Appendix I

Geotechnical Evaluation

March 5, 2021
File No. 25220091.00

TECHNICAL MEMORANDUM

ANALYZED BY: Keith Gilkey, PE
Deb Nelson, PE

REVIEWED BY: Phil Gearing, PE
Betsy Powers, PE

SUBJECT: Pipe Settlement Calculations
Eastern Vertical Expansion
Dane County Landfill Site No. 2

PURPOSE

Calculate soil settlement below the landfill Eastern Vertical Expansion area leachate collection lines. The proposed vertical expansion peak final grades above the existing leachate collection lines are present in Phase 10 (proposed final grade of approximate elevation 1026.5 feet above mean sea level (amsl)) and in Phase 4 (proposed final grade of approximate elevation 1065 feet amsl).

CONCLUSION

The pipe settlement calculation results confirm that the leachate collection lines below the Eastern Vertical Expansion will maintain a minimum of 0.5% slope across the landfill.

APPROACH

SCS Engineers (SCS) calculated soil settlement below the pipes for the clay liner, native clay and sand layers above bedrock. Clay liner and native clay settlement was calculated for both primary consolidation and secondary compression.

To meet code requirements for leachate collection lines with lengths greater than 1,200 feet, the settlement was calculated for 100% of primary consolidation and secondary compression for a period extending 100 years after closure of the landfill. The consolidation parameter values for the calculations were obtained from laboratory consolidation testing of clay samples collected from soil borings as part of the 2013 Feasibility Report. The UniSettle settlement calculation software used by SCS does not calculate consolidation settlement beyond 90% of primary consolidation. To estimate settlement at 100% of primary consolidation of the clays, SCS added 10% of the calculated settlement at 90% consolidation to the total settlement calculated by the software.

Immediate settlement calculated for the sand layers was added to the soil settlement total calculated at the leachate collection line locations. Standard Penetration Test blow counts (N values) for the sands as shown on the boring logs were used to calculate the elastic modulus E values for the sand layers that were used for the immediate settlement calculations.

RESULTS

The SCS calculations show maximum pipe settlements of approximately 28 inches for the Phase 4 pipe and 29 inches for the Phase 10 pipe due to the proposed final grades for the Eastern Vertical Expansion. Using a conservative assumption of no settlement of the pipes at the toe of the landfill perimeter berms, the final pipe slopes are calculated to be a minimum of 0.71% for Phase 4 and 0.51% for Phase 10. The leachate collection pipes will maintain a minimum pipe slope of 0.5%.

REFERENCES

1. SCS Engineers, 2021, Proposed Final Grades, Feasibility Report, Eastern Vertical Expansion.
2. TRC, 2014, Settlement Calculations, Eastern Expansion Plan of Operation, Appendix D.
3. TRC, 2014, Base Grades, Eastern Expansion Plan of Operation.
4. TRC, 2013, Geologic Cross Sections, Feasibility Report, Eastern Expansion.
5. TRC, 2013, boring logs M13B and B304B, Feasibility Report, Eastern Expansion.
6. UniSoft, LTD, UniSettle 4.0, settlement analysis software.

ASSUMPTIONS

- Based on the proposed Eastern Vertical Expansion final grades, the peak waste load will be present for the Phase 10 leachate collection line with an approximate base grade of elevation 875 feet amsl. Peak waste load for the Phase 4 leachate collection line will be present where the approximate base grade is elevation 883 feet amsl.
- The native soil profile below the Phase 10 leachate collection line is based on the boring log for B304B. The native soil profile below the Phase 4 leachate collection line is based on the boring log for M13B. The soil below the ends of the borings is assumed to be sand. The sand between the end of boring and a depth of 75 feet is assumed to have an N-value of 100 blows per foot. Below a depth of 75 feet, the sand is assumed to have an elastic modulus E of 2,000 kips per square foot (ksf) down to bedrock near elevation 730 feet amsl.
- Based on the 2013 Eastern Expansion Feasibility Report, the groundwater depth is approximately 12 feet below the Phase 10 leachate collection line and approximately 18 feet below the Phase 4 leachate collection line.
- Using the soil layers and the soil and waste unit weight values in the 2014 Eastern Expansion Plan of Operation calculation, the Eastern Vertical Expansion peak fill loads above the pipes are approximately 16.425 ksf in Phase 4 and 13.86 ksf in Phase 10.
- The load on the pipes from the Eastern Vertical Expansion was modeled by SCS as a triangle load as shown in the attached figure. The Boussinesq method was used to distribute the load with depth within the soil layers below the pipes.
- Based on the clay consolidation test results summarized in the 2014 Eastern Expansion Plan of Operation calculations, a conservative overconsolidation ratio of 2 was used to calculate the clay layer preconsolidation pressures used in the consolidation settlement calculations.
- Single direction drainage will occur for the clay liner due to the presence of the geomembrane liner over the clay. Double direction drainage will occur for the clay layer between the sand layers observed in the soil boring.

Attachments: Leachate Pipe Settlement Summary Tables

Location of Settlement Calculation Figure

Elastic Modulus E Calculations

UniSettle Input/Output for Phase 4 Pipe

UniSettle Input/Output for Phase 10 Pipe

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Leachate Pipe Settlement Summary
Dane County Landfill No. 2 (Rodefeld) Eastern Vertical Expansion

Phase 10 Base Grades as Designed

Pipe Invert Elevation of North Toe of Slope	Pipe Invert Elevation of Location of Peak Fill over	Distance between Points (feet)	Slope of Pipe
868.84	875.48	830	0.80%

Phase 10 Base Grades after Settlement

Pipe Invert Elevation of North Toe of Slope	Pipe Invert Settlement at Peak of Waste Location (inch)	Elevation of Location of Peak Fill over Pipe after Settlement	Distance between Points (feet)	Slope of Pipe After Settlement
868.84	28.6 *	873.10	830	0.51%

Note: Assumes no settlement of leachate pipe at north toe of slope.
* Total Settlement was calculated by adding 10% of the consolidation of the clay layers to the total settlement calculated by the Uni-Settle program: 28.6 inches total settlement = 0 .10 x (7.385 inch + 1.425 inch) + 27.664 inch

Phase 4 Base Grades as Designed

Pipe Invert Elevation of North Toe of Slope	Pipe Invert Elevation of Location of Peak Fill over	Distance between Points (feet)	Slope of Pipe
875.2	883.2	800	1.00%

Phase 4 Base Grades after Settlement

Pipe Invert Elevation of North Toe of Slope	Pipe Invert Settlement at Peak of Waste Location (inch)	Elevation of Location of Peak Fill over Pipe after Settlement	Distance between Points (feet)	Slope of Pipe After Settlement
875.2	27.7 *	880.89	800	0.71%

Note: Assumes no settlement of leachate pipe at north toe of slope.
* Total Settlement was calculated by adding 10% of the consolidation of the clay layer to the total settlement calculated by the Uni-Settle program: 27.7 inches total settlement = 0.10 x (9.139 inch) + 26.782 inch

KRG/DLN
3/5/2021
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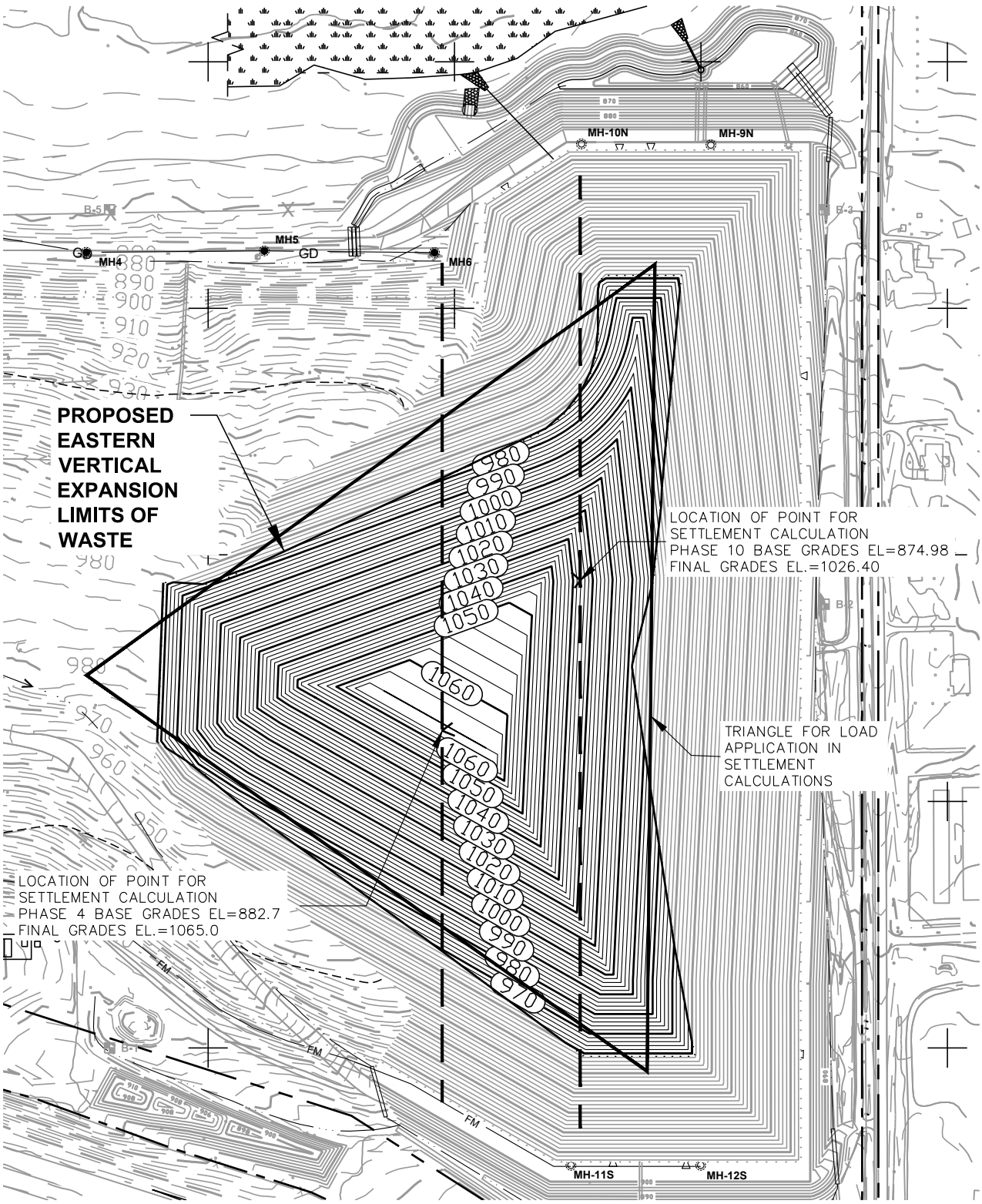

CLIENT	DANE COUNTY DEPARTMENT OF WASTE AND RENEWABLES 1919 ALLIANT ENERGY CENTER WAY MADISON, WI 53713	SITE	DANE COUNTY LANDFILL NO. 2 7102 US HWY 12/18 MADISON, WISCONSIN	LOCATION OF SETTLEMENT CALCULATION	
PROJECT NO.	25220091.00	DRAWN BY:	KRG	ENGINEER	SCS ENGINEERS 2830 DAIRY DRIVE MADISON, WI 53718-6751 PHONE: (608) 224-2830
DRAWN:	02/02/21	CHECKED BY:	DN		FIGURE 1-1
REVISED:	02/02/21	APPROVED BY:	BLP 05/14/2021		

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Modulus of Elasticity Estimate

$E_s = B_0 \times (OCR)^{1/2} + (B_1 \times N)$

Equation 7.17 from Foundation Design by D. P. Coduto

E_s = equilivent modulus of elasticity

B_0, B_1 = correlation factor from Coduto Table 7.4

OCR = overconsolidation ratio = 1.0 (for sands)

Phase 10

Boring B-304B **Top of Boring EL = 882.5** **Base Grades EL=875.0**

Soil	Depth on Boring Log (ft)	Elevation	B_0 (lb/ft^2)	B_1 (lb/ft^2)	Average N	E_s (lb/ft^2)	Notes
Silty Sand with Gravel (SM)	11 - 28	871 - 854	50,000	12,000	48.7	634,000	
Well Graded Sand (SW)	28 - 58	854 - 824	100,000	24,000	27.4	757,600	
Silty Clay (CL-ML)	58 - 61	824 - 821					
Well Graded Sand with Gravel (SW)	61 - 64	821 - 818	100,000	24,000	27.4	757,600	EOB at 64'
Sand (assumed)	64 - 75	818 - 807	100,000	24,000	100	2,500,000	Assumed Average N value
Sand (assumed)	75 - bedrock	807 - 730				2,000,000	Assumed E_s and bedrock elevation

Phase 4

Boring M-13B **Top of Boring EL = 910.5** **Base Grades EL=885.0**

Soil	Depth on boring Log	Elevation	B_0 (lb/ft^2)	B_1 (lb/ft^2)	Average N	E_s (lb/ft^2)	Notes
Compacted Clay Liner (5 ft)		885 - 880					
Tan Fine-Medium Sand and Gravel (SP)	30.5-34	880 - 876.5	100,000	24,000	26.0	724,000	
Brown Silty Sand and Gravel (SM)	34 - 38	876.5 - 872.5	50,000	12,000	46.0	602,000	
Tan Fine-Medium Sand and Gravel (SP)	38 - 63	872.5 - 847.5	100,000	24,000	61.0	1,564,000	
Fine Sand (SP)	63 - 83	847.5 - 827.5	100,000	24,000	65.0	1,660,000	EOB at 83'
Sand (assumed)	83 - bedrock	827.5 - 730				2,000,000	Assumed E_s and bedrock elevation

KRG/DLN

3/5/2021

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Project Information - Dane County Landfill No. 2 (Rodefeld) - Eastern Vertical

Project	
Name	Dane County Landfill No. 2 (Rodefeld) - Eastern Vertical Expansion
Number	25220091
Description	Phase 4 - Peak of Waste over Leachate Pipe
Date	2/2/21
Address	
Client	
Name	Dane County
Contact	
Address	
Engineer	
Name	Keith Gilkey
Firm	SCS Engineers
Department	
Custom	
Checked:	

Settings - Dane County Landfill No. 2 (Rodefeld) - Eastern Vertical Expansion

General Settings	
Water Density (lb/ft^3)	62.43
Gravity (ft/s^2)	32.19
Vertical Drains	
Drain Equivalent Diameter, d (in)	0.00
Drain Influence Zone, D (ft)	0.00
Time, t (month)	Initial
Analysis	
Stress Distribution	Boussinesq
Limit Secondary Settlement	No
Time Related Settlement Scale	Years

Pore Pressure: Initial Pore Pressure - Dane County Landfill No. 2 (Rodefeld) -

General	
Name	Initial Pore Pressure
Description	
Time, t (month)	Initial
Profile Type	Hydrostatic
Hydrostatic Profile	
G.W.T. Depth (ft)	18.00

Load: Waste - Dane County Landfill No. 2 (Rodefeld) - Eastern Vertical

	General			
	Name	Waste		
	Description	Fill over Leachate Pipe		
	Time, t (month)	1.00		
	Status	Enable		
	Shape	Triangle		
	Add (X,Y) to Mesh	No		
	Integration Steps			
	Along X Axis, nΔX	10		
	Along Y Axis, nΔY	10		
	Geometry			
	Depth, Z (ft)	0.00		
	x (ft)	**y (ft)**	**q (ksf)**	
1.	753.50	1,755.80	16.425	
2.	1,906.60	2,588.90	16.425	
3.	1,890.50	952.60	16.425	

Mesh Points - Dane County Landfill No. 2 (Rodefeld) - Eastern Vertical

Mesh Points Array

X1 Coordinate (ft)	0.00
Y1 Coordinate (ft)	0.00
X2 Coordinate (ft)	0.00
Y2 Coordinate (ft)	0.00
X Steps (ft)	0.0
Y Steps (ft)	0.0

Additional Points

	X (ft)	Y (ft)	Status	Name
1.	1,475.00	1,643.40	Enable	

Soil Layer: Clay Liner - Dane County Landfill No. 2 (Rodefeld) - Eastern

General	
Name	Clay Liner
Type	
Description	
Label	
Thickness (ft)	5.00
Depth (ft)	5.00
Z Steps (ft)	1.0
Layer Interpolation	Use layer average values
Density (lb/ft^3)	134.00
Initial Void Ratio, e_0	0.420
Compressibility	
Method	Conventional E, e0, Cc, Cr
Soil Response	Non-Linear
Preconsolidation Parameter	Use overconsolidation ratio, OCR
Overconsolidation Ratio, OCR	2.00
Immediate Compr. Modulus, E_i (ksf)	0.00
Immediate Recompr. Modulus, E_{ir} (ksf)	0.00
Compression Index, C_c	0.1400
Recompression Index, C_r	0.0200
Drainage	
Drainage Type	Vertical only
Drainage Path, Hdr	Single
Coefficient of Consolidation, c_v (ft^2/year)	146.000
Time to 90% Consolidation, t_{v90} (years)	0.145
Unloading Consolidation Factor, c_{vr}	1.00
Seconday Compression	
Secondary Compression Index, C_α	0.00200
Start of Consolidation, t_1 (years)	0.18
Duration of Consolidation, t_{90} (years)	0.00
Report Period, t_r (years)	100.00

Soil Layer: Fine-Medium Sand and Gravel - Dane County Landfill No. 2

General	
Name	Fine-Medium Sand and Gravel
Type	Sand
Description	
Label	
Thickness (ft)	3.50
Depth (ft)	8.50
Z Steps (ft)	1.0
Layer Interpolation	Use layer average values
Density (lb/ft^3)	120.00
Initial Void Ratio, e_0	0.330
Compressibility	
Method	Conventional E, e0, Cc, Cr
Soil Response	Non-Linear
Preconsolidation Parameter	Use preconsolidation margin, Δσ`
Preconsolidation Margin, Δσ` (ksf)	0.000
Immediate Compr. Modulus, E_i (ksf)	724.00
Immediate Recompr. Modulus, E_{ir} (ksf)	724.00
Compression Index, C_c	0.0000
Recompression Index, C_r	0.0000
Drainage	
Drainage Type	Immediate
Seconday Compression	
Secondary Compression Index, C_α	0.00000
Start of Consolidation, t_1 (years)	0.00
Duration of Consolidation, t_{90} (years)	0.00
Report Period, t_r (years)	0.00

Soil Layer: Silty Fine-Medium Sand and Gravel - Dane County Landfill No. 2

General	
Name	Silty Fine-Medium Sand and Gravel
Type	Sand
Description	
Label	
Thickness (ft)	4.00
Depth (ft)	12.50
Z Steps (ft)	1.0
Layer Interpolation	Use layer average values
Density (lb/ft^3)	120.00
Initial Void Ratio, e_0	0.330
Compressibility	
Method	Conventional E, e0, Cc, Cr
Soil Response	Non-Linear
Preconsolidation Parameter	Use preconsolidation margin, Δσ`
Preconsolidation Margin, Δσ` (ksf)	0.000
Immediate Compr. Modulus, E_i (ksf)	602.00
Immediate Recompr. Modulus, E_{ir} (ksf)	602.00
Compression Index, C_c	0.0000
Recompression Index, C_r	0.0000
Drainage	
Drainage Type	Immediate
Seconday Compression	
Secondary Compression Index, C_α	0.00000
Start of Consolidation, t_1 (years)	0.00
Duration of Consolidation, t_{90} (years)	0.00
Report Period, t_r (years)	0.00

Soil Layer: Fine-Medium Sand and Gravel - Dane County Landfill No. 2

General	
Name	Fine-Medium Sand and Gravel
Type	Sand
Description	
Label	
Thickness (ft)	25.00
Depth (ft)	37.50
Z Steps (ft)	1.0
Layer Interpolation	Use layer average values
Density (lb/ft^3)	120.00
Initial Void Ratio, e_0	0.330
Compressibility	
Method	Conventional E, e0, Cc, Cr
Soil Response	Non-Linear
Preconsolidation Parameter	Use preconsolidation margin, Δσ`
Preconsolidation Margin, Δσ` (ksf)	0.000
Immediate Compr. Modulus, E_i (ksf)	1,564.00
Immediate Recompr. Modulus, E_{ir} (ksf)	1,564.00
Compression Index, C_c	0.0000
Recompression Index, C_r	0.0000
Drainage	
Drainage Type	Immediate
Seconday Compression	
Secondary Compression Index, C_α	0.00000
Start of Consolidation, t_1 (years)	0.00
Duration of Consolidation, t_{90} (years)	0.00
Report Period, t_r (years)	0.00

Soil Layer: Fine Sand - Dane County Landfill No. 2 (Rodefeld) - Eastern

General	
Name	Fine Sand
Type	Sand
Description	
Label	
Thickness (ft)	20.00
Depth (ft)	57.50
Z Steps (ft)	1.0
Layer Interpolation	Use layer average values
Density (lb/ft^3)	120.00
Initial Void Ratio, e_0	0.330
Compressibility	
Method	Conventional E, e0, Cc, Cr
Soil Response	Non-Linear
Preconsolidation Parameter	Use preconsolidation margin, Δσ`
Preconsolidation Margin, Δσ` (ksf)	0.000
Immediate Compr. Modulus, E_i (ksf)	1,660.00
Immediate Recompr. Modulus, E_{ir} (ksf)	1,660.00
Compression Index, C_c	0.0000
Recompression Index, C_r	0.0000
Drainage	
Drainage Type	Immediate
Seconday Compression	
Secondary Compression Index, C_α	0.00000
Start of Consolidation, t_1 (years)	0.00
Duration of Consolidation, t_{90} (years)	0.00
Report Period, t_r (years)	0.00

Soil Layer: Sand - Dane County Landfill No. 2 (Rodefeld) - Eastern Vertical

General	
Name	Sand
Type	Sand
Description	
Label	
Thickness (ft)	97.50
Depth (ft)	155.00
Z Steps (ft)	1.0
Layer Interpolation	Use layer average values
Density (lb/ft^3)	120.00
Initial Void Ratio, e_0	0.330
Compressibility	
Method	Conventional E, e0, Cc, Cr
Soil Response	Non-Linear
Preconsolidation Parameter	Use preconsolidation margin, Δσ`
Preconsolidation Margin, Δσ` (ksf)	0.000
Immediate Compr. Modulus, E_i (ksf)	2,000.00
Immediate Recompr. Modulus, E_{ir} (ksf)	2,000.00
Compression Index, C_c	0.0000
Recompression Index, C_r	0.0000
Drainage	
Drainage Type	Immediate
Seconday Compression	
Secondary Compression Index, C_α	0.00000
Start of Consolidation, t_1 (years)	0.00
Duration of Consolidation, t_{90} (years)	0.00
Report Period, t_r (years)	0.00

Layer Compression - Dane County Landfill No. 2 (Rodefeld) - Eastern

Boussinesq at (1,475.00, 1,643.40)

Layer			Compression				
#	Name	Thickness	Immediate	Consolidation	Secondary	Total	Ratio
		(ft)	(in)	(in)	(in)	(in)	(%)
1	Clay Liner	5.00	0.000	9.139	0.385	9.524	15.874
2	Medium Sand and G	3.50	0.953	0.000	0.000	0.953	2.269
3	ıe-Medium Sand and	4.00	1.310	0.000	0.000	1.310	2.728
4	Medium Sand and G	25.00	3.150	0.000	0.000	3.150	1.050
5	Fine Sand	20.00	2.372	0.000	0.000	2.372	0.988
6	Sand	97.50	9.474	0.000	0.000	9.474	0.810
Total	All Layers	155.00	17.258	9.139	0.385	26.782	1.440

Total Settlement - Dane County Landfill No. 2 (Rodefeld) -

Boussinesq at (1,475.00, 1,643.40)

	Effective Stresses		Settlement			Total
Depth	Initial	Final	Immediate	Consolidation	Secondary	S
(ft)	(ksf)	(ksf)	(in)	(in)	(in)	(in)
Layer 1: Clay Liner (Conventional, Non-Linear)						
0.00	0.000	16.425	17.26	9.14	0.39	26.78
1.00	0.134	16.559	17.26	6.62	0.31	24.18
2.00	0.268	16.693	17.26	4.65	0.23	22.14
3.00	0.402	16.827	17.26	2.95	0.15	20.36
4.00	0.536	16.961	17.26	1.41	0.08	18.75
5.00	0.670	17.095	17.26	0.00	0.00	17.26
Layer 2: Fine-Medium Sand and Gravel (Conventional, Non-Linear)						
5.00	0.670	17.095	17.26	0.00	0.00	17.26
6.00	0.790	17.215	16.99	0.00	0.00	16.99
7.00	0.910	17.335	16.71	0.00	0.00	16.71
8.00	1.030	17.455	16.44	0.00	0.00	16.44
8.50	1.090	17.515	16.31	0.00	0.00	16.31
Layer 3: Silty Fine-Medium Sand and Gravel (Conventional, Non-Linear)						
8.50	1.090	17.515	16.31	0.00	0.00	16.31
9.50	1.210	17.635	15.98	0.00	0.00	15.98
10.50	1.330	17.755	15.65	0.00	0.00	15.65
11.50	1.450	17.875	15.32	0.00	0.00	15.32
12.50	1.571	17.995	15.00	0.00	0.00	15.00
Layer 4: Fine-Medium Sand and Gravel (Conventional, Non-Linear)						
12.50	1.571	17.995	15.00	0.00	0.00	15.00
13.50	1.691	18.115	14.87	0.00	0.00	14.87
14.50	1.811	18.235	14.74	0.00	0.00	14.74
15.50	1.931	18.355	14.62	0.00	0.00	14.62
16.50	2.051	18.475	14.49	0.00	0.00	14.49
17.50	2.171	18.595	14.37	0.00	0.00	14.37
18.00	2.231	18.655	14.30	0.00	0.00	14.30
18.50	2.260	18.683	14.24	0.00	0.00	14.24
19.50	2.317	18.741	14.11	0.00	0.00	14.11
20.50	2.375	18.798	13.99	0.00	0.00	13.99
21.50	2.432	18.856	13.86	0.00	0.00	13.86
22.50	2.490	18.913	13.74	0.00	0.00	13.74
23.50	2.548	18.970	13.61	0.00	0.00	13.61
24.50	2.605	19.027	13.48	0.00	0.00	13.48
25.50	2.663	19.085	13.36	0.00	0.00	13.36
26.50	2.720	19.142	13.23	0.00	0.00	13.23
27.50	2.778	19.199	13.11	0.00	0.00	13.11
28.50	2.835	19.256	12.98	0.00	0.00	12.98
29.50	2.893	19.313	12.85	0.00	0.00	12.85

Total Settlement - Dane County Landfill No. 2 (Rodefeld) -

Boussinesq at (1,475.00, 1,643.40)

	Effective Stresses		Settlement			Total
Depth	Initial	Final	Immediate	Consolidation	Secondary	S
(ft)	(ksf)	(ksf)	(in)	(in)	(in)	(in)
30.50	2.951	19.371	12.73	0.00	0.00	12.73
31.50	3.008	19.428	12.60	0.00	0.00	12.60
32.50	3.066	19.485	12.48	0.00	0.00	12.48
33.50	3.123	19.542	12.35	0.00	0.00	12.35
34.50	3.181	19.599	12.22	0.00	0.00	12.22
35.50	3.239	19.656	12.10	0.00	0.00	12.10
36.50	3.296	19.712	11.97	0.00	0.00	11.97
37.50	3.354	19.769	11.85	0.00	0.00	11.85
Layer 5: Fine Sand (Conventional, Non-Linear)						
37.50	3.354	19.769	11.85	0.00	0.00	11.85
38.50	3.411	19.826	11.73	0.00	0.00	11.73
39.50	3.469	19.883	11.61	0.00	0.00	11.61
40.50	3.527	19.940	11.49	0.00	0.00	11.49
41.50	3.584	19.996	11.37	0.00	0.00	11.37
42.50	3.642	20.053	11.25	0.00	0.00	11.25
43.50	3.699	20.110	11.13	0.00	0.00	11.13
44.50	3.757	20.166	11.02	0.00	0.00	11.02
45.50	3.815	20.223	10.90	0.00	0.00	10.90
46.50	3.872	20.279	10.78	0.00	0.00	10.78
47.50	3.930	20.336	10.66	0.00	0.00	10.66
48.50	3.987	20.392	10.54	0.00	0.00	10.54
49.50	4.045	20.448	10.42	0.00	0.00	10.42
50.50	4.102	20.504	10.30	0.00	0.00	10.30
51.50	4.160	20.561	10.18	0.00	0.00	10.18
52.50	4.218	20.617	10.07	0.00	0.00	10.07
53.50	4.275	20.673	9.95	0.00	0.00	9.95
54.50	4.333	20.729	9.83	0.00	0.00	9.83
55.50	4.390	20.785	9.71	0.00	0.00	9.71
56.50	4.448	20.841	9.59	0.00	0.00	9.59
57.50	4.506	20.897	9.47	0.00	0.00	9.47
Layer 6: Sand (Conventional, Non-Linear)						
57.50	4.506	20.897	9.47	0.00	0.00	9.47
58.50	4.563	20.953	9.38	0.00	0.00	9.38
59.50	4.621	21.009	9.28	0.00	0.00	9.28
60.50	4.678	21.064	9.18	0.00	0.00	9.18
61.50	4.736	21.120	9.08	0.00	0.00	9.08
62.50	4.794	21.176	8.98	0.00	0.00	8.98
63.50	4.851	21.231	8.88	0.00	0.00	8.88
64.50	4.909	21.287	8.79	0.00	0.00	8.79

Total Settlement - Dane County Landfill No. 2 (Rodefeld) -

Boussinesq at (1,475.00, 1,643.40)

	Effective Stresses		Settlement			Total
Depth	Initial	Final	Immediate	Consolidation	Secondary	S
(ft)	(ksf)	(ksf)	(in)	(in)	(in)	(in)
65.50	4.966	21.342	8.69	0.00	0.00	8.69
66.50	5.024	21.397	8.59	0.00	0.00	8.59
67.50	5.082	21.453	8.49	0.00	0.00	8.49
68.50	5.139	21.508	8.39	0.00	0.00	8.39
69.50	5.197	21.563	8.29	0.00	0.00	8.29
70.50	5.254	21.618	8.20	0.00	0.00	8.20
71.50	5.312	21.673	8.10	0.00	0.00	8.10
72.50	5.370	21.728	8.00	0.00	0.00	8.00
73.50	5.427	21.783	7.90	0.00	0.00	7.90
74.50	5.485	21.838	7.80	0.00	0.00	7.80
75.50	5.542	21.893	7.71	0.00	0.00	7.71
76.50	5.600	21.947	7.61	0.00	0.00	7.61
77.50	5.657	22.002	7.51	0.00	0.00	7.51
78.50	5.715	22.056	7.41	0.00	0.00	7.41
79.50	5.773	22.111	7.31	0.00	0.00	7.31
80.50	5.830	22.165	7.22	0.00	0.00	7.22
81.50	5.888	22.220	7.12	0.00	0.00	7.12
82.50	5.945	22.274	7.02	0.00	0.00	7.02
83.50	6.003	22.328	6.92	0.00	0.00	6.92
84.50	6.061	22.382	6.82	0.00	0.00	6.82
85.50	6.118	22.436	6.73	0.00	0.00	6.73
86.50	6.176	22.490	6.63	0.00	0.00	6.63
87.50	6.233	22.544	6.53	0.00	0.00	6.53
88.50	6.291	22.598	6.43	0.00	0.00	6.43
89.50	6.349	22.652	6.33	0.00	0.00	6.33
90.50	6.406	22.705	6.24	0.00	0.00	6.24
91.50	6.464	22.759	6.14	0.00	0.00	6.14
92.50	6.521	22.812	6.04	0.00	0.00	6.04
93.50	6.579	22.866	5.94	0.00	0.00	5.94
94.50	6.637	22.919	5.85	0.00	0.00	5.85
95.50	6.694	22.972	5.75	0.00	0.00	5.75
96.50	6.752	23.026	5.65	0.00	0.00	5.65
97.50	6.809	23.079	5.55	0.00	0.00	5.55
98.50	6.867	23.132	5.45	0.00	0.00	5.45
99.50	6.924	23.185	5.36	0.00	0.00	5.36
100.50	6.982	23.238	5.26	0.00	0.00	5.26
101.50	7.040	23.290	5.16	0.00	0.00	5.16
102.50	7.097	23.343	5.06	0.00	0.00	5.06
103.50	7.155	23.396	4.97	0.00	0.00	4.97

Total Settlement - Dane County Landfill No. 2 (Rodefeld) -

Boussinesq at (1,475.00, 1,643.40)

	Effective Stresses		Settlement			Total
Depth	Initial	Final	Immediate	Consolidation	Secondary	S
(ft)	(ksf)	(ksf)	(in)	(in)	(in)	(in)
104.50	7.212	23.448	4.87	0.00	0.00	4.87
105.50	7.270	23.501	4.77	0.00	0.00	4.77
106.50	7.328	23.553	4.67	0.00	0.00	4.67
107.50	7.385	23.605	4.58	0.00	0.00	4.58
108.50	7.443	23.658	4.48	0.00	0.00	4.48
109.50	7.500	23.710	4.38	0.00	0.00	4.38
110.50	7.558	23.762	4.29	0.00	0.00	4.29
111.50	7.616	23.814	4.19	0.00	0.00	4.19
112.50	7.673	23.866	4.09	0.00	0.00	4.09
113.50	7.731	23.917	3.99	0.00	0.00	3.99
114.50	7.788	23.969	3.90	0.00	0.00	3.90
115.50	7.846	24.021	3.80	0.00	0.00	3.80
116.50	7.904	24.072	3.70	0.00	0.00	3.70
117.50	7.961	24.124	3.61	0.00	0.00	3.61
118.50	8.019	24.175	3.51	0.00	0.00	3.51
119.50	8.076	24.226	3.41	0.00	0.00	3.41
120.50	8.134	24.278	3.32	0.00	0.00	3.32
121.50	8.192	24.329	3.22	0.00	0.00	3.22
122.50	8.249	24.380	3.12	0.00	0.00	3.12
123.50	8.307	24.431	3.02	0.00	0.00	3.02
124.50	8.364	24.482	2.93	0.00	0.00	2.93
125.50	8.422	24.532	2.83	0.00	0.00	2.83
126.50	8.479	24.583	2.73	0.00	0.00	2.73
127.50	8.537	24.634	2.64	0.00	0.00	2.64
128.50	8.595	24.684	2.54	0.00	0.00	2.54
129.50	8.652	24.735	2.45	0.00	0.00	2.45
130.50	8.710	24.785	2.35	0.00	0.00	2.35
131.50	8.767	24.835	2.25	0.00	0.00	2.25
132.50	8.825	24.885	2.16	0.00	0.00	2.16
133.50	8.883	24.936	2.06	0.00	0.00	2.06
134.50	8.940	24.986	1.96	0.00	0.00	1.96
135.50	8.998	25.035	1.87	0.00	0.00	1.87
136.50	9.055	25.085	1.77	0.00	0.00	1.77
137.50	9.113	25.135	1.67	0.00	0.00	1.67
138.50	9.171	25.185	1.58	0.00	0.00	1.58
139.50	9.228	25.234	1.48	0.00	0.00	1.48
140.50	9.286	25.284	1.39	0.00	0.00	1.39
141.50	9.343	25.333	1.29	0.00	0.00	1.29
142.50	9.401	25.382	1.19	0.00	0.00	1.19

Total Settlement - Dane County Landfill No. 2 (Rodefeld) -

Boussinesq at (1,475.00, 1,643.40)

	Effective Stresses		Settlement			Total
Depth	Initial	Final	Immediate	Consolidation	Secondary	S
(ft)	(ksf)	(ksf)	(in)	(in)	(in)	(in)
143.50	9.459	25.432	1.10	0.00	0.00	1.10
144.50	9.516	25.481	1.00	0.00	0.00	1.00
145.50	9.574	25.530	0.91	0.00	0.00	0.91
146.50	9.631	25.579	0.81	0.00	0.00	0.81
147.50	9.689	25.628	0.72	0.00	0.00	0.72
148.50	9.746	25.677	0.62	0.00	0.00	0.62
149.50	9.804	25.725	0.52	0.00	0.00	0.52
150.50	9.862	25.774	0.43	0.00	0.00	0.43
151.50	9.919	25.823	0.33	0.00	0.00	0.33
152.50	9.977	25.871	0.24	0.00	0.00	0.24
153.50	10.034	25.919	0.14	0.00	0.00	0.14
154.50	10.092	25.968	0.05	0.00	0.00	0.05
155.00	10.121	25.992	0.00	0.00	0.00	0.00

Project Information - Dane County Landfill No. 2 (Rodefeld)

Project	
Name	Dane County Landfill No. 2 (Rodefeld)
Number	25220091
Description	Phase 10 - Peak of Waste over Leachate Pipe
Date	2/2/21
Address	
Client	
Name	Dane County
Contact	
Address	
Engineer	
Name	Keith Gilkey
Firm	SCS Engineers
Department	
Custom	
Checked:	

Settings - Dane County Landfill No. 2 (Rodefeld)

General Settings	
Water Density (lb/ft^3)	62.43
Gravity (ft/s^2)	32.19
Vertical Drains	
Drain Equivalent Diameter, d (in)	0.00
Drain Influence Zone, D (ft)	0.00
Time, t (month)	Initial
Analysis	
Stress Distribution	Boussinesq
Limit Secondary Settlement	No
Time Related Settlement Scale	Years

Pore Pressure: Initial Pore Pressure - Dane County Landfill No. 2 (Rodefeld)

General	
Name	Initial Pore Pressure
Description	
Time, t (month)	Initial
Profile Type	Hydrostatic
Hydrostatic Profile	
G.W.T. Depth (ft)	12.00

Load: Waste - Dane County Landfill No. 2 (Rodefeld)

General				
	Name	Waste		
	Description	Fill over leachate pipe		
	Time, t (month)	1.00		
	Status	Enable		
	Shape	Triangle		
	Add (X,Y) to Mesh	Yes		
Integration Steps				
	Along X Axis, nΔX	10		
	Along Y Axis, nΔY	10		
Geometry				
	Depth, Z (ft)	0.00		
	x (ft)	**y (ft)**	**q (ksf)**	
1.	753.50	1,755.80	13.860	
2.	1,906.60	2,588.90	13.860	
3.	1,890.50	952.60	13.860	

Mesh Points - Dane County Landfill No. 2 (Rodefeld)

Mesh Points Array

X1 Coordinate (ft)	0.00
Y1 Coordinate (ft)	0.00
X2 Coordinate (ft)	0.00
Y2 Coordinate (ft)	0.00
X Steps (ft)	0.0
Y Steps (ft)	0.0

Additional Points

	X (ft)	Y (ft)	Status	Name
1.	1,755.30	1,948.10	Enable	

Soil Layer: Clay Liner - Dane County Landfill No. 2 (Rodefeld)

General	
Name	Clay Liner
Type	Clay
Description	
Label	
Thickness (ft)	4.00
Depth (ft)	4.00
Z Steps (ft)	1.0
Layer Interpolation	Use layer average values
Density (lb/ft^3)	134.00
Initial Void Ratio, e_0	0.420
Compressibility	
Method	Conventional E, e0, Cc, Cr
Soil Response	Non-Linear
Preconsolidation Parameter	Use overconsolidation ratio, OCR
Overconsolidation Ratio, OCR	2.00
Immediate Compr. Modulus, E_i (ksf)	0.00
Immediate Recompr. Modulus, E_{ir} (ksf)	0.00
Compression Index, C_c	0.1400
Recompression Index, C_r	0.0200
Drainage	
Drainage Type	Vertical only
Drainage Path, Hdr	Single
Coefficient of Consolidation, c_v (ft^2/year)	146.000
Time to 90% Consolidation, t_{v90} (years)	0.093
Unloading Consolidation Factor, c_{vr}	1.00
Seconday Compression	
Secondary Compression Index, C_α	0.00200
Start of Consolidation, t_1 (years)	0.18
Duration of Consolidation, t_{90} (years)	0.00
Report Period, t_r (years)	100.00

Soil Layer: Silty Sand with Gravel - Dane County Landfill No. 2 (Rodefeld)

General	
Name	Silty Sand with Gravel
Type	Sand
Description	
Label	
Thickness (ft)	17.00
Depth (ft)	21.00
Z Steps (ft)	1.0
Layer Interpolation	Use layer average values
Density (lb/ft^3)	120.00
Initial Void Ratio, e_0	0.330
Compressibility	
Method	Conventional E, e0, Cc, Cr
Soil Response	Non-Linear
Preconsolidation Parameter	Use preconsolidation margin, Δσ`
Preconsolidation Margin, Δσ` (ksf)	0.000
Immediate Compr. Modulus, E_i (ksf)	634.00
Immediate Recompr. Modulus, E_{ir} (ksf)	634.00
Compression Index, C_c	0.0000
Recompression Index, C_r	0.0000
Drainage	
Drainage Type	Immediate
Seconday Compression	
Secondary Compression Index, C_α	0.00000
Start of Consolidation, t_1 (years)	0.00
Duration of Consolidation, t_{90} (years)	0.00
Report Period, t_r (years)	0.00

Soil Layer: Well Graded Sand - Dane County Landfill No. 2 (Rodefeld)

General	
Name	Well Graded Sand
Type	Sand
Description	
Label	
Thickness (ft)	30.00
Depth (ft)	51.00
Z Steps (ft)	1.0
Layer Interpolation	Use layer average values
Density (lb/ft^3)	120.00
Initial Void Ratio, e_0	0.330
Compressibility	
Method	Conventional E, e0, Cc, Cr
Soil Response	Non-Linear
Preconsolidation Parameter	Use preconsolidation margin, Δσ`
Preconsolidation Margin, Δσ` (ksf)	0.000
Immediate Compr. Modulus, E_i (ksf)	757.60
Immediate Recompr. Modulus, E_{ir} (ksf)	757.60
Compression Index, C_c	0.0000
Recompression Index, C_r	0.0000
Drainage	
Drainage Type	Immediate
Seconday Compression	
Secondary Compression Index, C_α	0.00000
Start of Consolidation, t_1 (years)	0.00
Duration of Consolidation, t_{90} (years)	0.00
Report Period, t_r (years)	0.00

Soil Layer: Silty Clay - Dane County Landfill No. 2 (Rodefeld)

General	
Name	Silty Clay
Type	Clay
Description	
Label	
Thickness (ft)	3.00
Depth (ft)	54.00
Z Steps (ft)	1.0
Layer Interpolation	Use layer average values
Density (lb/ft^3)	134.00
Initial Void Ratio, e_0	0.420
Compressibility	
Method	Conventional E, e0, Cc, Cr
Soil Response	Non-Linear
Preconsolidation Parameter	Use overconsolidation ratio, OCR
Overconsolidation Ratio, OCR	2.00
Immediate Compr. Modulus, E_i (ksf)	0.00
Immediate Recompr. Modulus, E_{ir} (ksf)	0.00
Compression Index, C_c	0.1400
Recompression Index, C_r	0.0200
Drainage	
Drainage Type	Vertical only
Drainage Path, Hdr	Double
Coefficient of Consolidation, c_v (ft^2/year)	146.000
Time to 90% Consolidation, t_{v90} (years)	0.013
Unloading Consolidation Factor, c_{vr}	1.00
Seconday Compression	
Secondary Compression Index, C_α	0.00200
Start of Consolidation, t_1 (years)	0.09
Duration of Consolidation, t_{90} (years)	0.00
Report Period, t_r (years)	100.00

Soil Layer: Well Graded Sand with Gravel - Dane County Landfill No. 2

General	
Name	Well Graded Sand with Gravel
Type	Sand
Description	
Label	
Thickness (ft)	3.00
Depth (ft)	57.00
Z Steps (ft)	1.0
Layer Interpolation	Use layer average values
Density (lb/ft^3)	120.00
Initial Void Ratio, e_0	0.330
Compressibility	
Method	Conventional E, e0, Cc, Cr
Soil Response	Non-Linear
Preconsolidation Parameter	Use preconsolidation margin, Δσ`
Preconsolidation Margin, Δσ` (ksf)	0.000
Immediate Compr. Modulus, E_i (ksf)	757.60
Immediate Recompr. Modulus, E_{ir} (ksf)	757.60
Compression Index, C_c	0.0000
Recompression Index, C_r	0.0000
Drainage	
Drainage Type	Immediate
Seconday Compression	
Secondary Compression Index, C_α	0.00000
Start of Consolidation, t_1 (years)	0.00
Duration of Consolidation, t_{90} (years)	0.00
Report Period, t_r (years)	0.00

Soil Layer: Sand 1 - Dane County Landfill No. 2 (Rodefeld)

General	
Name	Sand 1
Type	Sand
Description	
Label	
Thickness (ft)	9.00
Depth (ft)	66.00
Z Steps (ft)	1.0
Layer Interpolation	Use layer average values
Density (lb/ft^3)	120.00
Initial Void Ratio, e_0	0.330
Compressibility	
Method	Conventional E, e0, Cc, Cr
Soil Response	Non-Linear
Preconsolidation Parameter	Use preconsolidation margin, Δσ`
Preconsolidation Margin, Δσ` (ksf)	0.000
Immediate Compr. Modulus, E_i (ksf)	2,500.00
Immediate Recompr. Modulus, E_{ir} (ksf)	2,500.00
Compression Index, C_c	0.0000
Recompression Index, C_r	0.0000
Drainage	
Drainage Type	Immediate
Seconday Compression	
Secondary Compression Index, C_α	0.00000
Start of Consolidation, t_1 (years)	0.00
Duration of Consolidation, t_{90} (years)	0.00
Report Period, t_r (years)	0.00

Soil Layer: Sand 2 - Dane County Landfill No. 2 (Rodefeld)

General	
Name	Sand 2
Type	Sand
Description	
Label	
Thickness (ft)	77.00
Depth (ft)	143.00
Z Steps (ft)	1.0
Layer Interpolation	Use layer average values
Density (lb/ft^3)	120.00
Initial Void Ratio, e_0	0.330
Compressibility	
Method	Conventional E, e0, Cc, Cr
Soil Response	Non-Linear
Preconsolidation Parameter	Use preconsolidation margin, Δσ`
Preconsolidation Margin, Δσ` (ksf)	0.000
Immediate Compr. Modulus, E_i (ksf)	2,000.00
Immediate Recompr. Modulus, E_{ir} (ksf)	2,000.00
Compression Index, C_c	0.0000
Recompression Index, C_r	0.0000
Drainage	
Drainage Type	Immediate
Seconday Compression	
Secondary Compression Index, C_α	0.00000
Start of Consolidation, t_1 (years)	0.00
Duration of Consolidation, t_{90} (years)	0.00
Report Period, t_r (years)	0.00

Layer Compression - Dane County Landfill No. 2 (Rodefeld)

Boussinesq at (1,755.30, 1,948.10)

Layer			Compression				
#	Name	Thickness	Immediate	Consolidation	Secondary	Total	Ratio
		(ft)	(in)	(in)	(in)	(in)	(%)
1	Clay Liner	4.00	0.000	7.385	0.308	7.693	16.028
2	ilty Sand with Grave	17.00	4.459	0.000	0.000	4.459	2.186
3	Well Graded Sand	30.00	6.561	0.000	0.000	6.561	1.823
4	Silty Clay	3.00	0.000	1.425	0.231	1.656	4.601
5	Graded Sand with G	3.00	0.651	0.000	0.000	0.651	1.809
6	Sand 1	9.00	0.590	0.000	0.000	0.590	0.546
7	Sand 2	77.00	6.053	0.000	0.000	6.053	0.655
Total	All Layers	143.00	18.314	8.810	0.540	27.664	1.612

Total Settlement - Dane County Landfill No. 2 (Rodefeld)

Boussinesq at (1,755.30, 1,948.10)

	Effective Stresses		Settlement			Total
Depth	Initial	Final	Immediate	Consolidation	Secondary	S
(ft)	(ksf)	(ksf)	(in)	(in)	(in)	(in)
Layer 1: Clay Liner (Conventional, Non-Linear)						
0.00	0.000	13.860	18.31	8.81	0.54	27.66
1.00	0.134	13.994	18.31	6.37	0.46	25.15
2.00	0.268	14.128	18.31	4.50	0.39	23.20
3.00	0.402	14.262	18.31	2.88	0.31	21.50
4.00	0.536	14.396	18.31	1.43	0.23	19.97
Layer 2: Silty Sand with Gravel (Conventional, Non-Linear)						
4.00	0.536	14.396	18.31	1.43	0.23	19.97
5.00	0.656	14.516	18.05	1.43	0.23	19.71
6.00	0.776	14.636	17.79	1.43	0.23	19.45
7.00	0.896	14.756	17.53	1.43	0.23	19.18
8.00	1.016	14.876	17.26	1.43	0.23	18.92
9.00	1.136	14.996	17.00	1.43	0.23	18.66
10.00	1.256	15.115	16.74	1.43	0.23	18.40
11.00	1.376	15.235	16.48	1.43	0.23	18.13
12.00	1.497	15.355	16.22	1.43	0.23	17.87
13.00	1.554	15.412	15.95	1.43	0.23	17.61
14.00	1.612	15.469	15.69	1.43	0.23	17.35
15.00	1.669	15.526	15.43	1.43	0.23	17.09
16.00	1.727	15.583	15.17	1.43	0.23	16.82
17.00	1.784	15.639	14.90	1.43	0.23	16.56
18.00	1.842	15.696	14.64	1.43	0.23	16.30
19.00	1.900	15.753	14.38	1.43	0.23	16.04
20.00	1.957	15.809	14.12	1.43	0.23	15.77
21.00	2.015	15.865	13.86	1.43	0.23	15.51
Layer 3: Well Graded Sand (Conventional, Non-Linear)						
21.00	2.015	15.865	13.86	1.43	0.23	15.51
22.00	2.072	15.922	13.64	1.43	0.23	15.29
23.00	2.130	15.978	13.42	1.43	0.23	15.07
24.00	2.188	16.034	13.20	1.43	0.23	14.85
25.00	2.245	16.089	12.98	1.43	0.23	14.63
26.00	2.303	16.145	12.76	1.43	0.23	14.42
27.00	2.360	16.201	12.54	1.43	0.23	14.20
28.00	2.418	16.256	12.32	1.43	0.23	13.98
29.00	2.476	16.311	12.10	1.43	0.23	13.76
30.00	2.533	16.366	11.88	1.43	0.23	13.54
31.00	2.591	16.421	11.66	1.43	0.23	13.32
32.00	2.648	16.476	11.44	1.43	0.23	13.10
33.00	2.706	16.530	11.22	1.43	0.23	12.88

Total Settlement - Dane County Landfill No. 2 (Rodefeld)

Boussinesq at (1,755.30, 1,948.10)

	Effective Stresses		Settlement			Total
Depth	Initial	Final	Immediate	Consolidation	Secondary	S
(ft)	(ksf)	(ksf)	(in)	(in)	(in)	(in)
34.00	2.764	16.585	11.01	1.43	0.23	12.66
35.00	2.821	16.639	10.79	1.43	0.23	12.44
36.00	2.879	16.693	10.57	1.43	0.23	12.22
37.00	2.936	16.747	10.35	1.43	0.23	12.01
38.00	2.994	16.801	10.13	1.43	0.23	11.79
39.00	3.051	16.854	9.91	1.43	0.23	11.57
40.00	3.109	16.907	9.69	1.43	0.23	11.35
41.00	3.167	16.961	9.47	1.43	0.23	11.13
42.00	3.224	17.014	9.26	1.43	0.23	10.91
43.00	3.282	17.066	9.04	1.43	0.23	10.69
44.00	3.339	17.119	8.82	1.43	0.23	10.48
45.00	3.397	17.171	8.60	1.43	0.23	10.26
46.00	3.455	17.223	8.38	1.43	0.23	10.04
47.00	3.512	17.275	8.17	1.43	0.23	9.82
48.00	3.570	17.327	7.95	1.43	0.23	9.60
49.00	3.627	17.379	7.73	1.43	0.23	9.39
50.00	3.685	17.430	7.51	1.43	0.23	9.17
51.00	3.743	17.481	7.29	1.43	0.23	8.95
Layer 4: Silty Clay (Conventional, Non-Linear)						
51.00	3.743	17.481	7.29	1.43	0.23	8.95
52.00	3.814	17.546	7.29	0.94	0.15	8.39
53.00	3.886	17.611	7.29	0.47	0.08	7.84
54.00	3.957	17.675	7.29	0.00	0.00	7.29
Layer 5: Well Graded Sand with Gravel (Conventional, Non-Linear)						
54.00	3.957	17.675	7.29	0.00	0.00	7.29
55.00	4.015	17.726	7.08	0.00	0.00	7.08
56.00	4.073	17.776	6.86	0.00	0.00	6.86
57.00	4.130	17.826	6.64	0.00	0.00	6.64
Layer 6: Sand 1 (Conventional, Non-Linear)						
57.00	4.130	17.826	6.64	0.00	0.00	6.64
58.00	4.188	17.876	6.58	0.00	0.00	6.58
59.00	4.245	17.925	6.51	0.00	0.00	6.51
60.00	4.303	17.975	6.45	0.00	0.00	6.45
61.00	4.361	18.024	6.38	0.00	0.00	6.38
62.00	4.418	18.073	6.31	0.00	0.00	6.31
63.00	4.476	18.121	6.25	0.00	0.00	6.25
64.00	4.533	18.170	6.18	0.00	0.00	6.18
65.00	4.591	18.218	6.12	0.00	0.00	6.12
66.00	4.648	18.267	6.05	0.00	0.00	6.05

Total Settlement - Dane County Landfill No. 2 (Rodefeld)

Boussinesq at (1,755.30, 1,948.10)

	Effective Stresses		Settlement			Total
Depth	Initial	Final	Immediate	Consolidation	Secondary	S
(ft)	(ksf)	(ksf)	(in)	(in)	(in)	(in)
Layer 7: Sand 2 (Conventional, Non-Linear)						
66.00	4.648	18.267	6.05	0.00	0.00	6.05
67.00	4.706	18.315	5.97	0.00	0.00	5.97
68.00	4.764	18.362	5.89	0.00	0.00	5.89
69.00	4.821	18.410	5.81	0.00	0.00	5.81
70.00	4.879	18.457	5.73	0.00	0.00	5.73
71.00	4.936	18.505	5.65	0.00	0.00	5.65
72.00	4.994	18.552	5.56	0.00	0.00	5.56
73.00	5.052	18.599	5.48	0.00	0.00	5.48
74.00	5.109	18.645	5.40	0.00	0.00	5.40
75.00	5.167	18.692	5.32	0.00	0.00	5.32
76.00	5.224	18.738	5.24	0.00	0.00	5.24
77.00	5.282	18.784	5.16	0.00	0.00	5.16
78.00	5.340	18.830	5.08	0.00	0.00	5.08
79.00	5.397	18.876	5.00	0.00	0.00	5.00
80.00	5.455	18.922	4.91	0.00	0.00	4.91
81.00	5.512	18.967	4.83	0.00	0.00	4.83
82.00	5.570	19.012	4.75	0.00	0.00	4.75
83.00	5.628	19.057	4.67	0.00	0.00	4.67
84.00	5.685	19.102	4.59	0.00	0.00	4.59
85.00	5.743	19.147	4.51	0.00	0.00	4.51
86.00	5.800	19.192	4.43	0.00	0.00	4.43
87.00	5.858	19.236	4.35	0.00	0.00	4.35
88.00	5.915	19.281	4.27	0.00	0.00	4.27
89.00	5.973	19.325	4.19	0.00	0.00	4.19
90.00	6.031	19.369	4.11	0.00	0.00	4.11
91.00	6.088	19.413	4.03	0.00	0.00	4.03
92.00	6.146	19.457	3.95	0.00	0.00	3.95
93.00	6.203	19.500	3.87	0.00	0.00	3.87
94.00	6.261	19.544	3.79	0.00	0.00	3.79
95.00	6.319	19.587	3.71	0.00	0.00	3.71
96.00	6.376	19.631	3.63	0.00	0.00	3.63
97.00	6.434	19.674	3.55	0.00	0.00	3.55
98.00	6.491	19.717	3.47	0.00	0.00	3.47
99.00	6.549	19.760	3.39	0.00	0.00	3.39
100.00	6.607	19.802	3.31	0.00	0.00	3.31
101.00	6.664	19.845	3.24	0.00	0.00	3.24
102.00	6.722	19.888	3.16	0.00	0.00	3.16
103.00	6.779	19.930	3.08	0.00	0.00	3.08

Total Settlement - Dane County Landfill No. 2 (Rodefeld)

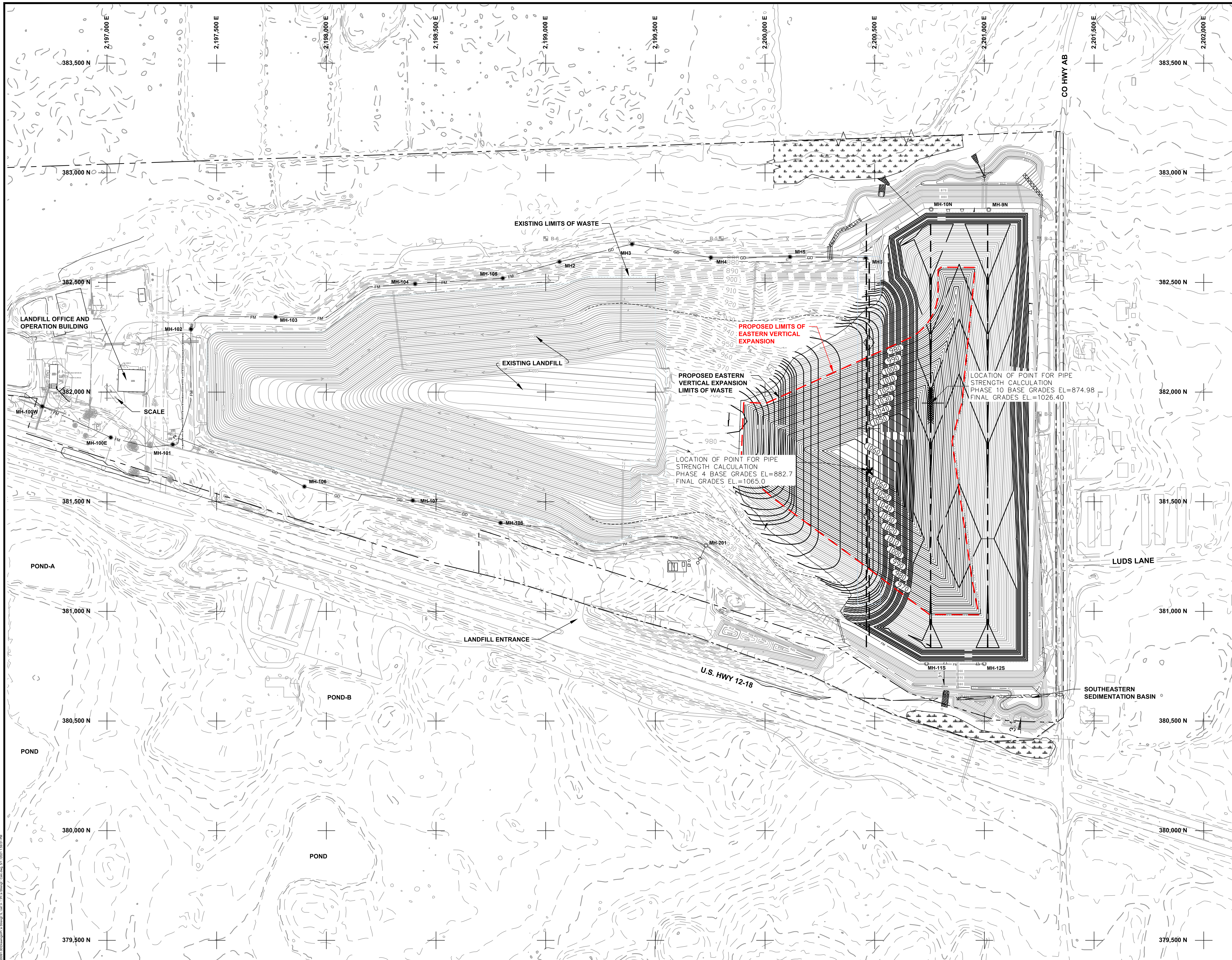
Boussinesq at (1,755.30, 1,948.10)

	Effective Stresses		Settlement			Total
Depth	Initial	Final	Immediate	Consolidation	Secondary	S
(ft)	(ksf)	(ksf)	(in)	(in)	(in)	(in)
104.00	6.837	19.972	3.00	0.00	0.00	3.00
105.00	6.895	20.014	2.92	0.00	0.00	2.92
106.00	6.952	20.057	2.84	0.00	0.00	2.84
107.00	7.010	20.099	2.76	0.00	0.00	2.76
108.00	7.067	20.140	2.68	0.00	0.00	2.68
109.00	7.125	20.182	2.61	0.00	0.00	2.61
110.00	7.183	20.224	2.53	0.00	0.00	2.53
111.00	7.240	20.266	2.45	0.00	0.00	2.45
112.00	7.298	20.307	2.37	0.00	0.00	2.37
113.00	7.355	20.348	2.29	0.00	0.00	2.29
114.00	7.413	20.390	2.22	0.00	0.00	2.22
115.00	7.470	20.431	2.14	0.00	0.00	2.14
116.00	7.528	20.472	2.06	0.00	0.00	2.06
117.00	7.586	20.513	1.98	0.00	0.00	1.98
118.00	7.643	20.554	1.90	0.00	0.00	1.90
119.00	7.701	20.595	1.83	0.00	0.00	1.83
120.00	7.758	20.636	1.75	0.00	0.00	1.75
121.00	7.816	20.677	1.67	0.00	0.00	1.67
122.00	7.874	20.718	1.60	0.00	0.00	1.60
123.00	7.931	20.759	1.52	0.00	0.00	1.52
124.00	7.989	20.799	1.44	0.00	0.00	1.44
125.00	8.046	20.840	1.36	0.00	0.00	1.36
126.00	8.104	20.880	1.29	0.00	0.00	1.29
127.00	8.162	20.921	1.21	0.00	0.00	1.21
128.00	8.219	20.961	1.14	0.00	0.00	1.14
129.00	8.277	21.001	1.06	0.00	0.00	1.06
130.00	8.334	21.042	0.98	0.00	0.00	0.98
131.00	8.392	21.082	0.91	0.00	0.00	0.91
132.00	8.450	21.122	0.83	0.00	0.00	0.83
133.00	8.507	21.162	0.75	0.00	0.00	0.75
134.00	8.565	21.202	0.68	0.00	0.00	0.68
135.00	8.622	21.243	0.60	0.00	0.00	0.60
136.00	8.680	21.283	0.53	0.00	0.00	0.53
137.00	8.737	21.323	0.45	0.00	0.00	0.45
138.00	8.795	21.363	0.38	0.00	0.00	0.38
139.00	8.853	21.402	0.30	0.00	0.00	0.30
140.00	8.910	21.442	0.23	0.00	0.00	0.23
141.00	8.968	21.482	0.15	0.00	0.00	0.15
142.00	9.025	21.522	0.07	0.00	0.00	0.07

Total Settlement - Dane County Landfill No. 2 (Rodefeld)

Boussinesq at (1,755.30, 1,948.10)

	Effective Stresses		Settlement			Total
Depth	Initial	Final	Immediate	Consolidation	Secondary	S
(ft)	(ksf)	(ksf)	(in)	(in)	(in)	(in)
143.00	9.083	21.562	0.00	0.00	0.00	0.00



LEGEND

- APPROXIMATE PROPERTY BOUNDARY
- GRID LOCATION
- EXISTING PAVED ROAD
- EXISTING UNPAVED ROAD
- EXISTING FENCE
- EXISTING BUILDING
- EXISTING 10' CONTOUR (920)
- EXISTING 2' CONTOUR
- EXISTING SPOT ELEVATION (x 815.1)
- EXISTING TREES AND/OR BRUSH
- EXISTING WET AREA AND WETLAND LIMITS
- EXISTING EDGE OF WATER
- DRAINAGE DITCH / SWALE
- EXISTING APPROVED LIMITS OF WASTE
- EXISTING EASTERN EXPANSION LIMITS OF WASTE
- PROPOSED EASTERN VERTICAL EXPANSION LIMITS OF WASTE
- PROPOSED 10' FINAL GRADE CONTOUR (1010)
- PROPOSED 2' FINAL GRADE CONTOUR
- CURRENTLY PERMITTED 10' FINAL GRADE CONTOUR (920)
- CURRENTLY PERMITTED 2' FINAL GRADE CONTOUR
- EXISTING LEACHATE FORCEMAIN LINE (FM)
- EXISTING LEACHATE GRAVITY DRAIN LINE (GD)
- EXISTING SANITARY SEWER LINE (SAN)
- LIMITS OF COMPOSITE FINAL COVER
- SLOPE AND DIRECTION (4:1)
- DOWNSLOPE FLUME WITH ENERGY DISSIPATOR

NOTES:

1. SCREENED GRADES IN THE EASTERN EXPANSION AREA REPRESENT THE TOP OF FINAL COVER GRADES ADJUSTED TO ACCOUNT FOR OVERFILLING IN OLDER PORTIONS OF THE LANDFILL BASED ON TOP OF WASTE GRADES BY TRC, ADJUSTED FOR THE 5-FOOT FINAL COVER.
2. BOLD GRADES REPRESENT THE CONCEPTUAL FINAL COVER GRADES FOR THE PROPOSED VERTICAL EXPANSION.

TOTAL CONCEPTUAL WASTE VOLUME SUMMARY			
CUT (CY)	FILL (CY)	NET (CY)	PEAK FINAL GRADE ELEVATION (FT)
0	990,300	990,300 (FILL)	1065

FIGURE I-2

CONCEPTUAL FINAL GRADES (5% CAP FROM 1065)
PROPOSED EASTERN VERTICAL EXPANSION

SITE: DANE COUNTY LANDFILL SITE NO. 2
7102 US HWY 12/18
MADISON, WISCONSIN

CLIENT: DANE COUNTY DEPARTMENT OF WASTE AND RENEWABLES
1919 ALLIANT ENERGY CENTER WAY
MADISON, WI 53713

ENGINEER: SCS ENGINEERS
2830 DAIRY DRIVE MADISON, WI 53718-6751
PHONE: (608) 224-2830

PROJECT NO.	25220091.00	DRAWN BY:	RBN/BSS
DRAWN:	03/24/2020	CHECKED BY:	KRG
REVISED:	02/03/2021	APPROVED BY:	BLP 05/14/2021

Purpose: To evaluate the pipe strength of 6-in. dia., Schedule 80 PVC leachate collection piping in the Phase 4 base system of the Dane County Landfill Site No. 2 Eastern Vertical Expansion using designed properties and parameters.

Approach: Use referenced formulas to determine the maximum height waste can be placed above the leachate piping and the specific physical pipe properties necessary to perform adequately.

References:

1. Vylon Pipe, "Plastic Pipe Design Manual", for PVC pipe, www.primeconduit.com
2. Plastics Pipe Institute, 2nd Edition Handbook of PE Pipe, Buried PE Pipe Design
3. U.S. Plastics, Physical Properties of PVC Pipe, www.usplastic.com (Page 5)
4. GF Harvel Plastics, PVC pipe physical properties and product specifications, www.gfps.com (Page 4)
5. TRC, Plan of Operation, Dane County No. 2 (Rodefeld) Landfill Plan of Operation, Base Grades Plan Sheets and Appendix I, March 2014.
6. "HDPE Leachate Collection Pipe Design by Fundamentals of Mechanics", Harrison and Watkins, 1996, Nineteenth International Madison Waste Conference.
7. SCS Engineers, Feasibility Report, Dane County Landfill Site No.2 Eastern Vertical Expansion, Final Grades Plan Sheet, March 2021.
8. Uni-Bell PVC Pipe Association, "Handbook of PVC Pipe: Design and Construction", 2012
9. Watkins, Reynold, 1989, Report on Metro Landfill – Pipe Design, Plan of Operation, Metro Landfill Western Expansion, Appendix F.

Assumptions:

1. Waste above the piping is assumed to be wet from leachate recirculation.
2. Wet waste unit weight is a conservative 119 pcf to include the effects of leachate recirculation.
3. Live loads are negligible above the piping. The maximum fill height over a 6-in PVC pipe will be 183 feet for the current design.
4. Leachate collection pipes are 6-in., Schedule 80 PVC.
5. Allowable compressive stress for PVC pipe is 2,000 psi based on Uni-Bell PVC Pipe Association, *Handbook of PVC Pipe: Design and Construction*

Calculations:

Pipe Loading, P_y $\quad P_y = DL + LL$

where, P_y = Pipe Load, lb/in²
DL = Dead Load, lb/in²
LL = Live Load, lb/in²

Dead Load, DL $\quad DL = \frac{\gamma \cdot H}{144}$

where,	γ	= Fill Unit Weight, lb/ft³	=	**119**	(waste unit weight with recirculation)
	H	= Height of Cover, ft	=	**183.0**	(max. waste height)
	DL	= Dead Load, lb/in²		**151**	

In our case the live load = 0, due to limited live loads above the piping after placement.

so, $P_y = DL =$ **151** lb/in²

Assuming, 6 inch Schedule 80 PVC for leachate collection piping

Outer Diameter of Pipe (OD) = **6.625** **in** (From Attachment 1)

Min. Pipe wall thickness (t) = **0.432** **in** (From Attachment 1)

Calculations: (cont.)

Deflection

A deflection of 5 to 7.5% has become the standard for limiting deflection in flexible pipes. Based on Figure 7.16 in Uni-Bell (1991) and Watkins (1989) a vertical strain of greater than 5% will never be reached for flexible pipe bedded in compacted gravel, independent of vertical soil pressure. At 90% compaction the vertical strain will always be less than 2%. The height of fill over the pipe is not a factor when the pipe is well bedded in gravel. These findings are consistent for HDPE piping with the Harrison and Watkins (1996) paper.

Wall Crushing

where,

σ = Compressive Stress, lb/in²
T = Wall Thrust, lb/in
A = Area of Pipe Wall, in²/in

$$\sigma = \frac{T}{A}$$

Wall Thrust, T

$$T = \frac{P_y \cdot D_o}{2}$$

Sch. 80 PVC Piping

where,	P_y	= Vertical Fill Pressure, lb/in^2	=	**151**	(Previously Calculated)
	D_o	= Outside Diameter, in	=	**6.625**	(Sch. 80 PVC, 6-inch)
	T	= Wall Thrust, lb/in	=	**501**	
	A	= Area of Pipe Wall, in²/in	=	**0.432**	(Solid=Thickness)
So,	σ	= Compressive Stress, lb/in²	=	**1160**	

Result: The maximum compressive strength of PVC pipe is 9,600 psi (2,000 psi allowable, safety factor of 4.8), so the calculated compressive stress values are acceptable and wall crushing of the pipe will be avoided when the pipe is at least Schedule 80, 6-inch diameter for the leachate collection pipe.
To account for the possible elevated temperature within the landfill, a temperature de-rating factor of 0.62 was applied to allowable compressive strength for PVC pipe. This makes the maximum compressive strength 1,240 psi. The calculated compressive stress is below this value.

Calculations: (cont.)

Wall Crushing cont.)

Leachate Collection Piping Maximum Height - Schedule 80 PVC

For	P_y	= Vertical Fill Pressure, lb/in^2	=	**162**	
	D_o	= Outside Diameter, in	=	**6.625**	(Sch. 80, 6-inch)
	T	= Wall Thrust, lb/in	=	**536**	
	A	= Area of Pipe Wall, in^2/in	=	**0.432**	(Solid=Thickness)
	σ	= Compressive Stress, lb/in^2	=	**1240**	(max. allowable for 4.8 safety factor and temperature reduction factor)

Maximum Height (feet) = Py*(144)/ɣ = **196**

Result: The maximum height of fill above the 6-inch Schedule 80 PVC piping is 196 feet for a fill unit weight of 119 lb/ft^3 to maintain the required minimum factor of safety against wall crushing. Wall crushing controls the maximum fill height that can be placed above the leachate collection pipes. The maximum fill height above the Phase 4, 6-inch diameter piping when the Eastern Vertical Expansion is filled will be approximately 183 feet, which is lower than the maximum allowable fill height.

Attachment 1:

+GF+

HARVEL

PVC Industrial Pipe: Product Specifications

www.gfpiping.com

Schedule 40 Dimensions

	Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. Wt./Ft.	Max. W.P.
*	4	4.500	3.998	0.237	2.118	220
	5	5.563	5.016	0.258	2.874	190
*	6	6.625	6.031	0.280	3.733	180
*	8	8.625	7.942	0.322	5.619	160
*	10	10.750	9.976	0.365	7.966	140
*	12	12.750	11.889	0.406	10.534	130
*	14	14.000	13.073	0.437	12.462	130
*	16	16.000	14.940	0.500	16.286	130
*	18	18.000	16.809	0.562	20.587	130

Schedule 80 Dimensions

Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. Wt./Ft.	Max. W.P.
4	4.500	3.786	0.337	2.938	320
5	5.563	4.768	0.375	4.078	290
6	6.625	5.709	0.432	5.610	280
8	8.625	7.565	0.500	8.522	250
10	10.750	9.493	0.593	12.635	230
12	12.750	11.294	0.687	17.384	230
14	14.000	12.410	0.750	20.852	220
16	16.000	14.213	0.843	26.810	220
18	18.000	16.014	0.937	33.544	220

Schedule 120 Dimensions

Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. Wt./Ft.	Max. W.P.
1/2	0.840	0.480	0.170	0.236	1010
3/4	1.050	0.690	0.170	0.311	770
1	1.315	0.891	0.200	0.464	720
1-1/4	1.660	1.204	0.215	0.649	600
1-1/2	1.900	1.423	0.225	0.787	540
2	2.375	1.845	0.250	1.111	470
2-1/2	2.875	2.239	0.300	1.615	470
3	3.500	2.758	0.350	2.306	440
4	4.500	3.574	0.437	3.713	430
6	6.625	5.434	0.562	7.132	370
8	8.625	7.189	0.718	11.277	380

Notes:

1. Tables from 2012 or earlier; information for this calcuation consistent with new website data.

Attachment 2:

Physical Properties for PVC and CPVC Pipe(Schedule 40 and 80)

Article Title: Physical Properties for PVC and CPVC Pipe(Schedule 40 and 80)

Article Summary: Physical, Mechanical, Electrical and Thermal Typical Properties.

Article Date: 2/4/2009

Article ID: 557

PVC and CPVC pipe

Properties	PVC Value	CPVC Value	Test Method
General			
Cell Classification	12,454	23,447	ASTM D1784
Maximum Service Temp.	140°F	200°F	
Color	White, Dark Gray	Medium Gray	
Specific Gravity (g/cu.cm @73°F)	1.40 +/-.02	1.52 +/- .02	ASTM D792
Water Absorption % increase 24 hrs @ 25°C	0.05	0.03	ASTM D570
Hardness, Rockwell	110-120	117-119	ASTM D785
Poisson's Ratio @ 73°F	0.410	0.386	
Hazen-Williams Factor	C = 150	C = 150	
Mechanical			
Tensile Strength, psi @ 73°F	7,450	7,320	ASTM D638
Tensile Modulus of Elasticity, psi @ 73°F	420,000	360,000	ASTM D638
Flexural Strength, psi @ 73°F	14,450	13,000	ASTM D790
Flexural Modulus, psi @ 73°F	360,000	360,000	ASTM D790
Compressive Strength, psi @ 73°F	9,600	10,000	ASTM D695
Izod Impact, notched, ft-lb/in @ 73°F	0.75	2.0	ASTM D256
Thermal			
Coefficient of Linear Expansion (in/in/°F)	2.9×10^{-5}	3.4×10^{-5}	ASTM D696
Coefficient of Thermal Conductivity			ASTM C177
Calories • cm/second • cm^2 • °C	3.5×10^{-4}	3.27×10^{-4}	
BTU • inches/hour • Ft^2 • °F	1.02	0.95	
Watt/m/K	0.147	0.137	
Heat deflection Temperature Under Load (264 psi, annealed)	170	226	ASTM D648
Electrical			
Dielectric Strength, volt/mil	1,413	1,250	ASTM D149
Dielectric Constant. 60Hz, 30°F	3.70	3.70	ASTM D150
Volume Resistivity, Ohm/cm @ 95°C	1.2×10^{12}	3.4×10^{12}	ASTM D257
Harvel PVC & CPVC pipe is Non-electrolytic			
Fire Performance			
Flammability Rating	V-0	V-0, 5VB, 5VA	UL-94
Flame Spread Rating	<10	<10	
Flame Spread	0-25	<25	ULC
Smoke Generation	80-225	<50	ULC
Flash Ignition Temp.	730°F	900°F	ASTM D635
Average Time of Burning (sec)	<5	<5	
Average Extent of Burning (mm)	<10	<10	
Burning Rate (in/min)	Self-extinguishing	Self-extinguishing	
Softening Starts (approx)	250°F	295°F	
Material Becomes Viscous	350°F	395°F	
Material Carbonizes	425°F	450°F	
Limiting Oxygen Index (LOI)		60	ASTM D2863
Clean Room Materials Flammability Test	NA	FPI=1.20 SDI=0.09	FM 4910

Data shown are average values and should not be used for specifications.

Purpose: To evaluate the pipe strength of 6-in. dia., SDR 11 HDPE leachate collection piping in the Phase 10 base system of the Rodefeld Landfill Vertical Expansion using designed properties and parameters.

Approach: Use referenced formulas to determine the maximum height waste can be placed above the leachate piping and the specific physical pipe properties necessary to perform adequately.

References:
1. Plastics Pipe Institute, 2nd Edition Handbook of PE Pipe, Buried PE Pipe Design (Attachment 1)
2. ISCO Industries, Typical Physical Properties and Dimension Charts, www.isco-pipe.com (Attachment 2)
3. "Soil Reaction for Buried Flexible Pipe", Amster K. Howard, U.S. Bureau of Reclamation
4. Plan of Operation, Metro Landfill Western Expansion, Appendix F - "Report on Metro Landfill - Pipe Design", Watkins, 1989
5. "HDPE Leachate Collection Pipe Design by Fundamentals of Mechanics", Harrison and Watkins, 1996, Nineteenth International Madison Waste Conference.
6. TRC, Plan of Operation, Dane County No. 2 (Rodefeld) Landfill Plan of Operation, Base Grades Plan Sheets and Appendix I, March 2014.
7. SCS Engineers, Feasibility Report, Rodefeld Landfill Vertical Expansion, Final Grades Plan Sheets, April 2021.

Assumptions:
1. Waste above the piping is assumed to be wet from leachate recirculation.
2. Wet waste unit weight is a conservative 119 pcf to include the effects of leachate recirculation.
3. Live loads are negligible above the piping. The maximum fill height over an 6-in SDR 11 HDPE pipe will be 152 feet for the current design for Phase 10.
4. Leachate collection pipes are 6-in., SDR 11 HDPE in Phase 10.
5. Allowable compressive stress for HDPE pipe is approximately 1,000 psi (Plastics Pipe Institute, Attachment 1).

Calculations: **Pipe Loading,** P_y $\qquad P_y = DL + LL$

where, P_y = Pipe Load, lb/in²
DL = Dead Load, lb/in²
LL = Live Load, lb/in²

Dead Load, DL $\qquad DL = \frac{\gamma \cdot H}{144}$

where,

γ	= Fill Unit Weight, lb/ft^3	=	**119**	(waste unit weight with recirculation)
H	= Height of Cover, ft	=	**152**	(max. waste height)
DL	= Dead Load, lb/in²		**126**	

In our case the live load = 0, due to limited live loads above the piping after placement.

so, $P_y = DL$ **126** lb/in²

Based on 6 inch SDR 11 HDPE for leachate collection piping

Outer Diameter of Pipe (OD) = **6.625** **in** (From Attachment 2)

Min. Pipe wall thickness (t) = **0.602** **in** (From Attachment 2)

Calculations: (cont.)

Deflection

A deflection of 5 to 7.5% has become the standard for limiting deflection in flexible pipes. Based on Figure 7.16 in Uni-Bell (1991) and Watkins (1989) a vertical strain of greater than 5% will never be reached for flexible pipe bedded in compacted gravel, independent of vertical soil pressure. At 90% compaction the vertical strain will always be less than 2%. The height of fill over the pipe is not a factor when the pipe is well bedded in gravel. These findings are consistent for HDPE piping with the Harrison and Watkins (1996) paper.

Wall Crushing

where,

σ = Compressive Stress, lb/in²
T = Wall Thrust, lb/in
A = Area of Pipe Wall, in²/in

$$\sigma = \frac{T}{A}$$

Wall Thrust, T

$$T = \frac{P_y \cdot D_o}{2}$$

SDR 11 HDPE Piping

where,	P_y	= Vertical Fill Pressure, lb/in^2	=	**126**	(Previously Calculated)
	D_o	= Outside Diameter, in	=	**6.625**	(SDR 11, 6-inch)
	T	= Wall Thrust, lb/in	=	**416**	
	A	= Area of Pipe Wall, in²/in	=	**0.602**	(Solid=Thickness)
So,	σ	= Compressive Stress, lb/in²	=	**691**	

Result: The allowable compressive strength of HDPE pipe is approximately 1,000 psi, so the calculated compressive stress values are acceptable and wall crushing of the pipe will be avoided when the pipe is at least SDR 11, 6-inch diameter for the leachate collection pipe. To account for the possible elevated temperature within the landfill, a temperature de-rating factor of 0.78 was applied to allowable compressive strength for HDPE pipe. This makes the maximum compressive strength 780 psi. The calculated compressive stress is below this value.

Calculations: (cont.) **Wall Crushing ont.)**

Leachate Collection Piping Maximum Height - SDR 11 HDPE

For	P_y	= Vertical Fill Pressure, lb/in^2	=	**142**	
	D_o	= Outside Diameter, in	=	**6.625**	(SDR 11, 6-inch)
	T	= Wall Thrust, lb/in	=	**470**	
	A	= Area of Pipe Wall, in^2/in	=	**0.602**	(Solid=Thickness)
	σ	= Compressive Stress, lb/in^2	=	**780**	(max. allowable with temp. reduction factor)

Maximum Height (feet) = Py*(144)/ɣ = **172**

Result: The maximum height of fill above the 6-inch SDR 11 HDPE piping is 172 feet for a fill unit weight of 119 lb/ft^3 to maintain the required minimum factor of safety against wall crushing. Wall crushing controls the maximum fill height that can be placed above the leachate collection pipes. The maximum fill height above the Phase10, 6-inch diameter piping when the Vertical Expansion is filled will be approximately 152 feet, which is lower than the maximum allowable fill height.

Attachment 1
From the Handbook of PE Pipe 2008, Second Edition by the Plastics Pipe Institute

TABLE C.1
Allowable Compressive Stress for 73°F (23°C)

	Pe Pipe Material Designation Code (1)					
	PE 2406		PE3408		PE 4710	
	PE 2708		PE 3608			
			PE 3708			
			PE 3710			
			PE 4708			
	psi	MPa	psi	MPa	psi	MPa
Allowable Compressive Stress	800	5.52	1000	6.90	1150	7.93

(1) See Chapter 5 for an explanation of the PE Pipe Material Designation Code.

Attachment 2
From the ISCO Product Catalog

4710 HDPE PIPE SIZES IPS

PE4710 Tamaños HDPE tuberías IPS

DR		11			13.5			15.5		
PE4710 Pressure Rating Resistencia a la Presión		200 psi			160 psi			138 psi		
Nom. OD DE Nominal (in)	Actual OD DE Actual (in)	Min Wall Espesor Mínimo de Pared (in)	Avg ID DI Promedio (in)	Weight Peso (lb/ft)	Min Wall Espesor Mínimo de Pared (in)	Avg ID DI Promedio (in)	Weight Peso (lb/ft)	Min Wall Espesor Mínimo de Pared (in)	Avg ID DI Promedio (in)	Weight Peso (lb/ft)
¾"	1.05	0.095	0.848	0.13	---	---	---	---	---	---
1"	1.315	0.12	1.062	0.2	---	---	---	---	---	---
1¼"	1.66	0.151	1.34	0.314	---	---	---	---	---	---
1½"	1.9	0.173	1.534	0.411	---	---	---	---	---	---
2"	2.375	0.216	1.917	0.642	0.176	2.002	0.534	0.153	2.05	0.47
3"	3.5	0.318	2.825	1.395	0.259	2.95	1.16	0.226	3.021	1.02
4"	4.5	0.409	3.633	2.31	0.333	3.793	1.92	0.29	3.885	1.687
5"	5.375	0.489	4.339	3.29	0.398	4.531	2.73	0.347	4.64	2.4
5"	5.563	0.506	4.491	3.523	0.412	4.689	2.928	0.359	4.802	2.58
6"	6.625	0.602	5.348	5	0.491	5.585	4.152	0.427	5.719	3.656
7"	7.125	0.648	5.752	5.78	0.528	6.006	4.8	0.46	6.15	4.21
8"	8.625	0.784	6.963	8.47	0.639	7.271	7.04	0.556	7.445	6.197
10"	10.75	0.977	8.678	13.16	0.796	9.062	10.932	0.694	9.28	9.626
12"	12.75	1.159	10.293	18.51	0.944	10.748	15.38	0.823	11.006	13.53
14"	14	1.273	11.302	22.32	1.037	11.801	18.54	0.903	12.085	16.31
16"	16	1.455	12.916	29.15	1.185	13.487	24.22	1.032	13.812	21.3
18"	18	1.636	14.531	36.89	1.333	15.173	30.651	1.161	15.538	26.95
20"	20	1.818	16.145	45.541	1.481	16.859	37.84	1.29	17.265	33.28
22"	22	2	17.76	55.105	1.63	18.545	45.79	1.419	18.991	39.712
24"	24	2.182	19.375	65.58	1.778	20.231	54.49	1.548	20.717	47.92
26"	26	2.364	20.989	77.44	1.926	21.917	64.261	1.677	22.444	56.532
28"	28	2.545	22.604	89.785	2.074	23.603	74.522	1.806	24.17	65.563
30"	30	2.727	24.218	103.076	2.222	25.289	85.543	1.935	25.897	75.264
32"	32	2.909	25.833	117.285	2.37	26.975	97.324	2.065	27.623	85.672
34"	34	3.091	27.447	132.411	2.519	28.661	109.905	2.194	29.35	96.714
36"	36	3.273	29.062	148.454	2.667	30.347	123.208	2.323	31.076	108.424
42"	42	---	---	---	3.111	35.404	167.675	2.71	36.255	147.568
48"	48	---	---	---	---	---	---	3.097	41.435	192.774
54"	54	---	---	---	---	---	---	3.484	46.614	243.921

1. Pressures are based on using water at 23°C (73°F).
2. Average inside diameter calculated using actual OD and minimum wall plus 6% for use in estimating fluid flows. Actual ID will vary.
3. Other piping sizes or DR's may be available upon request.
4. Standard Lengths:
   - 40' for 2"-24"
   - 50' for 26" and larger
   - Coils available for ¾ - 4" (6" by special order)

1. Las presiones están basadas en el uso de agua a 23°C (73°F)
2. El diámetro interno promedio calculado el diámetro externo real y la pared mínima más 6% para uso la estimación de flujos de fluidos. El diámetro interno real variará.
3. Otros tamaños o DR de tubería pueden estar disponibles bajo pedido.
4. Longitudes estándar
   - 40 pies para 2 -24 pulgadas
   - 50 pies para 26 pulgadas o mayores
   - Bobinas disponibles para ¾ a 6 pulgadas (8 pulgadas para pedidos especiales)

March 5, 2021
File No. 25220091.00

TECHNICAL MEMORANDUM

ANALYSIS BY: Keith Gilkey, PE
Deb Nelson, PE

REVIEWED BY: Phil Gearing, PE
Betsy Powers, PE

SUBJECT: Waste Slope Stability Analyses
Eastern Vertical Expansion
Dane County Landfill Site No. 2

PURPOSE

The purpose of the slope stability analysis was to evaluate the final 4H:1V waste slope at the highest waste grade and longest slope length in the area of the proposed Eastern Vertical Expansion (vertical expansion) at Dane County Landfill Site No. 2.

CONCLUSION

The attached results confirm that the vertical expansion final waste slope of 4H:1V and peaked out at an approximate elevation of 1,065 feet above mean sea level will be stable.

APPROACH

SCS Engineers (SCS) evaluated the waste mass slope stability of the final waste slope. The location of the cross-section is shown on the attached figure. The final waste slope was evaluated for block failure and circular failure. The properties of wet waste due to the effects of leachate recirculation were used for the analyses.

RESULTS

SCS recommends a minimum safety factor of 1.5 for the final waste slope. The results indicate that the 4H:1V waste slope with the assumed parameters has an acceptable minimum safety factor of approximately 2.2 for block failure and 2.7 for circular failure, which exceed the minimum recommended safety factor of 1.5.

REFERENCES

1. TRC, 2014, Global Slope Stability, Eastern Expansion Plan of Operation, Appendix F.
2. Geo-Slope International, Ltd., GeoStudio 2016, Version 8.16.2.14053, Slope/W slope stability software.

ASSUMPTIONS

- The waste is municipal solid waste (MSW). The waste properties will likely change over time due to the effects of leachate recirculation.

- A final waste fill slope of 4H:1V is representative of the design final waste slope for the vertical expansion waste material.

- Circular (Spencer's method) and sliding block (Janbu's method) failure stability analyses are appropriate to evaluate the waste mass stability.

- The geomembrane liner will be smooth on the base and textured on the sidewalls. An interface friction angle for smooth geomembrane was used for the analyses. This approach is conservative. It is inferred that the textured geomembrane along the sidewalls will further increase the slope stability safety factors.

- Low-strength waste materials, if any, will be well mixed with the municipal solid waste to avoid low-strength waste zones. The site will be operated to avoid buildup of liquids or gas that could result in unstable waste slope conditions.

- Material properties are as shown in the table below, based on the indicated 2014 Eastern Expansion Plan of Operation reference:

Material	Unit Weight (pcf)	Friction Angle (degrees)	Cohesion (psf)	Reference
MSW with Leachate Recirculation	119	30	300	1
Geosynthetic Liner Interfaces	115	11	0	1
Cover General Fill	115	30	0	1
Compacted General Fill	125	30	0	1
Clay Liner	130	30	0	1
Silty Sand – Till 1	115	32	0	1
Sand - Outwash	115	32	0	1
Clay - Lacustrine	128	30	0	1
Silty Sand – Till 2	123	35	0	1

Attachments: Cross Section Location Figure
Slope/W Outputs

DLN/lmh/KRG/PEG/BLP
Slope/W coordinates checked by BSS

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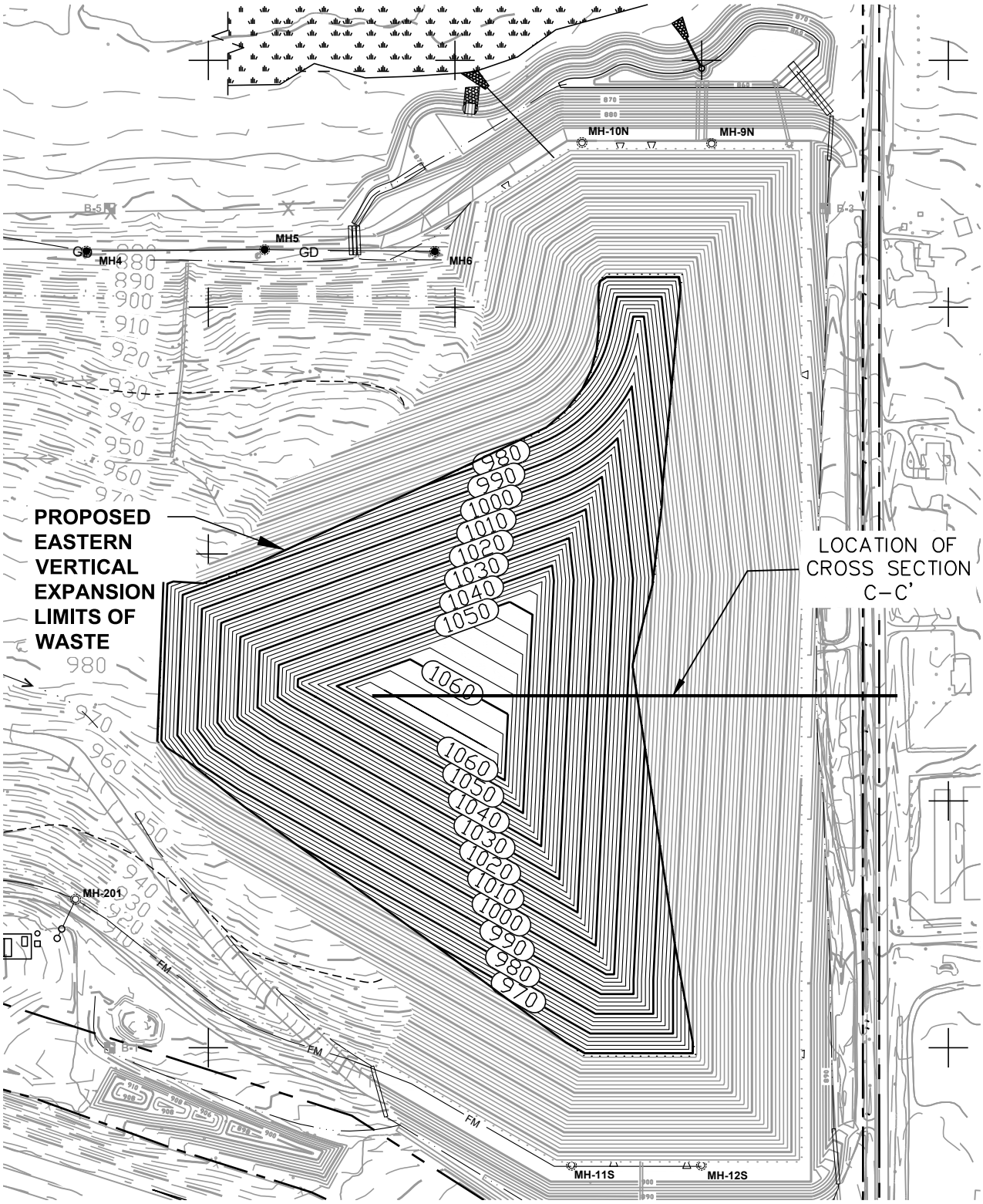


CLIENT	DANE COUNTY DEPARTMENT OF WASTE AND RENEWABLES 1919 ALLIANT ENERGY CENTER WAY MADISON, WI 53713	SITE	DANE COUNTY LANDFILL NO. 2 7102 US HWY 12/18 MADISON, WISCONSIN
			LOCATION OF STABILITY ANALYSIS CROSS SECTION C–C'

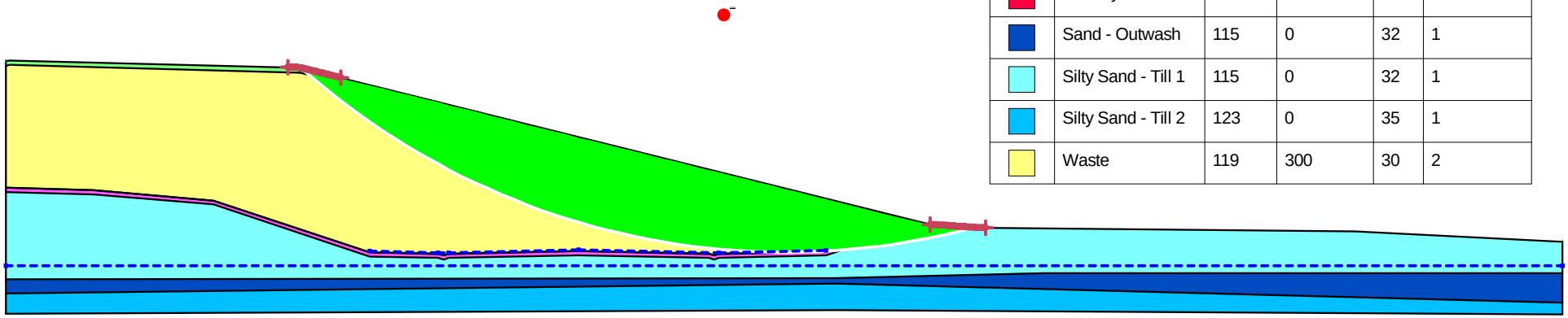
PROJECT NO.	25220091.00	DRAWN BY:	KRG	ENGINEER	FIGURE
DRAWN:	02/02/21	CHECKED BY:	DN	SCS ENGINEERS 2830 DAIRY DRIVE MADISON, WI 53718-6751 PHONE: (608) 224-2830	1-3
REVISED:	02/02/21	APPROVED BY:	BLP 05/14/2021		

I:\25220091.00\Drawings\Stability Analysis\Location Stability Analysis Cross Section.dwg, 5/12/2021 1:49:50 PM

F of S: 2.660

Name: Dane County Vertical Expansion
Description: Cross Section C-C'
Date: 2/16/2021
File Name: Slope C-C'_Circular_210216.gsz

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Piezometric Line
	Compacted Liner	130	0	30	
	General Fill Cover	115	0	30	
	Geosnythetic	115	0	11	
	Sand - Outwash	115	0	32	1
	Silty Sand - Till 1	115	0	32	1
	Silty Sand - Till 2	123	0	35	1
	Waste	119	300	30	2



Dane County Vertical Expansion

File Information

File Version: 8.16
Created By: Gilkey, Keith
Last Edited By: Gilkey, Keith
Revision Number: 42
Date: 2/16/2021
Time: 8:15:23 AM
Tool Version: 8.16.5.15361
File Name: Slope C-C'_Circular_210216.gsz
Directory: I:\25220091.00\Data and Calculations\Geotechnical Calculations\Slope Stability\
Last Solved Date: 2/16/2021
Last Solved Time: 8:16:54 AM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Dane County Vertical Expansion

Description: Cross Section C-C'
Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °

Driving Side Maximum Convex Angle: 5 °
Optimize Critical Slip Surface Location: No
Tension Crack
Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 50
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Waste

Model: Mohr-Coulomb
Unit Weight: 119 pcf
Cohesion': 300 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 2

Compacted Liner

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °

General Fill Cover

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °

Silty Sand - Till 1

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °

Pore Water Pressure
Piezometric Line: 1

Sand - Outwash

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Silty Sand - Till 2

Model: Mohr-Coulomb
Unit Weight: 123 pcf
Cohesion': 0 psf
Phi': 35 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Geosnythetic

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 11 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (272.1808, 1,058.4798) ft
Left-Zone Right Coordinate: (323.1, 1,048.3581) ft
Left-Zone Increment: 50
Right Projection: Range
Right-Zone Left Coordinate: (890.5, 906.9) ft
Right-Zone Right Coordinate: (943.9, 903.8918) ft
Right-Zone Increment: 50
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (0, 1,064.5) ft
Right Coordinate: (1,500, 890) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	867
Coordinate 2	1,500	867

Piezometric Line 2

Coordinates

	X (ft)	Y (ft)
Coordinate 1	350.8	880.9
Coordinate 2	416.5	879.6
Coordinate 3	427	879.6
Coordinate 4	552.2	882.1
Coordinate 5	687	879.6
Coordinate 6	790.4	881.9

Points

	X (ft)	Y (ft)
Point 1	0	942.2
Point 2	84.7	940
Point 3	200	930
Point 4	350.8	879.8
Point 5	416.5	878.5
Point 6	422.2	876.9
Point 7	427	878.5
Point 8	552.2	881
Point 9	677.4	878.5
Point 10	682.2	876.9
Point 11	687	878.5
Point 12	790.4	880.8
Point 13	868.9	907
Point 14	0	1,064.5

Point 15	283.7	1,058.2
Point 16	889	907
Point 17	0	938.2
Point 18	84.7	936
Point 19	200	926
Point 20	350.8	875.8
Point 21	416.5	874.5
Point 22	422.2	872.9
Point 23	427	874.5
Point 24	552.2	877
Point 25	677.4	874.5
Point 26	682.2	872.9
Point 27	687	874.5
Point 28	790.4	876.8
Point 29	868.9	903
Point 30	0	942.3
Point 31	84.7	940.1
Point 32	200	930.1
Point 33	350.8	879.9
Point 34	416.5	878.6
Point 35	422.2	877
Point 36	427	878.6
Point 37	552.2	881.1
Point 38	677.4	878.6
Point 39	682.2	877
Point 40	687	878.6
Point 41	790.4	880.9
Point 42	868.9	907.1
Point 43	0	1,059.5
Point 44	283.7	1,053.2
Point 45	889	903
Point 46	0	840
Point 47	800	850
Point 48	800	824
Point 49	1,500	831.5
Point 50	1,500	820

Point 51	0	820.5
Point 52	0	854
Point 53	800	855
Point 54	1,000	860
Point 55	1,500	860
Point 56	934	904
Point 57	1,300	900
Point 58	1,500	890
Point 59	3.7	1,065
Point 60	3.7	1,061

Regions

	Material	Points	Area (ft²)
Region 1	Silty Sand - Till 2	51,46,47,49,50,48	31,325
Region 2	Sand - Outwash	52,53,54,55,49,47,46	20,575
Region 3	Compacted Liner	17,18,19,20,21,22,23,24,25,26,27,28,29,45,16,13,12,11,10,9,8,7,6,5,4,3,2,1	3,556
Region 4	General Fill Cover	43,60,44,42,13,16,15,59,14	4,229.9
Region 5	Geosnythetic	1,2,3,4,5,6,7,8,9,10,11,12,13,42,41,40,39,38,37,36,35,34,33,32,31,30	86.89
Region 6	Waste	43,60,44,42,41,40,39,38,37,36,35,34,33,32,31,30	92,614
Region 7	Silty Sand - Till 1	17,18,19,20,21,22,23,24,25,26,27,28,29,45,16,56,57,58,55,54,53,52	60,248

Current Slip Surface

Slip Surface: 13,699
F of S: 2.660
Volume: 35,473.375 ft³
Weight: 4,209,687.5 lbs
Resisting Moment: 1.759734e+009 lbs-ft
Activating Moment: 6.6160152e+008 lbs-ft
Resisting Force: 2,384,530.4 lbs
Activating Force: 896,546.59 lbs
F of S Rank (Analysis): 1 of 54,621 slip surfaces
F of S Rank (Query): 1 of 54,621 slip surfaces
Exit: (933.20293, 904.05314) ft
Entry: (284.65988, 1,057.9602) ft

Radius: 700.9388 ft
Center: (751.31251, 1,580.9808) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	288.63369	1,054.4682	0	213.99694	123.55119	0
Slice 2	299.88156	1,044.8513	0	767.70245	443.23321	300
Slice 3	314.42969	1,032.9278	0	1,538.3612	888.17326	300
Slice 4	328.97781	1,021.637	0	2,272.1411	1,311.8213	300
Slice 5	343.52594	1,010.9411	0	2,969.1746	1,714.2538	300
Slice 6	357.37	1,001.2728	-7,519.3732	3,599.6922	2,078.2833	300
Slice 7	370.51	992.5563	-6,991.6888	4,166.4842	2,405.5208	300
Slice 8	383.65	984.25648	-6,490.0041	4,703.7167	2,715.6921	300
Slice 9	396.79	976.35614	-6,013.2473	5,211.5189	3,008.8718	300
Slice 10	409.93	968.83982	-5,560.4526	5,690.009	3,285.1282	300
Slice 11	421.75	962.37886	-5,165.401	6,097.1293	3,520.1793	300
Slice 12	433.26	956.39418	-4,784.157	6,468.0672	3,734.3403	300
Slice 13	445.78	950.17442	-4,380.4435	6,847.5725	3,953.4478	300
Slice 14	458.3	944.26157	-3,995.8822	7,200.7322	4,157.3446	300
Slice 15	470.82	938.64718	-3,629.9439	7,527.5714	4,346.0454	300
Slice 16	483.34	933.32346	-3,282.144	7,828.0958	4,519.5532	300

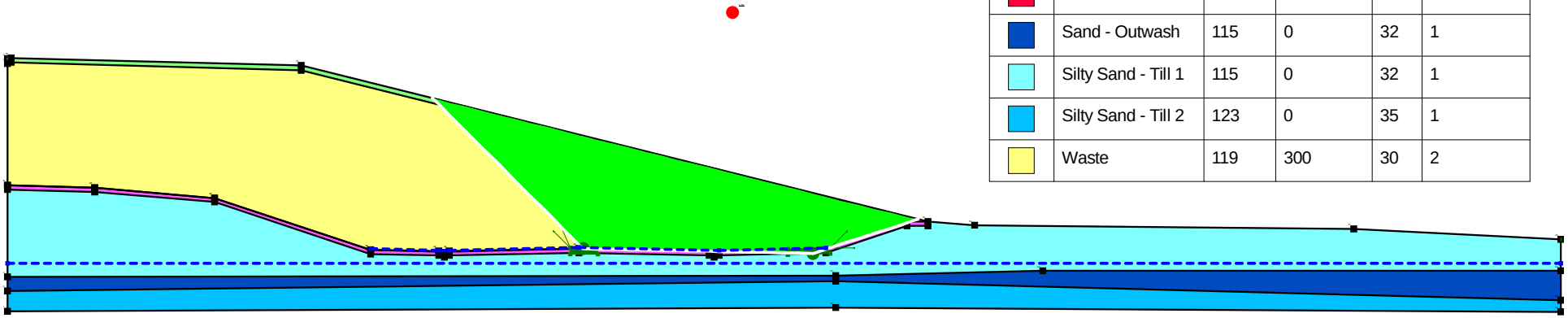
Slice 17	495.86	928.28331	-2,952.0385	8,102.2906	4,677.8597	300
Slice 18	508.38	923.5202	-2,639.2202	8,350.1197	4,820.9439	300
Slice 19	520.9	919.02814	-2,343.3157	8,571.525	4,948.7723	300
Slice 20	533.42	914.80165	-2,063.9828	8,766.4257	5,061.2982	300
Slice 21	545.94	910.8357	-1,800.9078	8,934.7174	5,158.4615	300
Slice 22	558.94	906.9935	-1,561.1546	9,080.6032	5,242.6887	300
Slice 23	572.42	903.29056	-1,345.6908	9,201.8334	5,312.681	300
Slice 24	585.9	899.87451	-1,148.1292	9,291.6541	5,364.539	300
Slice 25	599.38	896.74105	-968.20164	9,349.8014	5,398.1104	300
Slice 26	612.86	893.88632	-805.66667	9,375.9732	5,413.2207	300
Slice 27	626.34	891.30686	-660.30823	9,369.8271	5,409.6722	300
Slice 28	639.82	888.99959	-531.93417	9,330.9785	5,387.2429	300
Slice 29	653.3	886.96178	-420.37502	9,258.9982	5,345.6851	300
Slice 30	666.78	885.19107	-325.48299	9,153.41	5,284.7237	300
Slice 31	680.26	883.68543	-247.13105	9,013.6877	5,204.055	300
Slice 32	693.59111	882.454	-168.94121	8,841.5431	5,104.6673	300
Slice 33	706.77334	881.48968	-90.470347	8,637.1631	4,986.6685	300
Slice 34	719.95557	880.77483	-27.566888	8,398.3334	4,848.7801	300
Slice 35	732.86916	880.31324	19.16049	8,129.7075	4,682.6265	300

Slice 36	745.51413	880.09451	50.36049	7,832.1746	4,492.8325	300
Slice 37	754.71097	880.05614	0	7,311.9352	1,421.2962	0
Slice 38	766.89875	880.27724	0	6,953.2587	1,351.5766	0
Slice 39	779.08432	880.5983	0	6,578.9462	1,278.8176	0
Slice 40	786.17823	880.92245	55.139551	6,648.4281	3,806.6369	300
Slice 41	790.81959	881.15639	0	6,494.9478	3,749.8599	300
Slice 42	798.95685	881.70592	0	6,185.949	3,571.4593	0
Slice 43	812.89707	882.78061	-984.71003	5,704.5618	3,564.6058	0
Slice 44	825.34217	883.99039	-1,060.2	5,171.5051	3,231.5151	0
Slice 45	837.78726	885.42492	-1,149.7149	4,599.5406	2,874.1119	0
Slice 46	850.23236	887.0856	-1,253.3417	3,987.3146	2,491.5507	0
Slice 47	862.67745	888.97407	-1,371.1821	3,333.3524	2,082.9098	0
Slice 48	873.925	890.86826	-1,489.3796	2,719.9975	1,699.6431	0
Slice 49	883.975	892.72964	-1,605.5295	2,155.1377	1,346.6795	0
Slice 50	896.36716	895.25663	-1,763.214	1,526.7251	954.00375	0
Slice 51	911.10147	898.54002	-1,968.097	959.84756	599.77933	0
Slice 52	925.83578	902.15906	-2,193.9255	331.922	207.40788	0

F of S: 2.198

Name: Dane County Vertical Expansion
Description: Cross Section C-C'
Date: 2/16/2021
File Name: Slope C-C' - Sliding Block_210216.gsz

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Piezometric Line
	Compacted Liner	130	0	30	
	General Fill Cover	115	0	30	
	Geosnythetic	115	0	11	
	Sand - Outwash	115	0	32	1
	Silty Sand - Till 1	115	0	32	1
	Silty Sand - Till 2	123	0	35	1
	Waste	119	300	30	2



Dane County Vertical Expansion

File Information

File Version: 8.16
Created By: Gilkey, Keith
Last Edited By: Gilkey, Keith
Revision Number: 70
Date: 2/16/2021
Time: 8:26:09 AM
Tool Version: 8.16.5.15361
File Name: Slope C-C' - Sliding Block_210216.gsz
Directory: I:\25220091.00\Data and Calculations\Geotechnical Calculations\Slope Stability\
Last Solved Date: 2/16/2021
Last Solved Time: 8:48:40 AM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Dane County Vertical Expansion

Description: Cross Section C-C'
Kind: SLOPE/W
Method: Janbu
Settings
- PWP Conditions Source: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Block
- Critical slip surfaces saved: 1
- Resisting Side Maximum Convex Angle: 1 °

Driving Side Maximum Convex Angle: 5 °
Restrict Block Crossing: No
Optimize Critical Slip Surface Location: No
Tension Crack
Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft

Materials

Waste

Model: Mohr-Coulomb
Unit Weight: 119 pcf
Cohesion': 300 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 2

Compacted Liner

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °

General Fill Cover

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °

Silty Sand - Till 1

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Sand - Outwash

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Silty Sand - Till 2

Model: Mohr-Coulomb
Unit Weight: 123 pcf
Cohesion': 0 psf
Phi': 35 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Geosnythetic

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 11 °
Phi-B: 0 °

Slip Surface Limits

Left Coordinate: (0, 1,064.5) ft
Right Coordinate: (1,500, 890) ft

Slip Surface Block

Left Grid
Upper Left: (543.575, 881.7) ft
Lower Left: (543.8, 876.05) ft
Lower Right: (570.05, 876.05) ft
X Increments: 15
Y Increments: 15
Starting Angle: 115 °
Ending Angle: 135 °
Angle Increments: 5
Right Grid
Upper Left: (753.6, 880.625) ft
Lower Left: (753.6, 875.475) ft
Lower Right: (794.475, 876.475) ft
X Increments: 10
Y Increments: 10

Starting Angle: 0 °
Ending Angle: 45 °
Angle Increments: 5

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	867
Coordinate 2	1,500	867

Piezometric Line 2

Coordinates

	X (ft)	Y (ft)
Coordinate 1	350.8	880.9
Coordinate 2	416.5	879.6
Coordinate 3	427	879.6
Coordinate 4	552.2	882.1
Coordinate 5	687	879.6
Coordinate 6	790.4	881.9

Points

	X (ft)	Y (ft)
Point 1	0	942.2
Point 2	84.7	940
Point 3	200	930
Point 4	350.8	879.8
Point 5	416.5	878.5
Point 6	422.2	876.9
Point 7	427	878.5
Point 8	552.2	881
Point 9	677.4	878.5
Point 10	682.2	876.9

Point 11	687	878.5
Point 12	790.4	880.8
Point 13	868.9	907
Point 14	0	1,064.5
Point 15	283.7	1,058.2
Point 16	889	907
Point 17	0	938.2
Point 18	84.7	936
Point 19	200	926
Point 20	350.8	875.8
Point 21	416.5	874.5
Point 22	422.2	872.9
Point 23	427	874.5
Point 24	552.2	877
Point 25	677.4	874.5
Point 26	682.2	872.9
Point 27	687	874.5
Point 28	790.4	876.8
Point 29	868.9	903
Point 30	0	942.3
Point 31	84.7	940.1
Point 32	200	930.1
Point 33	350.8	879.9
Point 34	416.5	878.6
Point 35	422.2	877
Point 36	427	878.6
Point 37	552.2	881.1
Point 38	677.4	878.6
Point 39	682.2	877
Point 40	687	878.6
Point 41	790.4	880.9
Point 42	868.9	907.1
Point 43	0	1,059.5
Point 44	283.7	1,053.2
Point 45	889	903
Point 46	0	840

Point 47	800	850
Point 48	800	824
Point 49	1,500	831.5
Point 50	1,500	820
Point 51	0	820.5
Point 52	0	854
Point 53	800	855
Point 54	1,000	860
Point 55	1,500	860
Point 56	934	904
Point 57	1,300	900
Point 58	1,500	890
Point 59	3.7	1,065
Point 60	3.7	1,061

Regions

	Material	Points	Area (ft²)
Region 1	Silty Sand - Till 2	51,46,47,49,50,48	31,325
Region 2	Sand - Outwash	52,53,54,55,49,47,46	20,575
Region 3	Compacted Liner	17,18,19,20,21,22,23,24,25,26,27,28,29,45, 16,13,12,11,10,9,8,7,6,5,4,3,2,1	3,556
Region 4	General Fill Cover	43,60,44,42,13,16,15,59,14	4,229.9
Region 5	Geosnythetic	1,2,3,4,5,6,7,8,9,10,11,12,13,42,41,40,39,38,37, 36,35,34,33,32,31,30	86.89
Region 6	Waste	43,60,44,42,41,40,39,38,37,36,35,34,33,32,31,30	92,614
Region 7	Silty Sand - Till 1	17,18,19,20,21,22,23,24,25,26,27,28,29,45,16,56, 57,58,55,54,53,52	60,248

Current Slip Surface

Slip Surface: 940,275
F of S: 2.198
Volume: 29,496.04 ft³
Weight: 3,503,621.5 lbs
Resisting Force: 1,433,666 lbs
Activating Force: 652,377.89 lbs
F of S Rank (Analysis): 1 of 1,115,136 slip surfaces
F of S Rank (Query): 1 of 1,115,136 slip surfaces

Exit: (879.22909, 909.44071) ft
Entry: (410.20072, 1,026.6009) ft
Radius: 231.43522 ft
Center: (666.6643, 1,055.891) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	413.35036	1,023.4513	0	215.21077	124.252	0
Slice 2	421.75	1,015.0517	-8,452.184	693.14071	400.18497	300
Slice 3	434.825	1,001.9767	-7,626.554	1,617.2133	933.69853	300
Slice 4	450.475	986.32667	-6,630.494	2,723.7593	1,572.5632	300
Slice 5	466.125	970.67667	-5,634.434	3,830.3053	2,211.4278	300
Slice 6	481.775	955.02667	-4,638.374	4,936.8513	2,850.2924	300
Slice 7	497.425	939.37667	-3,642.314	6,043.3973	3,489.157	300
Slice 8	513.075	923.72667	-2,646.254	7,149.9433	4,128.0217	300
Slice 9	528.725	908.07667	-1,650.194	8,256.4893	4,766.8863	300
Slice 10	544.375	892.42667	-654.134	9,363.0353	5,405.7509	300
Slice 11	553.47447	883.3272	-78.052	10,006.421	5,777.2097	300
Slice 12	555.26098	881.54069	31.358528	10,139.26	5,835.7994	300
Slice 13	563.41057	880.83876	0	12,743.417	2,477.0694	0
Slice 14	578.64469	880.49997	0	12,337.437	2,398.1547	0
Slice 15	593.83781	880.20217	0	11,922.003	2,317.4026	0

Slice 16	609.03094	879.90438	0	11,506.569	2,236.6505	0
Slice 17	624.22406	879.60658	0	11,091.136	2,155.8984	0
Slice 18	639.41719	879.30878	0	10,675.702	2,075.1462	0
Slice 19	654.61031	879.01098	0	10,260.268	1,994.3941	0
Slice 20	669.80344	878.71319	0	9,844.8344	1,913.642	0
Slice 21	682.2	878.47021	76.05408	9,471.6982	5,424.5776	300
Slice 22	694.59375	878.22728	0	9,140.3906	5,277.207	0
Slice 23	709.78125	877.92959	0	8,733.4541	5,042.2621	0
Slice 24	724.96875	877.6319	0	8,326.5176	4,807.3172	0
Slice 25	740.15625	877.33422	0	7,919.5811	4,572.3723	0
Slice 26	755.34375	877.03653	0	7,512.6446	4,337.4274	0
Slice 27	770.53125	876.73884	0	7,105.7081	4,102.4825	0
Slice 28	784.2625	878.58419	0	7,103.7763	4,101.3672	0
Slice 29	798.25	883.12901	0	6,036.4143	3,485.1254	0
Slice 30	813.95	888.23025	0	4,864.1826	2,808.3371	0
Slice 31	829.65	893.33149	0	3,691.9509	2,131.5488	0
Slice 32	845.35	898.43273	0	2,519.7191	1,454.7605	0
Slice 33	861.05	903.53397	0	1,347.4874	777.97224	0
Slice 34	870.30868	906.54229	0	652.07719	376.47694	0

Slice 35	875.47322	908.22036	0	271.3914	156.6879	0