, as previously described
- All seaming equipment, personnel, and operation procedures used in repair work shall meet the same requirements as for new seaming operations

The POR or his/her qualified representative shall observe all non-destructive testing of repairs and shall record the number of each repair, type, date, and test outcome. Repairs that pass the non-destructive tests shall be taken as an indication of an adequate repair. Repairs more than 150 feet long shall also be required to have a destructive test performed. Repairs that fail the initial retest shall be redone and retested until a passing test results. All work and testing of repairs shall be fully documented in a repair log.

When placing overlying material on the geomembrane, effort must be made to minimize wrinkle development. If possible, cover should be placed during the coolest weather available. Small wrinkles should be isolated and covered as quickly as possible to prevent their growth. In no case shall the geomembrane be allowed to fold over on itself.

5.0 LEACHATE COLLECTION SYSTEM

5.1 Leachate Collection System and Drainage Materials

The overliner leachate collection and associated leachate removal systems will be constructed of materials that are chemically resistant to the leachate expected to be generated; of sufficient strength and thickness to prevent collapse under the pressures exerted by overlying wastes, waste cover materials, and by any equipment used at the landfill; and designed and operated to function through the scheduled closure and post-closure period of the landfill.

The overliner leachate collection trenches shall be constructed in conjunction with liner construction. All GCL and geomembrane testing shall be completed prior to installing the leachate collection system on the area under evaluation. The locations of the trenches and design details are shown in Attachment 3, Waste Management Unit Design, Figures III-3-7 and III-3-8. The installation of the leachate collection system and protective cover system will have continuous inspection by the POR or his/her qualified representative(s). Quality assurance monitoring shall consist of measuring the dimensions of the excavated trenches, and documenting that the pipe, geotextile filters, bedding materials, and drainage layers have been placed in accordance with the design details. All data and observations regarding construction of the leachate collection system shall be documented in the Geomembrane Liner Evaluation Report (GLER).

Materials selected for use in the leachate collection system and drainage layers shall be verified by the POR to comply with this OQCP. Granular materials for drainage media shall be tested or otherwise certified at appropriate frequencies for conformance to gradation and permeability requirements specified in the design.

5.1.1 Geocomposite Drainage Layer

Geosynthetic drainage layers shall conform to the material and performance properties specified in Table III-3H-4. Manufacturers' certificates of material and performance characteristics shall be obtained and documented at the minimum frequency shown on Table III-3H-4, with no less than one per resin lot. Geosynthetic drainage layer conformance testing will consist of transmissivity testing on each material type using the test set-up described in Table III-3H-4.

The drainage layer for the overliner leachate collection system will consist of a geonet with a non-woven geotextile heat-bonded to both sides. The geosynthetic drainage layer shall be anchored in an anchor trench.

Geotextile panels placed in the leachate collection system shall be overlapped and either heat-bonded or field sewn. Only low ground pressure rubber-tired support equipment approved by the POR may be allowed on the geotextile. Personnel working on the geotextile shall not smoke, wear damaging shoes, or engage in any activity that damages the geotextile or underlying geosynthetics.

Table III-3H-4: Overliner Geosynthetic Drainage Layer Specifications(1)

GEOCOMPOSITE					
Property	**Qualifier**	**Unit**	**Value**	**Test Method**	**Frequency**
Transmissivity	Min.	m^2/sec	6.1×10^{-5}	ASTM D4716(2)	200,000 ft^2
Ply Adhesion	Min.	lb/in	0.5	ASTM D7005	200,000 ft^2
GEONET CORE					
Property	**Qualifier**	**Unit**	**Value**	**Test Method**	**Frequency**
Thickness	Min.	mils	200	ASTM D5199	200,000 ft^2
Density (black resin)	Min.	g/cm^3	0.940	ASTM D1505	200,000 ft^2
Carbon Black Content	Range	%	2 to 3	ASTM D4218	200,000 ft^2
GEOTEXTILE					
Property	**Qualifier**	**Unit**	**Value**	**Test Method**	**Frequency**
Mass per Unit Area	MARV	oz/yd^2	6	ASTM D5261	200,000 ft^2
AOS		US Sieve (mm)	70 (0.210)	ASTM D4751	540,000 ft^2

Notes:
(1) See Appendix III-3G-4 for design calculations for the overliner geocomposite. These calculations shall be referenced to determine the suitability of the alternate materials.
(2) Transmissivity shall be measured at a minimum gradient of 0.33 under a minimum normal pressure of 10,000 psf with a minimum seating period of 1 hour.

5.1.2 Filter Geotextile

The leachate drainage material that is placed in the collection trenches shall be wrapped in a geotextile filter fabric. The geotextile shall have the minimum properties listed in Table III-3H-5.

Table III-3H-5: Non-woven Filter Geotextile Specifications

Property	**Qualifier**	**Unit**	**Value**	**Test Method**	**Frequency**
Mass per Unit Area	MARV	oz/yd^2	7.5	ASTM D5261	100,000 ft^2
AOS		US Sieve (mm)	80 (0.15)	ASTM D4751	550,000 ft^2
Puncture Resistance		lb	550	ASTM D6241	550,000 ft^2
Grab Tensile Strength		lb	205	ASTM D4632	100,000 ft^2

5.1.3 Leachate Pipe

The leachate piping includes perforated collection trench pipes. The leachate piping shall have the minimum SDR rating and perforation schedule shown on the plans and specifications.

5.1.4 Drainage Material

Granular drainage materials shall be selected to meet the performance requirements specified in the Site Development Plan (SDP). At least one set of pre-construction tests shall be conducted for each drainage medium from each proposed source. Pre-construction tests shall include a complete grain-size analysis, including minus No. 200 Sieve (ASTM D422), and calcium carbonate content (ASTM D3042 modified to use hydrochloric acid with a pH of 5 or the J&L method). The grain-size analysis will be used to determine if the material is compatible with the perforations in the leachate collection pipes and if the material is expected to achieve a minimum permeability of 1×10^{-2} cm/sec. The measured calcium carbonate content must not exceed 15 percent.

Granular drainage materials selected for use shall be tested at regular intervals for conformance during construction. Minimum testing frequency shall include one grain-size analysis for every 3,000 cubic yards, or portion thereof, for each material being used.

Prior to the beginning of construction activities, the POR shall conduct confirmatory testing of geosynthetic materials to be used in the leachate collection system to ensure that the strengths of materials assumed in the stability calculations presented in Appendix III-3G-5 are available. Test results from materials used during one construction event may be used in subsequent events provided the materials used are the same and approved by the POR.

5.2 Protective Cover Material

Protective cover materials shall be free of deleterious materials that could puncture the synthetic lining system. The protective cover material shall be selected and placed so as not to harm the geomembrane or other geosynthetic layers. The installation of the leachate collection system and protective cover system will have continuous inspection by the POR or his/her qualified representative(s).

Visual observations shall be made to verify that no deleterious materials are present in the protective cover that could damage the lining and leachate collection systems or impede their performance as designed.

Alternate protective cover material, such as shredded tire chips, may only be used when overlying a protective layer of sufficient puncture resistance to prevent penetration of steel belting fragments or other deleterious materials through the geosynthetic drainage layers or geomembrane. Prior to using an alternate protective cover material, written approval will be obtained from the TCEQ.

Protective cover does not require compaction control; however, it should be stable for construction and disposal traffic. Care shall be exercised in placement so as not to shift, wrinkle, or damage the underlying geosynthetic layers, and the placement methods shall be documented. Protective cover placement should be conducted at the coolest part of the day to minimize the development of wrinkles in the geosynthetic materials.

The protective cover shall be placed such that the top surface, while spreading, is at least 2 feet above the geosynthetic layers at all times unless low ground pressure dozers are used (i.e., track pressure less than 5 psi). A greater thickness shall be maintained to support loaded hauling trucks and trailers and for turning areas. Drivers shall proceed with caution when on the overlying soil and prevent spinning tires, quick stops, or sharp turns.

The final thickness of the protective cover shall be a minimum 24 inches above a geosynthetic drainage layer. The required thickness of protective cover shall be verified by survey methods on an established grid system with not less than one verification point per 5,000 square feet of surface area.

6.0 MARKING AND IDENTIFYING EVALUATED AREAS

In accordance with 30 TAC §330.143(b)(1) and (6), markers shall be placed so that all areas for which GCLER and GLER have been submitted and approved by the TCEQ are readily identifiable. Such markers are to provide site workers with immediate knowledge of the extent of approved disposal areas and shall be placed in accordance with the Site Operating Plan.

Markers shall be metal, wooden, or recycled posts and shall extend at least 6 feet above ground level. Limits of the evaluated area shall be referenced to the site grid system. Markers shall not be placed inside the evaluated area. Markers shall be color coded in accordance with 30 TAC §330.143(b)(1). GCLER and GLER markers shall be red in color.

Since the overliner system is located entirely within waste footprint, the markers within the area will not be permanent.

7.0 DOCUMENTATION AND REPORTING

7.1 Liner Evaluation Reports

Upon completion of all required liner construction and evaluation, the POR shall prepare and submit the GCLER and the GLER to the TCEQ for review and approval. Multiple submittals of the reports or documentation during the project may be made, if they may facilitate TCEQ's review of the project.

The GCLER and the GLER shall be signed and sealed by the POR performing the evaluation and counter-signed by the site operator or his/her authorized representative. The overliner area covered by this OQCP shall not be used for the receipt of solid waste until written acceptance of the GCLER or GLER document(s) is received from the TCEQ. If no response, either written or verbal, is received within 14 days, the GCLER or GLER shall be considered accepted and the owner or operator may continue facility construction or operations.

The construction documentation provided in the GCLER or GLER will contain a narrative describing the conduct of work and testing programs required by the OQCP, "as-built" or record drawings, and appendices of field and laboratory data. Because the volume of data for these projects can be quite large, the documents may be divided for ease of review. The preferred document format for larger reports will include the GCLER, its narrative, as-built drawings, and summaries of test results in a single volume; the GLER, its narrative, as-built drawings, and summaries of test results in a second volume, and the supporting appendices placed in separate accompanying volumes, as needed.

The construction documentation report will contain or discuss the following information at a minimum:

For GCLs:

- Roll shipment and receipt information
- Manufacturer's quality control certificates and results
- Storage and handling information
- Conformance test sampling and test results
- Subgrade acceptance
- Anchor trench preparation and backfilling
- Panel deployment, identification, and placement
- Equipment placed or operated on GCL
- 100 percent visual inspection for defects, damage, etc.
- Seaming methods
- Repairs, including patch size and shape

For geomembrane liners:

- Roll shipment and receipt information
- Manufacturer's quality control certificates and results
- Storage and handling information
- Conformance test sampling and test results
- Seamer's names and resumes of experience and qualifications
- Subgrade acceptance
- Anchor trench preparation and backfilling
- Panel deployment, identification, and placement
- Seam preparation, orientation, and identification
- Equipment placed or operated on geomembrane
- 100 percent visual inspection for defects, damage, etc.
- Trial seam tests for each combination of seaming equipment and personnel
- Seaming methods, times, temperature, and equipment shutdowns and startups
- Continuous 100 percent non-destructive seam testing, methods, criteria, and results
- Destructive testing methods, criteria, and results
- Repairs, including preparation and procedures, failure delineation, patch size and shape, and retesting
- Material properties and placement of drainage materials and protective cover
- Confirmation of the interface friction angle for the geomembrane/adjoin material interface and a recalculation of the factor of safety, if needed.

The report shall also include pertinent record drawings including:

- Phase layout plan
- Location of the subject cell with GCLER/GLER markers
- Previous filled and active areas
- As-built GCL panel layout drawings, showing locations of patches and repairs
- As-built geomembrane panel layout drawings, showing location of destructive test samples, patches, and repairs
- As-built drawings showing elevations of protective cover to confirm its thickness

7.2 Interim Status Report

An Interim Status Report (ISR) should be provided to the TCEQ for portions of a liner system that remain uncovered with waste for more than six months from the date that the protective cover was applied, and the area shall be reevaluated by a POR.