

**HAM-75-7.85
HAM-75-0857
I-75 OVER TOWNE STREET
PID NO. 77889
HAMILTON COUNTY, OHIO**

**DRAFT STRUCTURE
FOUNDATION EXPLORATION
REPORT**

Prepared For:
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Rii Project No. B-10-020

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May 14, 2012 (Revised August 8, 2013)

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Director of Transportation
EMH&T
5500 New Albany Road
Columbus, OH 43054

**Re: Draft Structure Foundation Exploration
HAM-75-7.85
HAM-75-0857 – I-75 over Towne Street
PID No. 77889
Rii Project No. B-10-020**

Dear Mr. Kagel:

Resource International, Inc. (Rii) is pleased to submit this DRAFT structure foundation exploration report for the referenced project. This report includes recommendations for the proposed replacement of the HAM-75-0857 bridge carrying I-75 over Towne Street as part of the HAM-75-7.85 project. The proposed bridge is located approximately 2.0 miles south of the Lockland Split on the north side of Cincinnati, in Hamilton County, Ohio.

We sincerely appreciate the opportunity to be of service to you on this project. If you have any questions regarding the structure foundation exploration or this report, please contact us.

Sincerely,

RESOURCE INTERNATIONAL, INC.

Brian R. Trenner, P.E.
Project Engineer

Jonathan P. Sterenberg, P.E.
Director of Geotechnical Services

Enclosure: DRAFT Structure Foundation Exploration Report

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EXECUTIVE SUMMARY

Resource International, Inc. (Rii) has completed a DRAFT structure foundation exploration performed for the HAM-75-0857 bridge structure carrying I-75 over Towne Street, as shown on the Vicinity Map and Boring Plan presented in Appendix II of the full report. The existing structure is a three-span bridge with a total length of approximately 163 feet. It is understood that the existing structure will be completely removed and that the proposed structure will consist of a single-span bridge with semi-integral abutments supported on deep foundations consisting of driven piles and MSE walls embankments.

A preliminary structure foundation exploration was performed by CTL Engineering for this bridge structure replacement as part of the HAM-75-2.30 Step 7 Preliminary Engineering (PID No. 76257) and their findings are presented in the report dated December 15, 2007. No additional borings were obtained at this structure for the current exploration. Therefore, all recommendations contained herein are based on information obtained from the preliminary exploration. For a complete summary of the field operations and findings for the borings performed by CTL Engineering, please reference the December 2007 report.

Exploration and Findings

Two borings, designated as B-181-0-07 and B-182-0-07, were performed by CTL for this bridge, one at each proposed abutment location. The borings were advanced to depths of 60.0 and 105.0 feet below the existing ground surface, respectively, and SPT sampling was performed at a maximum of 5.0-foot intervals to obtain representative soil samples for laboratory classification testing.

In general, the borings performed by CTL encountered soft to hard cohesive soils generally described as brown, dark brown and gray sandy silt, silt and clay, silty clay and clay (ODOT A-4a, A-6a, A-6b, A-7-6) overlying very loose to very dense granular soils generally described as brown gravel, gravel and sand, gravel with sand and silt, fine sand and coarse and fine sand (ODOT A-1-a, A-1-b, A-2-4, A-3, A-3a). Groundwater was encountered in borings B-181 and B-182 at an elevation of 499.8 and 497.0 feet msl, respectively.

Bedrock was not encountered in any of the borings performed for this exploration.

Analyses and Recommendations

Proposed structural data was obtained from preliminary design details provided by the Rii design team and are included in Section 5.0 of the full report. It is understood that the new structure will consist of a single-span bridge with semi-integral abutments supported on deep foundations consisting of driven piles and MSE walls embankments.



Bridge Foundation Recommendations

It is recommended that a deep foundation system consisting of driven piles be employed for support of the proposed bridge foundation elements. Based on the soil encountered at this site, it is recommended that 12.0-inch cast-in-place (CIP) pipe piles (ODOT Item 507.06) be employed for foundation support. The following table shows recommended pile lengths of the CIP pipe piles and the corresponding ultimate bearing value (R_{ndr}) and AASHTO LRFD reduction factors (ϕ).

Pile Recommendations

Boring No.	Ground Elevation ¹	Pile Size ²	Elevations (ft msl)		Embedment Depth ⁴ (feet)	R_{ndr} ^{5,6} (kips/pile)	Sleeve Length ⁷ (ft)	ϕ ⁸
			Top ³	Tip				
B-181 (Rear Abutment)	539.8	12" CIP	549.2	493.0	38	225	18.2	0.70
B-182 (Forward Abutment)	531.0	12" CIP	549.7	484.6	47	215	18.1	0.70

1. Ground elevation listed is the ground elevation at the boring location.
2. The pile wall thickness utilized in the analysis was determined in accordance with the equation provided in ODOT Item 507.06 and was rounded up to the nearest 1/16-inch increment. For both substructures, the fuel setting for the hammer in the driveability analysis was reduced from maximum to limit the stroke of the hammer and reduce the driving stresses induced on the pile.
3. Pile top elevation is at the proposed bottom of footing elevation.
4. Embedment depths represent the length of pile in contact with the soil.
5. The embedment depth and corresponding ultimate bearing value listed are based on the maximum driving depth that can be achieved based on driveability requirements for the pile wall thickness required per ODOT Item 506.07.
6. The ultimate bearing value listed does not include capacity reduction due to downdrag loads. Downdrag loads and considerations are presented in Section 5.1.2.
7. Sleeve length represents the required length of pile that should be sleeved within the MSE wall backfill.
8. The resistance factor listed assumes dynamic testing of the pile elements per Section 303.4.2.7 of the ODOT BDM. Alternate resistance factors may be applied based on the type and frequency of field testing specified.

NOTE: The top of pile elevation coincides with the bottom of footing elevations, and the estimated pile lengths reflect exclusively the length of the pile in contact with the soil. **Embedment length of the pile into the footing is not included.** Estimated pile lengths are rounded up to the nearest foot.

The total anticipated settlement at the rear and forward abutments at the face of the wall are 0.75 inches and 0.90 inches, respectively. Based on the total anticipated settlement at the face of the wall, downdrag loads are anticipated to develop if the piles are driven to the design tip elevation prior to construction of the MSE walls. If it is considered that

the settlement of the granular material will take place immediately following construction of the MSE walls, the total anticipated settlement at the rear and forward abutments at the face of the wall will be reduced to 0.30 inches and 0.33 inches, respectively. Therefore, provided that piles are installed to the design tip elevation following completion of the MSE walls, downdrag loads are not anticipated to develop.

MSE Wall Recommendations

Based upon the proposed plan information, wall heights at the rear and forward abutments are anticipated to be 28.2 feet from the top of the leveling pad to the proposed profile grade of the roadway at each abutment location.

Soft to medium stiff silt and clay (ODOT A-6a) were encountered at the ground surface, which is also at the proposed bearing elevation, in boring B-182 and extending to a depth of 7.5 feet below the ground surface. Hand penetrometer values were not provided on the boring logs; however, based on the low blow counts obtained within this soil layer, it recommended that this material be stabilized or excavated and replaced with suitable embankment fill to provide a stable bearing surface for the MSE wall. Material identified as sandy silt (ODOT A-4a) material was encountered at the proposed bearing elevation in boring B-181. Based on gradation results provided on the boring log at this elevation, the silt content neared a level of 50 percent. The bearing soils in this area should be closely observed during construction to verify that unstable soils high in silt content are not present at the bearing elevation.

The anticipated bearing materials at the abutment locations consist of loose sandy silt (ODOT A-4a) and soft to medium stiff silt and clay (ODOT A-6a). As noted above, it is recommended that the soft to medium stiff silt and clay encountered at the bearing elevation in boring B-182 be excavated and replaced with suitable embankment material as noted in Section 5.2.1 of the full report. MSE wall foundations bearing on these soils or engineered fill, placed and compacted as described in Section 5.4 of the full report, may be proportioned for a nominal bearing resistance as indicated in the following table. A geotechnical resistance factor of $\phi_b=0.65$ was considered in calculating the factored nominal bearing resistance at the strength limit state. Based on the minimum length of reinforced soil mass presented in the table below and utilizing the soil parameters listed in Section 5.2.1 of the full report, the bearing pressures on the front portion of the wall **will not exceed** the factored nominal bearing resistance at the strength limit state at either of the abutment locations provided the subgrade at each abutment location is prepared as noted above.



HAM-75-0857 MSE Wall Spread Footing Design Parameters

Boring No.	Maximum Wall Height (ft)	Minimum Reinforcement Length ¹	Nominal Bearing Resistance (ksf)		Total Settlement ³ (in)
			Service	Strength ²	
B-181 (Rear Abutment)	28.2	0.70(H)	9.3	28.0	2.43 / 0.75
B-182 (Forward Abutment)	28.2	0.75(H)	3.4	10.3	1.65 / 0.90

1. The minimum reinforcement length is expressed as a percentage of the wall height, H, at the respective location.
2. The nominal bearing resistance at the strength limit state is unfactored. Rii recommends that a resistance factor of $\phi_b=0.65$ be considered when calculating the factored nominal bearing resistance at the strength limit state.
3. The first value represents the anticipated total settlement at the center of the reinforced soil mass, and the second values represents the anticipated total settlement at the facing of the wall.

For MSE walls bearing on soil, the limiting eccentricity is one-fourth of the base width of the wall. Based on the soil parameters listed in Section 5.2.1 of the full report, for MSE walls designed with minimum strap lengths as noted above, the calculated eccentricity of the resultant force **will not exceed** the limiting eccentricity at the strength limit state.

Based on the soil parameters listed in Section 5.2.1 of the full report for the foundation and retained material, a coefficient of sliding friction of 0.42 was utilized for design. A geotechnical resistance factor of $\phi_\tau=1.0$ was considered when calculating the factored shear resistance between the soil and foundation for sliding. Based on the soil parameters listed in Section 5.2.1 of the full report, for MSE walls designed with minimum strap lengths as noted above, the resultant horizontal forces on the back of the MSE wall **will not exceed** the factored shear resistance at the strength limit state.

Overall (global) stability for MSE walls supporting structural foundations on spread footings is satisfied when a minimum factor of safety of 1.5 is obtained under loading conditions at the service limit state. Based on the soil parameters listed in Section 5.2.1 of the full report, for MSE walls designed with minimum strap lengths as noted above, the resulting factor of safety under drained and undrained conditions was greater than 1.5.

Please note that this executive summary does not contain all the information presented in the report. The unabridged subsurface exploration report should be read in its entirety to obtain a more complete understanding of the information presented.



1.0 INTRODUCTION

The overall purpose of this project is to provide detailed subsurface information and recommendations for the design and construction of the HAM-75-7.85 project in Hamilton County, Ohio. This project represents the northern portion of HAM-75-2.30 Mill Creek Expressway improvements. The overall project will consist of roadway improvements, and several retaining wall and bridge replacements along I-75 from Vine Street to State Route 126. The project site is located in the community limits of St. Bernard, Elmwood Place, Roselawn, and Cincinnati, in Hamilton County, Ohio.

This DRAFT report is a presentation of the structure foundation exploration performed for the HAM-75-0857 bridge structure carrying I-75 over Towne Street, as shown on the Vicinity Map and Boring Plan presented in Appendix II. The existing structure is a three-span bridge with a total length of approximately 163 feet. It is understood that the existing structure will be completely removed and that the proposed structure will consist of a single-span bridge with semi-integral abutments supported on deep foundations consisting of driven piles and MSE walls embankments.

A preliminary structure foundation exploration was performed by CTL Engineering for this bridge structure replacement as part of the HAM-75-2.30 Step 7 Preliminary Engineering (PID No. 76257) and their findings are presented in the report dated December 15, 2007. No additional borings were obtained at this structure for the current exploration. Therefore, all recommendations contained herein are based on information obtained from the preliminary exploration. For a complete summary of the field operations and findings for the borings performed by CTL Engineering, please reference the December 2007 report.

2.0 GEOLOGY AND OBSERVATIONS OF THE PROJECT

2.1 Site Geology

Both the Illinoian and Wisconsinan glaciers advanced over two-thirds of the State of Ohio, leaving behind glacial features such as moraines, kame deposits, lacustrine deposits and outwash terraces. The glacial and non-glacial regions comprise five physiographic sections grouped by age, depositional process and geomorphic occurrence. Physiographically, the site lies within the Illinoian Till Plain of the Till Plains Section. This area is characterized by rolling ground moraine deposits with many buried valleys alternating between broad floodplains and bedrock gorges. The project area contains silty loam till deposited as ground moraine covered with loess and dissected by the modern day Mill Creek. Ground moraines are deposited during the retreat of a glacier which results in an undifferentiated mixture of clay, silt, sand and gravel. The valley area also contains outwash and alluvium which eroded from hills and valleys with moderate relief. Outwash deposits consist of undifferentiated sand and gravel deposited by meltwater in front of glacial ice and often occurs as valley terraces or low plains.



Alluvium and alluvial terrace deposits range in composition from silty clay size particles to cobbles, usually deposited in present and former floodplain areas.

Based on Bedrock Geology and Topography Maps of the area, from the Ohio Department of Natural Resources (ODNR), the underlying bedrock consists of the Ordovician-aged Point Pleasant Formation. The Point Pleasant Formation is comprised of interbedded limestone and shale, averaging 60 percent limestone and 40 percent shale, and ranges from 0 to 80 feet thick. The bedrock surface forms a valley, roughly beneath and following the alignment of Mill Creek, which trends northeast-to-southwest. I-75 roughly follows parallel to this bedrock valley approximately from State Route 126 to Laidlaw Avenue, and lies just east of the bottom of the valley. In this area, the bedrock surface directly beneath I-75 is positioned along the slope of the bedrock valley, with the top of bedrock ranging between approximate elevations of 375 to 425 feet msl. Overall, the bedrock surface slopes downward to the west beneath the bridge site. According to bedrock topography mapping, the overburden soil in the vicinity of the structure is approximately 110 to 130 feet thick. An illustration of the general geology of Ohio is presented in Appendix I.

2.2 Existing Conditions

The site for the proposed HAM-75-0857 structure is located at the existing overpass of I-75 over Towne Street, approximately 2.0 miles south of the Lockland Split. The existing structure is a three-span bridge that is approximately 103 feet wide and 163 feet long and carries both the northbound and southbound traffic for I-75 over Towne Street. I-75 at the existing structure location is a six-lane road with an exit and entrance ramp between I-75 northbound and Towne Street. There are currently no interchange ramps between I-75 southbound and Towne Street. Towne Street is aligned east-to-west and extends east to the intersection with Paddock Road. West of the structure, the roadway is named Township Avenue. The existing Towne Street roadway is a two-lane, asphalt paved roadway with parking lanes on both sides that traverses residential and commercial properties.

3.0 EXPLORATION

A preliminary geotechnical exploration was performed within this project study area by CTL Engineering for the HAM-75-2.30 project (PID No. 76257). Their findings were published in a report dated December 15, 2007. Two borings, designated as B-181-0-07 and B-182-0-07, were performed by CTL for this bridge, one at each proposed abutment location. The borings were advanced to depths of 60.0 and 105.0 feet below the existing ground surface, respectively, and SPT sampling was performed at a maximum of 5.0-foot intervals to obtain representative soil samples for laboratory classification testing. Rii has included a plan showing the soil borings performed in the project area in Appendix II.



An automatic drop hammer was utilized by CTL Engineering to generate consistent energy transfer to the sampler. The driving resistance is presented on the boring logs in terms of blows per 6-inch interval of the driving distance. The second and third intervals are added to obtain the number of blows per foot (N). For SPT testing conducted using an automatic drop hammer, the measured blow count (N) values are corrected to an equivalent (60%) energy ratio, N_{60} , by the following equation.

$$N_{60} = N_m * (ER/60)$$

Where:

N_m = measured N value

ER = drill rod energy ratio, expressed as a percent, for the system used

No calibration data is available for the hammer used during the SPT testing at the time these borings were performed. Therefore, an estimated drill rod energy ratio of 80 percent was utilized to determine the energy corrected blow counts.

4.0 FINDINGS

In general, the borings performed by CTL encountered soft to hard cohesive soils generally described as brown, dark brown and gray sandy silt, silt and clay, silty clay and clay (ODOT A-4a, A-6a, A-6b, A-7-6) overlying very loose to very dense granular soils generally described as brown gravel, gravel and sand, gravel with sand and silt, fine sand and coarse and fine sand (ODOT A-1-a, A-1-b, A-2-4, A-3, A-3a). Groundwater was encountered in borings B-181 and B-182 at an elevation of 499.8 and 497.0 feet msl, respectively.

5.0 ANALYSES AND RECOMMENDATIONS

Data obtained from the drilling and testing program have been used to determine foundation support capabilities and the settlement potential for the soil encountered at the site. These parameters have been used to provide guidelines for the design of the structure foundation systems, as well as the construction specifications related to the placement of foundation systems and general earthwork recommendations, which are discussed in the following paragraphs.

Proposed structural data was obtained from design details provided by the Rii design team and are included in Table 1. It is understood that the new structure will consist of a single-span bridge with semi-integral abutments supported on deep foundations consisting of driven piles and MSE walls embankments.



Table 1. Structure & Bridge Design Elevations

Reference	Structure Component	Elevation (feet) ¹
Rear Abutment	Profile Grade	559.2
	Bottom of Footing	549.2
	Bottom of Wall (Leveling Pad)	531.0
Forward Abutment	Profile Grade	559.8
	Bottom of Footing	549.7
	Bottom of Wall (Leveling Pad)	531.6

1. Elevations based on structure information provided by Rii design team.

In addition to the design elevations, proposed structural loading information was provided by the Rii design team for each substructure unit and are included in Table 2:

Table 2. Structural Loading Details

Substructure Reference	Maximum Factored Load per Pile (kips)	Required R_{ndr} per Pile ¹ (kips)
Rear Abutment	150	215
Forward Abutment	150	215

1. Required R_{ndr} based on a resistance factor of 0.7.

5.1 Deep Foundation Recommendations

It is recommended that a deep foundation system consisting of driven piles be employed for support of the proposed bridge foundation elements. Based on the soil encountered at this site, it is recommended that 12.0-inch cast-in-place (CIP) pipe piles (ODOT Item 507.06) be employed for foundation support. Table 3 shows recommended pile lengths of the CIP pipe piles and the corresponding ultimate bearing value (R_{ndr}) and AASHTO LRFD reduction factors (ϕ).



Table 3. Pile Recommendations

Boring No.	Ground Elevation ¹	Pile Size ²	Elevations (ft msl)		Embedment Depth ⁴ (feet)	R _{ndr} ^{5,6} (kips/pile)	Sleeve Length ⁷ (ft)	φ ⁸
			Top ³	Tip				
B-181 (Rear Abutment)	539.8	12" CIP	549.2	493.0	38	225	18.2	0.70
B-182 (Forward Abutment)	531.0	12" CIP	549.7	484.6	47	215	18.1	0.70

1. Ground elevation listed is the ground elevation at the boring location.
2. The pile wall thickness utilized in the analysis was determined in accordance with the equation provided in ODOT Item 507.06 and was rounded up to the nearest 1/16-inch increment. For both substructures, the fuel setting for the hammer in the driveability analysis was reduced from maximum to limit the stroke of the hammer and reduce the driving stresses induced on the pile.
3. Pile top elevation is at the proposed bottom of footing elevation.
4. Embedment depths represent the length of pile in contact with the soil.
5. The embedment depth and corresponding ultimate bearing value listed are based on the maximum driving depth that can be achieved based on driveability requirements for the pile wall thickness required per ODOT Item 506.07.
6. The ultimate bearing value listed does not include capacity reduction due to downdrag loads. Downdrag loads and considerations are presented in Section 5.1.2.
7. Sleeve length represents the required length of pile that should be sleeved within the MSE wall backfill.
8. The resistance factor listed assumes dynamic testing of the pile elements per Section 303.4.2.7 of the ODOT BDM. Alternate resistance factors may be applied based on the type and frequency of field testing specified.

NOTE: The top of pile elevation coincides with the bottom of footing elevations, and the estimated pile lengths reflect exclusively the length of the pile in contact with the soil. **Embedment length of the pile into the footing is not included.** Estimated pile lengths are rounded up to the nearest foot.

The piles were analyzed utilizing DRIVEN software (Appendix V). Soil-pile setup was considered in the analysis; however, given the primarily granular nature of the subsurface profile, soil-pile setup was considered negligible. A drivability analysis in accordance with Section 10.7.8 of the 2010 AASHTO LRFD Bridge Design Specifications (BDS) was also performed using the GRLWEAP program, and results of this analysis are presented in Section 5.1.1 of this report. Please note that the embedment depth and corresponding ultimate bearing value for CIP piles presented in Table 3 are based on the maximum embedment depth that can be achieved for the required pile wall thickness as determined below based on driveability requirements. The minimum wall thickness utilized in the driveability analysis for CIP piles was determined from the following equation per ODOT Item 507.06 for the ultimate bearing value listed in Table 3 for the respective pile size. Settlement is estimated to be less than 1.0 inch for CIP piles driven to the frictional resistance values presented in Table 3.



$$t = UBV / 900,000$$

Where:

t = pile wall thickness in inches

UBV = design ultimate bearing value in pounds

We emphasize that the pile lengths and ultimate bearing values presented in Table 3 are estimates using empirical equations based on the derived characteristics of the soils encountered in the subject borings drilled. The most accurate method for determining pile capacities and lengths is to drive test piling at the site and perform static load testing in accordance with the ASTM D1143 procedure. Dynamic pile load testing should be performed in accordance with ASTM D4945. The actual pile capacities should be verified using static or dynamic pile load testing as detailed in the 2007 ODOT Bridge Design Manual (BDM). Further installation considerations are presented in Section 5.1.3.

The geotechnical resistance factor listed in Table 3 represents the recommended value based on the performance of a minimum of two dynamic pile load tests at the site as specified in Section 303.4.2.7 of the 2007 ODOT BDM. A higher resistance factor may be utilized if alternate or additional field load testing of the pile elements is performed. The 2010 AASHTO LRFD BDS provides alternate resistance factors for use in design based on the type and frequency of field load testing. Figure 1 presents the various testing types and frequency of testing, and lists the corresponding resistance factor that may be selected. ***If no field load testing of the piles (static or dynamic) is performed, then a geotechnical resistance factor of 0.35 should be used for design.*** Based on the similar subsurface soils encountered in each of the borings, it is recommended that the entire site be considered as a single site condition.



Figure 1: AASHTO Resistance Factors for Driven Pile Foundations

Table 10.5.5.2.3-1—Resistance Factors for Driven Piles

Condition/Resistance Determination Method		Resistance Factor
Nominal Bearing Resistance of Single Pile—Dynamic Analysis and Static Load Test Methods, $\phi_{b,dr}$	Driving criteria established by successful static load test of at least one pile per site condition and dynamic testing* of at least two piles per site condition, but no less than 2% of the production piles	0.80
	Driving criteria established by successful static load test of at least one pile per site condition without dynamic testing	0.75
	Driving criteria established by dynamic testing* conducted on 100% of production piles	0.75
	Driving criteria established by dynamic testing,* quality control by dynamic testing* of at least two piles per site condition, but no less than 2% of the production piles	0.65
	Wave equation analysis, without pile dynamic measurements or load test but with field confirmation of hammer performance	0.50
	FHWA-modified Gates dynamic pile formula (End of Drive condition only)	0.40
	Engineering News (as defined in Article 10.7.3.8.5) dynamic pile formula (End of Drive condition only)	0.10

* Dynamic testing requires signal matching, and best estimates of nominal resistance are made from a restrrike. Dynamic tests are calibrated to the static load test, when available.

5.1.1 Driveability

Rii performed a driveability analysis using GRLWEAP (Appendix VI). In our driveability analysis, a Delmag 19-42 hammer with a rated energy of approximately 43,000 ft-lbs was used in conjunction with CIP pipe pile sections. Based on the results of this analysis using a wall thickness as determined from ODOT Item 507.06, it appears that the driving stresses induced on the CIP pipe piles **would not exceed** 90 percent of the yield stress for A252, Grade 2 steel ($f_y = 35$ ksi, $0.9f_y = 31.5$ ksi) if driven to the depths provided in Table 3. Please note that the required pile wall thickness was determined using the equation provided in ODOT Item 507.06, and that the pile wall thickness utilized in the driveability analysis was rounded up to the near 1/16-inch increment. For both substructures, the fuel setting for the hammer in the driveability analysis was reduced from maximum to limit the stroke of the hammer and reduce the driving stresses induced on the pile.

Actual driving conditions during pile installation may differ from the conditions predicted in the analysis. It is recommended that test piles be installed at both abutments locations at both the east and west ends of the abutment to verify that the driving conditions predicted will be valid for all of the piles installed along the length of the abutments.

5.1.2 Downdrag Forces

Downdrag was evaluated using the traditional method to determine the depth of downdrag. Per the traditional method for calculating the depth of downdrag, downdrag



loads will develop along the portion of the pile above the interface where the relative soil movement from consolidation with respect to the pile is greater than 0.40 inches. The total anticipated settlement at the rear and forward abutments at the face of the wall are 0.75 inches and 0.90 inches, respectively. Based on the total anticipated settlement at the face of the wall, downdrag loads are anticipated to develop if the piles are driven to the design tip elevation prior to construction of the MSE walls.

It is anticipated that the settlement of the granular material will take place immediately following construction of the MSE walls. Since the majority of the subsurface profile consists of granular material comprised of gravel and sand, it is anticipated that the majority of the total settlement predicted will be complete at the end of the construction of the MSE walls. If it is considered that the settlement of the granular material will take place immediately following construction of the MSE walls, the total anticipated settlement at the rear and forward abutments at the face of the wall will be reduced to 0.30 inches and 0.33 inches, respectively. Therefore, provided that piles are installed to the design tip elevation following completion of the MSE walls, downdrag loads are not anticipated to develop. Prior to construction of the MSE walls, it is recommended that the piles be pre-driven into the soil only as far as necessary to remain vertical and that the MSE walls should be constructed around the piles. If the piles are not pre-driven, then the MSE walls should be constructed with pile sleeves, and the piles should be driven through these sleeves following completion of the MSE walls.

5.1.3 Driven Pile Considerations

Proper pile installation is as important as pile design in order to obtain a cost effective and safe product. Driven piles must be installed to develop adequate soil resistance without structural damage. Because piles cannot be visually inspected after installation, direct quality control of the finished product is impossible. Consequently, substantial control must be exercised over peripheral operations leading to the pile placement within the foundation. It is essential that installation be considered during the design stage to insure that piles shown on the plans can be installed. Construction monitoring should be employed in (1) pile materials, (2) installation equipment, and (3) the estimation of the static load capacity.

It is recommended that the contractor submit a wave equation analysis (bearing graph) of his driving equipment, or the necessary pile driving and equipment data to perform the wave equation analysis, for hammer approval. A constant capacity wave equation analysis (inspector's chart) should also be performed to assist field personnel during inspection in accordance with the 2007 ODOT BDM.

5.2 MSE Wall Recommendations

It is proposed to construct MSE walls at the forward and rear abutments. MSE walls are constructed on earthen foundations at a minimum depth of 3.0 feet below grade, as defined by the top of the leveling pad to the ground surface located 4.0 feet from the



face of the wall. Note that the reinforced soil mass extends from the foundation bearing elevation to the top of MSE wall. The width of the MSE wall foundation (B) is defined by the length of the reinforced soil mass. Per the ODOT BDM (October 2007) and Supplemental Specification (SS) 840, the minimum length of the reinforced soil mass is equal to 70 percent the height of the MSE wall or 8 feet whichever is greater. A non-structural bearing leveling pad consisting of a minimum of 6-inches of unreinforced concrete should be placed at the base of the wall for constructability purposes. Please note that the leveling pad is not a structural foundation.

Based upon the proposed plan information, wall heights at the rear and forward abutments are anticipated to be 28.2 feet from the top of the leveling pad to the proposed profile grade of the roadway at each abutment location. Therefore, it is considered that the minimum reinforcement length and the effective foundation width (B) of the MSE walls for external and global stability calculations will be approximately 19.7 feet. For the analysis, the foundation width was set at 70 percent of the wall height and the foundation width was increased, if required, until external and global stability requirements were satisfied for various wall heights and subsurface conditions.

It is recommended that the foundation subgrade (beneath the reinforced soil mass) for the MSE wall be critically proof-rolled and stabilized to create a workable subgrade for the MSE wall reinforced soil mass. Unstable soils, primarily those containing silt (A-4a/A-4b), if encountered, may be stabilized as noted below:

- § Undercut 24 inches +/- pending results of proof-roll;
- § Place ODOT Item 712.09 Type D Geotextile Fabric;
- § Placement of 24 inches of 703. 02A Granular Fill.

Please note that this recommendation for stabilization of unsuitable soils, as identified during the proof roll of the subgrade, are in addition to the foundation preparation measures provided in ODOT SS 840.

Soft to medium stiff silt and clay (ODOT A-6a) were encountered at the ground surface, which is also at the proposed bearing elevation, in boring B-182 and extending to a depth of 7.5 feet below the ground surface. Hand penetrometer values were not provided on the boring logs; however, based on the low blow counts obtained within this soil layer, it recommended that this material be stabilized or excavated and replaced with suitable embankment fill to provide a stable bearing surface for the MSE wall. Material identified as sandy silt (ODOT A-4a) material was encountered at the proposed bearing elevation in boring B-181. Based on gradation results provided on the boring log at this elevation, the silt content neared a level of 50 percent. The bearing soils in this area should be closely observed during construction to verify that unstable soils high in silt content are not present at the bearing elevation.



Please note that the bearing soils present at the proposed bearing elevation along the length of the abutments may vary from those encountered in the borings performed for this exploration. The entire bearing surface at each abutment location should be closely observed to verify that adequate bearing soils are present at the proposed bearing elevation.

For MSE walls, Rii recommends that consideration be given to driving the piles prior to the placement of fill and sleeving the piles extending above the existing ground surface with a plastic pipe casing as noted in Section 5.1.2. The MSE wall may then be constructed around the pile sleeves to full height.

5.2.1 Strength Parameters Utilized in External and Global Stability Analyses

The shear strength parameters utilized in the external and global stability analyses for the MSE walls at the abutments are provided in Table 4.

Table 4. Shear Strength Parameters Utilized in Stability Analyses

Material Type	Unit Weight, γ (pcf)	Effective Friction Angle, ϕ' (°)	Effective Cohesion, c' (psf)	Undrained Shear Strength, S_u (psf)
MSE Wall Backfill (Select granular fill)	120	34	0	N/A
Embankment Fill (Fill material derived from onsite soils)	120	30	400	1,700
Loose Sandy Silt (Bearing soil at Rear Abutment)	120	28	0	N/A
Very Stiff to Hard Sandy Silt	120	27	235	3,000
Granular Soils	120 to 130	28 to 34	0	N/A

Shear strength parameters for the reinforced soil backfill are provided in ODOT SS 840. Per SS 840, the select granular backfill in the reinforced zone must meet the shear strength requirements provided in Table 4. Shear strength parameters for new embankment fill were determined using ODOT Geotechnical Bulletin 6 (GB-6) as a guide. The shear strength parameters for the embankment fill listed in Table 4 above are the limiting values based on the assumption that the embankment fill utilized will consist of silt and clay, sandy silt (ODOT A-6a, A-4a) or granular material. The friction



angle for the natural granular soil encountered was determined based on correlations with the N_{60} value from the SPT testing of the soil. The long term shear strength parameters (drained/effective stress) for the small seam of natural cohesive soil encountered in boring B-181 were determined from a consolidated undrained (CU) triaxial compression test performed on an undisturbed sample from boring B-016-0-11 performed by Rii in 2011 for Retaining Wall H, which the proposed location is planned to connect to the rear abutment and continue adjacent to I-75 along the west side of the roadway. The CU triaxial test was performed on material classified as silt and clay (ODOT A-6a). The result of the CU test yielded a friction angle of 27 degrees with cohesion intercept of 235 pounds per square foot (psf). The undrained shear strength for this seam is based an indirect correlation with SPT blow counts of the soil. The laboratory test results referenced above are provided in Appendix IV.

5.2.2 Bearing Stability

The anticipated bearing materials at the abutment locations consist of loose sandy silt (ODOT A-4a) and soft to medium stiff silt and clay (ODOT A-6a). As noted in Section 5.2, it is recommended that the soft to medium stiff silt and clay encountered at the bearing elevation in boring B-181 be excavated and replaced with suitable embankment material as noted in Section 5.2.1. MSE wall foundations bearing on these soils or engineered fill, placed and compacted as described in Section 5.4, may be proportioned for a nominal bearing resistance as indicated in Table 5. A geotechnical resistance factor of $\phi_b=0.65$ was considered in calculating the factored nominal bearing resistance at the strength limit state. The reinforcement lengths presented in the following table represent the minimum foundation widths required to satisfy external and global stability requirements, expressed as a percentage of the wall height.

Table 5. HAM-75-0857 MSE Wall Spread Footing Design Parameters

Boring No.	Maximum Wall Height (ft)	Minimum Reinforcement Length ¹	Nominal Bearing Resistance (ksf)		Total Settlement ³ (in)
			Service	Strength ²	
B-181 (Rear Abutment)	28.2	0.70(H)	9.3	28.0	2.43 / 0.75
B-182 (Forward Abutment)	28.2	0.75(H)	3.4	10.3	1.65 / 0.90

1. The minimum reinforcement length is expressed as a percentage of the wall height, H, at the respective location.
2. The nominal bearing resistance at the strength limit state is unfactored. Rii recommends that a resistance factor of $\phi_b=0.65$ be considered when calculating the factored nominal bearing resistance at the strength limit state.
3. The first value represents the anticipated total settlement at the center of the reinforced soil mass, and the second values represents the anticipated total settlement at the facing of the wall.



Rii performed a verification of the bearing pressure exerted on the subgrade soils for the maximum specified wall heights indicated in Table 5. Based on the minimum length of reinforced soil mass presented in Table 5 and utilizing the soil parameters listed in Section 5.2.1, the bearing pressures on the front portion of the wall **will not exceed** the factored nominal bearing resistance at the strength limit state at either of the abutment locations provided the subgrade at each abutment location is prepared as noted above.

Based on profile information provided by M•E Companies, it is anticipated that approximately 5.0 feet of cut will be required to achieve the proposed bottom of wall elevation at the rear and forward abutment. Therefore, the net embankment height (embankment height above existing grade up to the proposed profile grade) considered in the settlement calculations is 23.2 feet. Differential settlement of 1.68 and 0.76 inches is expected between the center of the reinforced soil mass and the wall facing at the rear and forward abutments, respectively. Per Section 204.6.2.1 of the ODOT BDM, “the maximum allowable differential settlement in the longitudinal direction (regardless of the size of panels) is one (1) percent.” Based on the total anticipated settlement at the facing of the wall, maximum differential settlement in the longitudinal direction is anticipated to be less than 1/1000, which is within the tolerable limit of 1/100. If either the total or differential settlement predicted presents an issue with respect to the deformation tolerances that the walls can withstand, then measures should be taken to minimize the amount of settlement that will occur. This can be achieved by preloading the site and consolidating the underlying soils prior to constructing the wall. Settlement calculations are provided in Appendix VII.

5.2.3 Eccentricity (Overturning Stability)

The resistance of the MSE wall to overturning will be dependent on the location of the resultant force at the bottom of the wall due to the overturning and resisting moments acting on the wall. For MSE walls, overturning stability is determined by calculating the eccentricity of the resultant force from the midpoint of the base of the wall and comparing this value to a limiting eccentricity value. Per Section 11.10.5.5 of the 2010 AASHTO LRFD BDS, for foundations bearing on soil or bedrock, the location of the resultant of the reaction forces shall be within the middle one-half of the base width. Therefore, the limiting eccentricity is one-fourth of the base width of the wall. Rii performed a verification of the eccentricity of the resultant force for the maximum specified wall heights indicated in Table 5. Based on the minimum length of reinforced soil mass presented in Table 5 and utilizing the soil parameters listed in Section 5.2.1 for the retained embankment material, the calculated eccentricity of the resultant force **will not exceed** the limiting eccentricity at the strength limit state.

5.2.4 Sliding Stability

The resistance of the MSE walls to sliding will be dependent on the friction between the reinforced soil backfill and bearing soils per Section 11.10.5.3 of the 2010 AASHTO LRFD BDS. For MSE walls, sliding resistance is determined by multiplying a coefficient



of sliding friction “ f ” times the total vertical force at the base of the wall. The coefficient of sliding friction is determined based on the limiting friction angle between the foundation soil and the reinforced soil backfill. Based on the soil parameters listed in Section 5.2.1 for the foundation and retained material, a coefficient of sliding friction of 0.53 and 0.58 was utilized for design at the rear and forward abutments, respectively. A geotechnical resistance factor of $\phi_{\tau}=1.0$ was considered when calculating the factored shear resistance between the soil and foundation for sliding. Based on the minimum length of reinforced soil mass presented in Table 5 and utilizing the soil parameters listed in Section 5.2.1 for the retained embankment material, the resultant horizontal forces on the back of the MSE wall **will not exceed** the factored shear resistance at the strength limit state.

5.2.5 Overall (Global) Stability

A slope stability analysis was performed to check the global stability of the wall. As per AASHTO LRFD BDS, safety against soil failure shall be evaluated at the service limit state by assuming the reinforced soil mass to be a rigid body. Soil parameters utilized in external stability analyses are presented in Section 5.2.1. For the global stability condition, it was considered that the failure plane will not cross through the reinforced soil mass.

Per Section 11.6.2.3 of the 2010 AASHTO LRFD BDS, overall (global) stability for MSE walls supporting structural foundations on spread footings is satisfied if the product of the factor of safety from the slope stability output multiplied by the resistance factor $\phi=0.65$ is greater than 1.0. Therefore, global stability is satisfied when a minimum factor of safety of 1.5 is obtained. For MSE walls designed with minimum strap lengths listed in Table 5, the resulting factor of safety under drained conditions (long-term stability) greater than 1.5. The wall was also evaluated under undrained conditions (short-term stability) to verify the stability of the wall during and immediately following construction. The resulting factor of safety under undrained conditions was also greater than 1.5.

Calculations for external (bearing and sliding resistance and limiting eccentricity) and overall (global) stability of the MSE walls are provided in Appendix VIII.

5.2.6 Final MSE Wall Considerations

Based on the results of the external and global stability analysis performed for the MSE walls, the recommended controlling strap lengths are 0.7 and 0.75 times the maximum height of the MSE wall (measured from the top of the leveling pad to the proposed profile grade of the roadway) at the rear and forward abutments, respectively. All of the external and global stability calculations indicate that adequate resistance is available for support of the MSE wall at the rear abutment for a strap length equal to 70 percent of the wall height. Bearing resistance and global stability were the controlling factors in the determination of the recommended strap length of 75 percent of the wall height required at the forward abutment.



5.3 Lateral Earth Pressure

For the soil types encountered in the borings, the “in-situ” unit weight (γ), cohesion (c), effective angle of friction (ϕ'), and lateral earth pressure coefficients for at-rest conditions (k_o), active conditions (k_a), and passive conditions (k_p) have been estimated and are provided in Table 6 and Table 7.

Table 6. Estimated Undrained (Short-term) Soil Parameters for Design

Soil Type	γ (pcf) ¹	c (psf)	ϕ'	k_a	k_o	k_p
Soft to Medium Stiff Cohesive Soil	110	750	0°	1.0	1.0	1.0
Stiff to Very Stiff Cohesive Soil	115	1,500	0°	1.0	1.0	1.0
Very Loose to Loose Granular Soil	120	0	28°	0.36	0.53	2.77
Medium Dense Granular Soil	125	0	30°	0.33	0.50	3.00
Dense to Very Dense Granular Soil	130	0	34°	0.28	0.44	3.54
Compacted Cohesive Engineered Fill	125	1,500	0°	1.0	1.0	1.0
Compacted Granular Engineered Fill	135	0	33°	0.30	0.46	3.39

1. When below groundwater table, use effective unit weight, $\gamma' = \gamma - 62.4$ pcf and add hydrostatic water pressure.

Table 7. Estimated Drained (Long-term) Soil Parameters for Design

Soil Type	γ (pcf) ¹	c (psf)	ϕ'	k_a	k_o	k_p
Natural Cohesive Soil	115	0	26°	0.39	0.56	2.56
Very Loose to Loose Granular Soil	120	0	28°	0.36	0.53	2.77
Medium Dense Granular Soil	125	0	30°	0.33	0.50	3.00
Dense to Very Dense Granular Soil	130	0	34°	0.28	0.44	3.54
Compacted Cohesive Engineered Fill	125	0	28°	0.36	0.53	2.77
Compacted Granular Engineered Fill	135	0	33°	0.30	0.46	3.39

1. When below groundwater table, use effective unit weight, $\gamma' = \gamma - 62.4$ pcf and add hydrostatic water pressure.

These parameters are considered appropriate for the design of all subsurface structures and any excavation support systems. Subsurface structures (where the top of the structure is restrained from movement) should be designed based on at-rest conditions (k_o). For proposed temporary retaining structures (where the top of the structure is allowed to move), earth pressure distributions should be based on active (k_a) and passive (k_p) conditions. The values in this table have been estimated from correlation charts based on minimum standards specified for compacted engineered fill materials.



These recommendations do not take into consideration the effect of any surcharge loading or a sloped ground surface (a flat surface is assumed). Earth pressures on excavation support systems will be dependent on the type of sheeting and method of bracing or anchorage.

5.4 Construction Considerations

All site work shall conform to local codes and to the latest ODOT Construction and Materials Specifications (CMS), including that all excavation and embankment preparation and construction should follow ODOT Item 200 (Earthwork).

Fill soil placed for foundation and pavement support should be placed in loose lifts not to exceed 8.0 inches. Fill soil placed under pavement or structures shall be compacted to not less than 100 percent of maximum dry density obtained by the Standard Proctor Test (ASTM D698). Fill soil containing excess moisture shall be required to dry prior to or during compaction to a moisture content not greater than 3.0 percent above or below optimum. However, for material that displays pronounced elasticity or deformation under the action of loaded rubber tire construction equipment, the moisture content shall be reduced to optimum if necessary to secure stability. Drying of wet soil shall be expedited by the use of plows, discs, or by other approved methods when so ordered by the site geotechnical engineer.

Generally, materials utilized for engineered fill should free of waste construction debris and other deleterious materials and meet the following requirements:

- Maximum Dry Density per ASTM D698 > 110 pcf
- Liquid Limit < 40
- Plasticity Index < 15
- Organic Matter < 3 percent
- Maximum Particle Size < 3 inches
- Silt Content (between 0.075 and 0.005 mm) < 45 percent

Compacted granular fill shall meet the above specification and additionally shall have a maximum 35 percent passing the No. 200 sieve.

5.4.1 Excavation Considerations

All excavations should be shored / braced or laid back at a safe angle in accordance to Occupational Safety and Health Administration (OSHA) guidelines. During excavation, if slopes cannot be laid back to OSHA Standards due to adjacent structures or other obstructions, temporary shoring may be required. The following table should be utilized as a general guide for implementing OSHA guidelines when estimating excavation back slopes at the various boring locations. Actual excavation back slopes must be field



verified by qualified personnel at the time of excavation in strict accordance with OSHA guidelines.

Table 8. Excavation Back Slopes

Soil	Maximum Back Slope	Notes
Soft to Medium Stiff Cohesive	1.5 : 1.0	Above Ground Water Table and No Seepage
Stiff Cohesive	1.0 : 1.0	Above Ground Water Table and No Seepage
Very Stiff to Hard Cohesive	0.75 : 1.0	Above Ground Water Table and No Seepage
All Granular & Cohesive Soil Below Ground Water Table or with Seepage	1.5 : 1.0	None
Rock to 3.0' +/- below Auger Refusal	0.75 : 1.0	Above Ground Water Table and No Seepage
Stable Rock	Vertical	Above Ground Water Table and No Seepage

5.4.2 Groundwater Considerations

Based on the groundwater observations made during drilling, little to no groundwater seepage is anticipated during construction. However, where/if groundwater is encountered, proper groundwater control should be employed and maintained to prevent disturbance to excavation bottoms consisting of cohesive soil, and to prevent the possible development of a quick or "boiling" condition where soft silts and/or fine sands are encountered. It is preferable that the groundwater level, if encountered, be maintained at least 36 inches below the deepest excavation. Any seepage or groundwater encountered at this site should be able to be controlled by pumping from temporary sumps. Additional measures may be required depending on seasonal fluctuations of the groundwater level. Note that determining and maintaining actual groundwater levels during construction is the responsibility of the contractor.

6.0 LIMITATIONS OF STUDY

The above recommendations are predicated upon construction inspection by a qualified soil technician under the direct supervision of a professional geotechnical engineer. Adequate testing and inspection during construction are considered necessary to assure an adequate foundation system and are part of our recommendations.

Our recommendations for this project were developed utilizing soil and bedrock information obtained from the test borings that were made at the proposed site for the current investigation. Resource International is not responsible for the data,



conclusions, opinions or recommendations made by others during previous investigations at this site. At this time we would like to point out that soil borings only depict the soil and bedrock conditions at the specific locations and time at which they were made. The conditions at other locations on the site may differ from those occurring at the boring locations.

The conclusions and recommendations herein have been based upon the available soil and bedrock information and the preliminary design details furnished by a representative of the owner of the proposed project. Any revision in the plans for the proposed construction from those anticipated in this report should be brought to the attention of the geotechnical engineer to determine whether any changes in the foundation or earthwork recommendations are necessary. If deviations from the noted subsurface conditions are encountered during construction, they should also be brought to the attention of the geotechnical engineer.

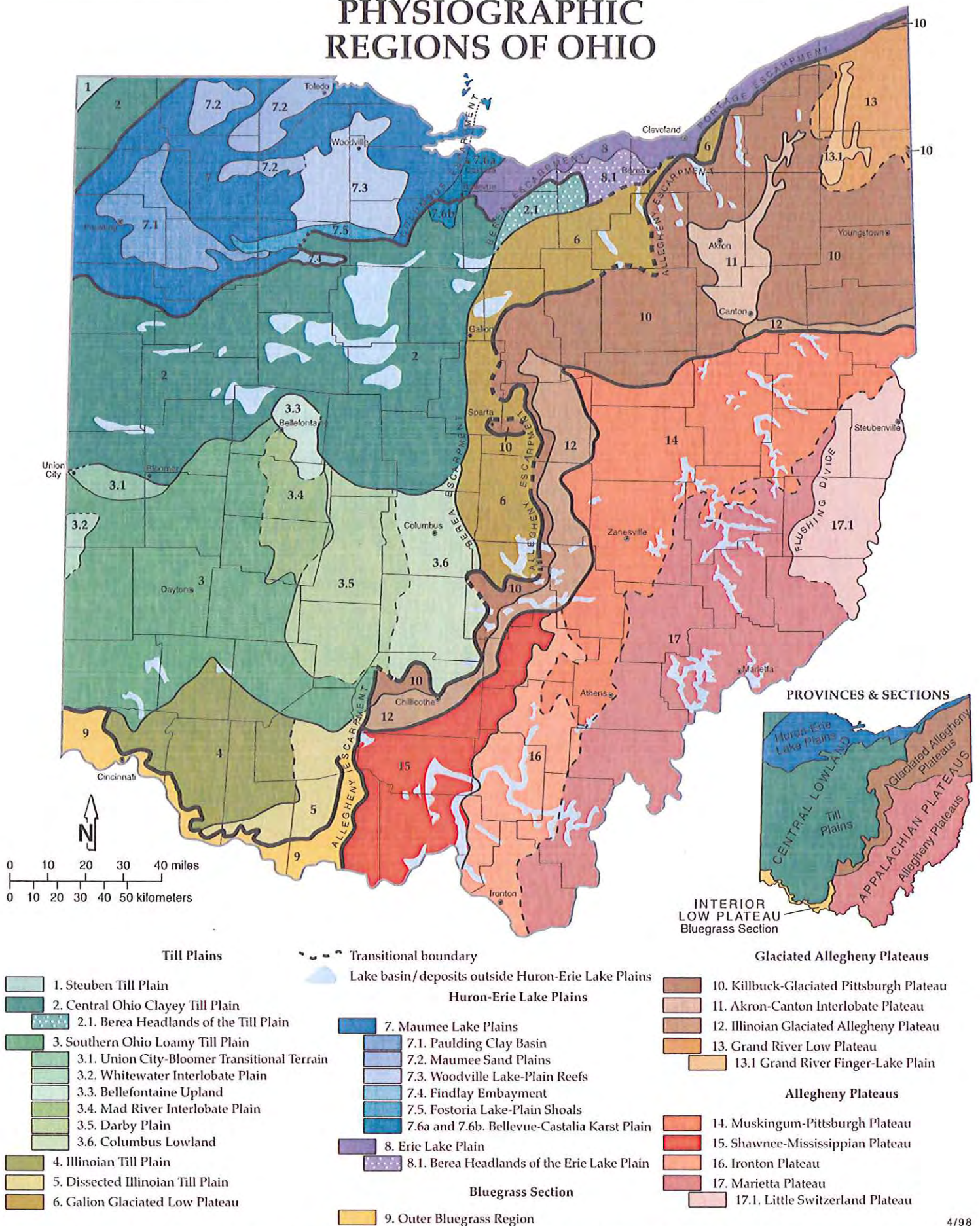
The scope of our services does not include any environmental assessment or investigation for the presence or absence of hazardous or toxic materials in the soil, groundwater, or surface water within or beyond the site studied. Any statements in this report or on the test boring logs regarding odors, staining of soils, or other unusual conditions observed are strictly for the information of our client.

Our professional services have been performed, our findings obtained, and our recommendations prepared in accordance with generally accepted Geotechnical engineering principles and practices. Resource International is not responsible for the conclusions, opinions or recommendations made by others based upon the data included.

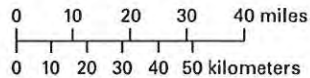
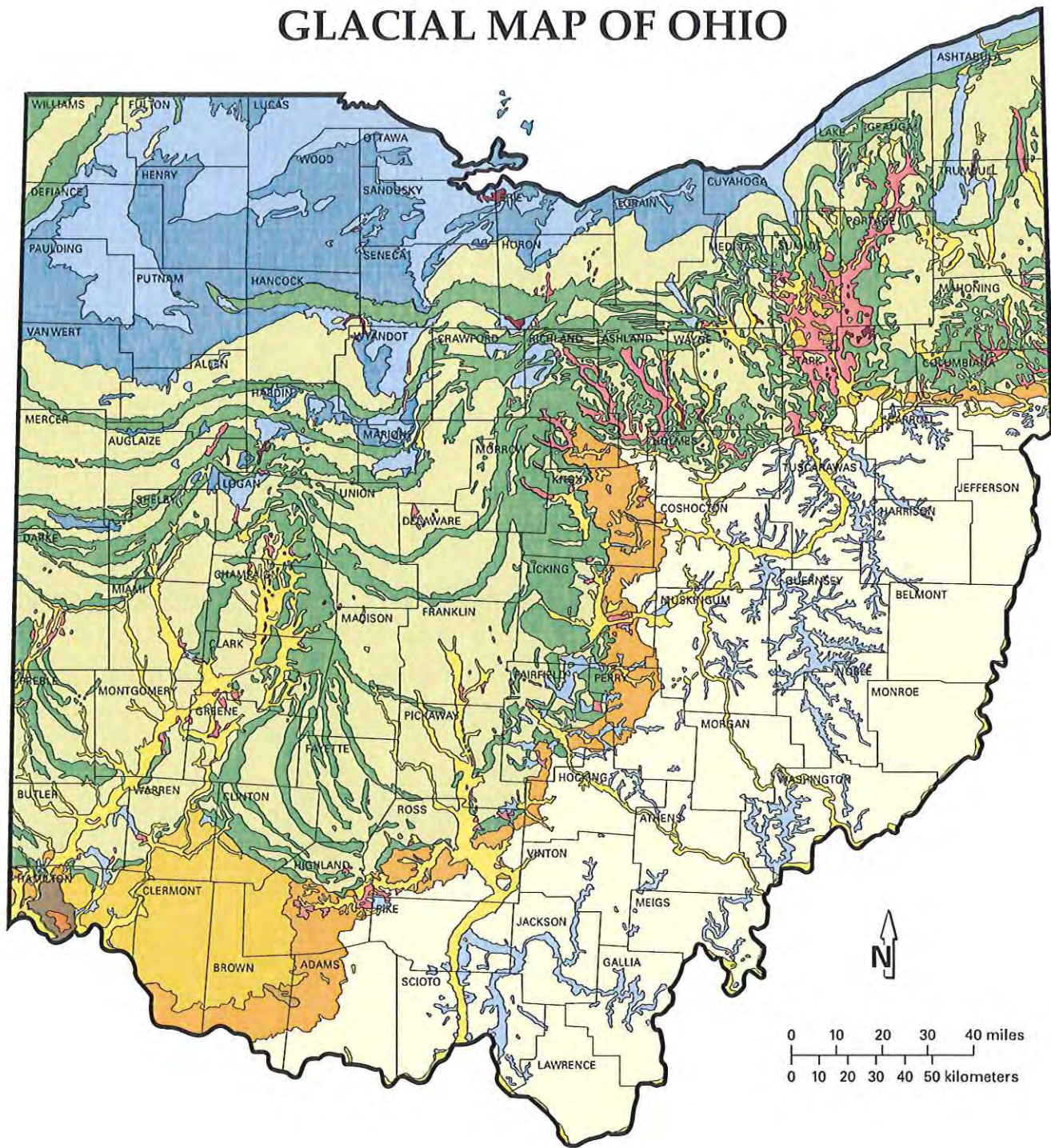


APPENDIX I
STATE GEOLOGY

PHYSIOGRAPHIC REGIONS OF OHIO



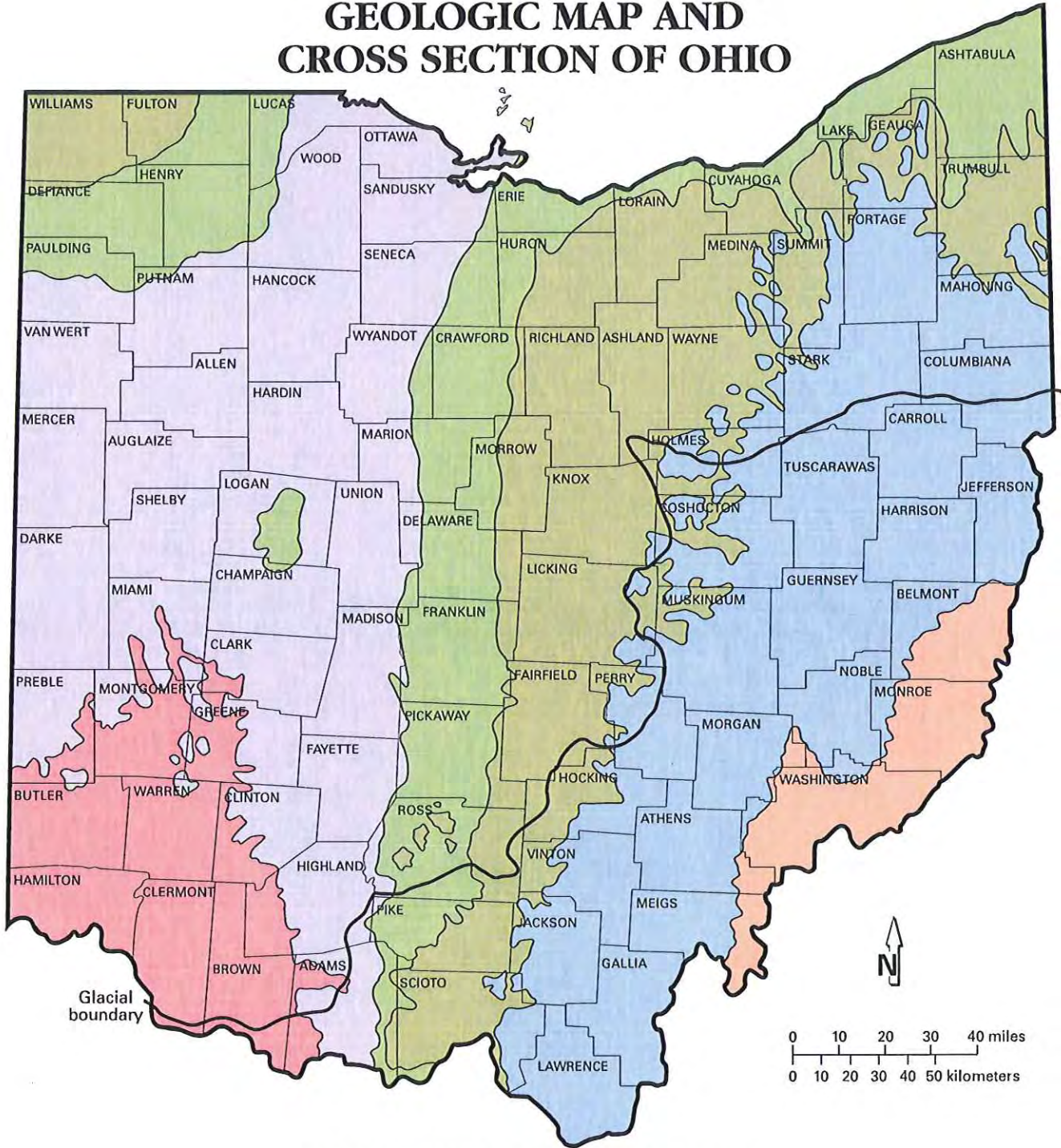
GLACIAL MAP OF OHIO









WISCONSINAN (14,000 to 24,000 years old)		ILLINOIAN (130,000 to 300,000 years old)		PRE-ILLINOIAN (older than 300,000 years)			
	Ground moraine		Ground moraine		Ground moraine		Kames and eskers
	Wave-planed ground moraine		Dissected ground moraine		Dissected ground moraine		Outwash
	End moraine		Hummocky moraine				Lake deposits
							Peat
							Colluvium

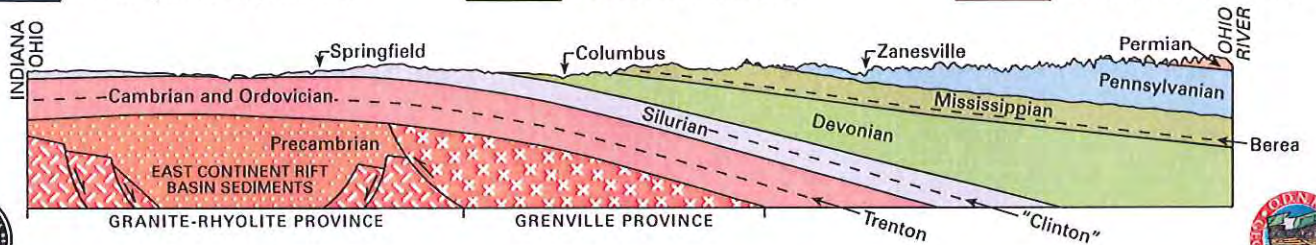


GEOLOGIC MAP AND CROSS SECTION OF OHIO



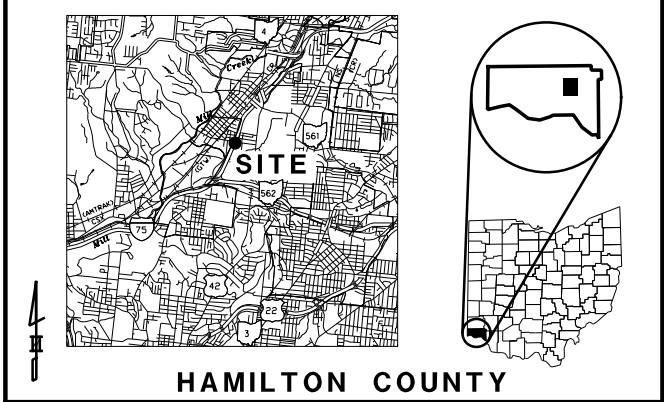
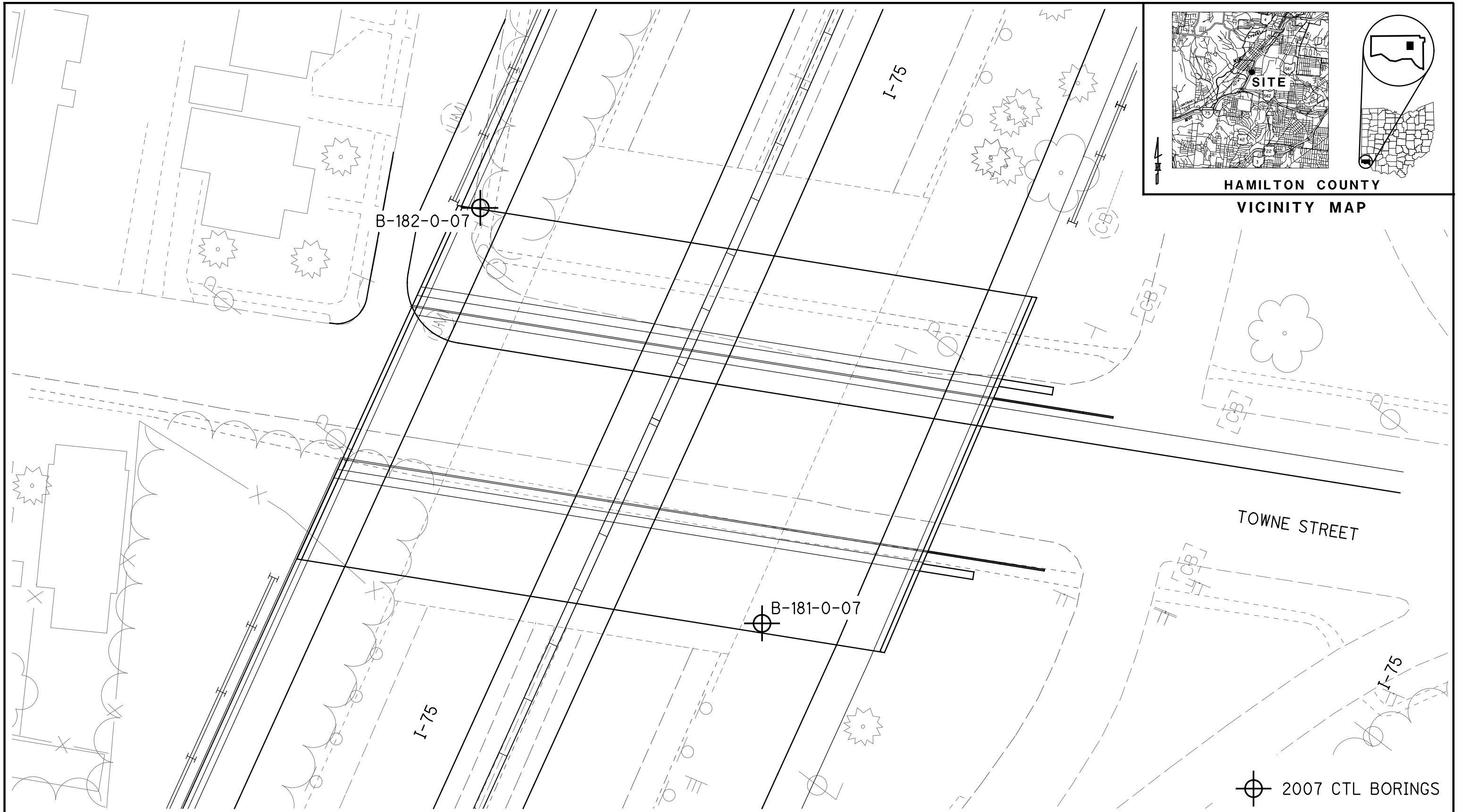
GEOLOGIC SYSTEM (million years before present)

- | | | |
|---|---|--|
|  Permian (286-245) |  Mississippian (360-320) |  Silurian (438-408) |
|  Pennsylvanian (320-286) |  Devonian (408-360) |  Ordovician (505-438) |



APPENDIX II

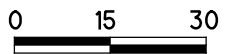

VICINITY MAP AND BORING PLAN



HAMILTON COUNTY
VICINITY MAP

 2007 CTL BORINGS

BORING PLAN
HAM-75-TOWNE - TOWNE STREET OVER I-75
HAMILTON COUNTY, OHIO

PROJECT NO. Rii B-10-020	DRAWN RRM
SCALE: 1"=30'	REVIEWED BRT
	DATE 4-13-12
	



APPENDIX III

2007 CTL ENGINEERING BORING LOGS

LOG OF BORING

Project Identification: HAM-75-2.30 PID 76257

Date Started 7/31/07 Sampler: Type SS Dia. 1.375"
 Date Completed 7/31/07 Casing: Length 60.0ft Dia. 3.25"

Hamilton County, Ohio

Water Elev. 499.8ft

Surface Elev. 539.8ft

Boring No. B-181 Station & Offset 452+04.9, 93.5 RT

CTL Project No. 04120070g

Elev. (ft)	Depth (ft)	Std. Pen./ RQD	Rec. (ft)	Loss (ft)	Description	Sample No.	Physical Characteristics							ODOT Class			
							% Agg	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.		W.C.		
539.8	0				0.5' TOPSOIL (.5')												VISUAL
539.8		AUGERED			VERY STIFF, BROWN SILTY CLAY, LITTLE GRAVEL, LITTLE SAND, DAMP	1	14	4	14	40	28	36	17	14			A-6b
539.3	10/10/8																
	2				2.5' STIFF, DARK BROWN AND BROWN CLAY, AND SILT, SOME SAND, TRACE GRAVEL, DAMP TO MOIST -ORGANICS PRESENT	2	1	6	24	44	25	51	33	20			A-7-6
536.8	7/5/7																
	4				8.0' STIFF, GRAY SILT AND CLAY, AND SAND, MOIST	3									28		VISUAL
534.3	2/4/5																
	8				11.0' MEDIUM STIFF, GRAY SANDY SILT, TRACE CLAY, TRACE GRAVEL, MOIST	4	0	4	41	34	21	28	12	21			A-6a
531.3	4/6/6																
	10				16.0' VERY STIFF, GRAY TO DARK BROWN SANDY SILT, SOME GRAVEL, LITTLE CLAY, DAMP	5									23		VISUAL
528.8	3/3/4																
	12				18.5' HARD, GRAY TO DARK BROWN SANDY SILT, SOME GRAVEL, LITTLE CLAY, DAMP	6	3	7	40	44	6	NP	NP	26			A-4a
526.3	2/3/4																
	14				22.0' MEDIUM DENSE TO DENSE, BROWN COARSE AND FINE SAND, TRACE GRAVEL, TRACE SILT, TRACE CLAY, DAMP	7	21	12	16	35	16	23	8	9			A-4a
523.8	4/6/10																
	16				33.5' DENSE, BROWN FINE SAND, TRACE GRAVEL, TRACE SILT, TRACE CLAY, DAMP	8									10		VISUAL
521.3	35/38/31																
	18				33.5' DENSE, BROWN FINE SAND, TRACE GRAVEL, TRACE SILT, TRACE CLAY, DAMP	9	6	42	41	9	2	NP	NP	3			A-3a
516.3	10/13/17																
	20				33.5' DENSE, BROWN FINE SAND, TRACE GRAVEL, TRACE SILT, TRACE CLAY, DAMP	10									3		VISUAL
511.3	16/22/25																
	22				33.5' DENSE, BROWN FINE SAND, TRACE GRAVEL, TRACE SILT, TRACE CLAY, DAMP	11	4	25	61	9	1	NP	NP	4			A-3
506.3	15/15/25																
	24																
	26																
	28																
506.3	34																

OH DOT 2 CTL OH DOT.GDT ODOT LIBRARY BY AMC 9-14-06 GLB 04120070G HAM-75 B BORINGS.GPJ 12/11/07

Particle Sizes: Agg => 2.00mm, Coarse Sand = 2.00-0.42mm, Fine Sand = 0.42-0.074mm, Silt = 0.074-0.005mm, Clay =< 0.005mm.

LOG OF BORING (Continued)

Project Identification: HAM-75-2.30 PID 76257

Hamilton County, Ohio

Boring No. B-181

Elev. (ft)	Depth (ft)	Std. Pen./ RQD	Rec. (ft)	Loss (ft)	Description	Sample No.	Physical Characteristics							ODOT Class			
							% Agg	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.		W.C.		
504.8	36																
	38				FS												
501.3	38.0'	25/30/33			DENSE TO VERY DENSE, BROWN GRAVEL AND/ OR STONE FRAGMENTS, AND SAND, LITTLE TO TRACE SILT, TRACE CLAY, MOIST	12	54	19	18	7	2	NP	NP	11		A-1-a	
	40																
	42																
496.3		15/20/14				13								11		VISUAL	
	44																
	46																
	48																
491.3		50-6"				14								7		VISUAL	
	50																
	52																
486.3		10/16/16				15								14		VISUAL	
	54																
	56																
	58																
481.3		50-6"				16	32	21	19	23	5	NP	NP	7		A-2-4	
	58.5'				VERY DENSE, BROWN GRAVEL AND/ OR STONE FRAGMENTS WITH SAND AND SILT, TRACE CLAY, DAMP												
479.8	60				BOTTOM OF BORING = 60.0'												

OH DOT 2 CTL OH DOT GDT ODOT LIBRARY BY AMC 9-14-06 GLB 04120070G HAM-75 B BORINGS.GPJ 12/11/07

LOG OF BORING (Continued)

Project Identification: HAM-75-2.30 PID 76257

Hamilton County, Ohio

Boring No. B-182

Elev. (ft)	Depth (ft)	Std. Pen./ RQD	Rec. (ft)	Loss (ft)	Description	Sample No.	Physical Characteristics							ODOT Class		
							% Agg	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.		W.C.	
457.9																
457.5	74	6/9/13				19									19	VISUAL
	76															
	78				FS											
452.5		9/15/23				20									21	VISUAL
	80															
	82															
					82.0'											
447.5	84	20/37/37				21	0	0	90	10	0	NP	NP	15	A-3	
	86															
	88															
442.5		22/35/41				22									18	VISUAL
	90															
	92															
437.5	94	15/35/43				23									14	VISUAL
	96															
	98															
432.5		17/32/39				24									17	VISUAL
	100															
	102															
427.5	104	18/34/36				25									24	VISUAL
426.0																

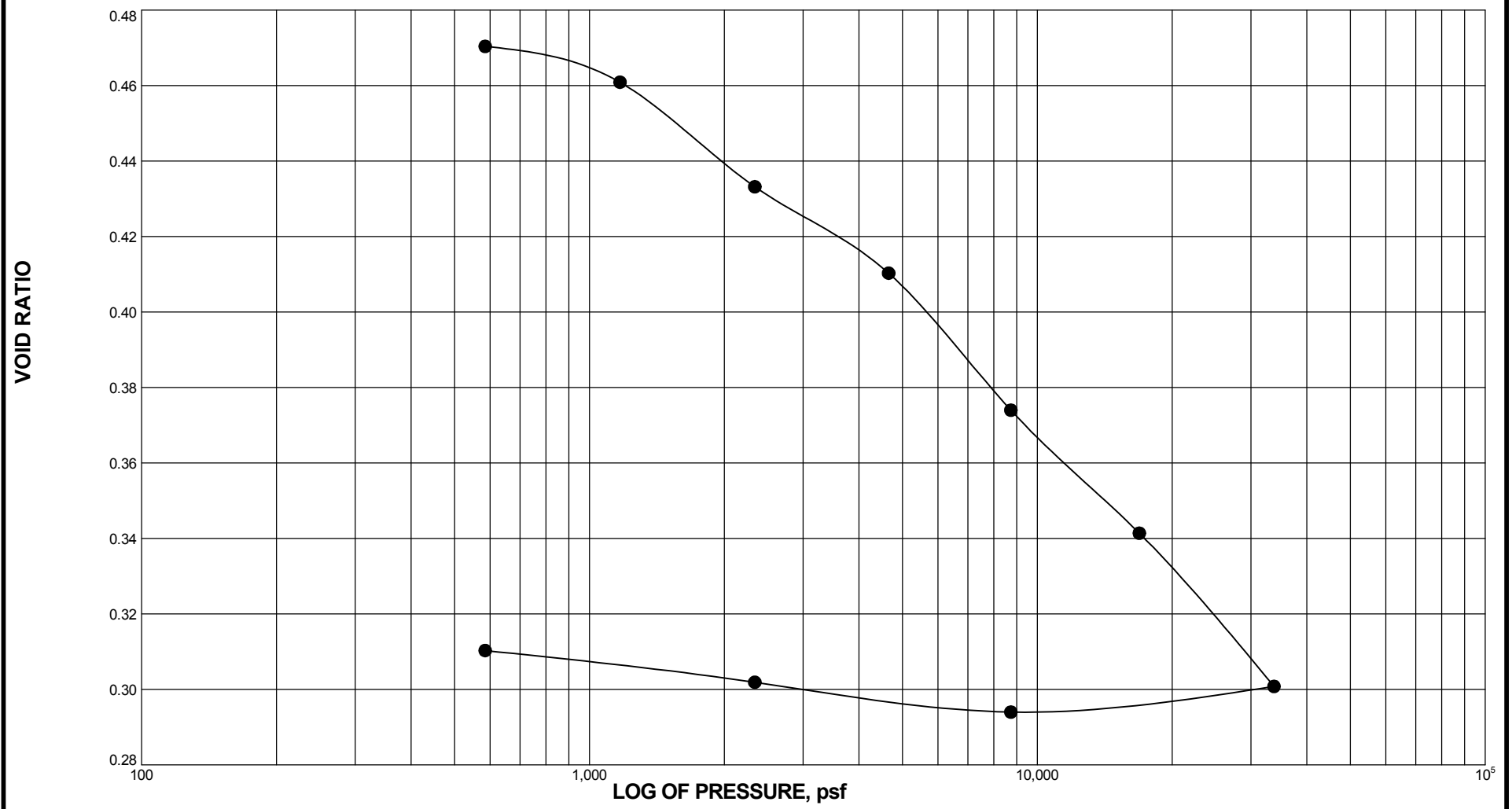
BOTTOM OF BORING = 105.0'

OH DOT 2 CTL OH DOT.GDT ODOT LIBRARY BY AMC 9-14-06.GLB 04120070G HAM-75 B BORINGS.GPJ 12/11/07

APPENDIX IV

LABORATORY TEST RESULTS

PRESSURE - VOID RATIO CURVE



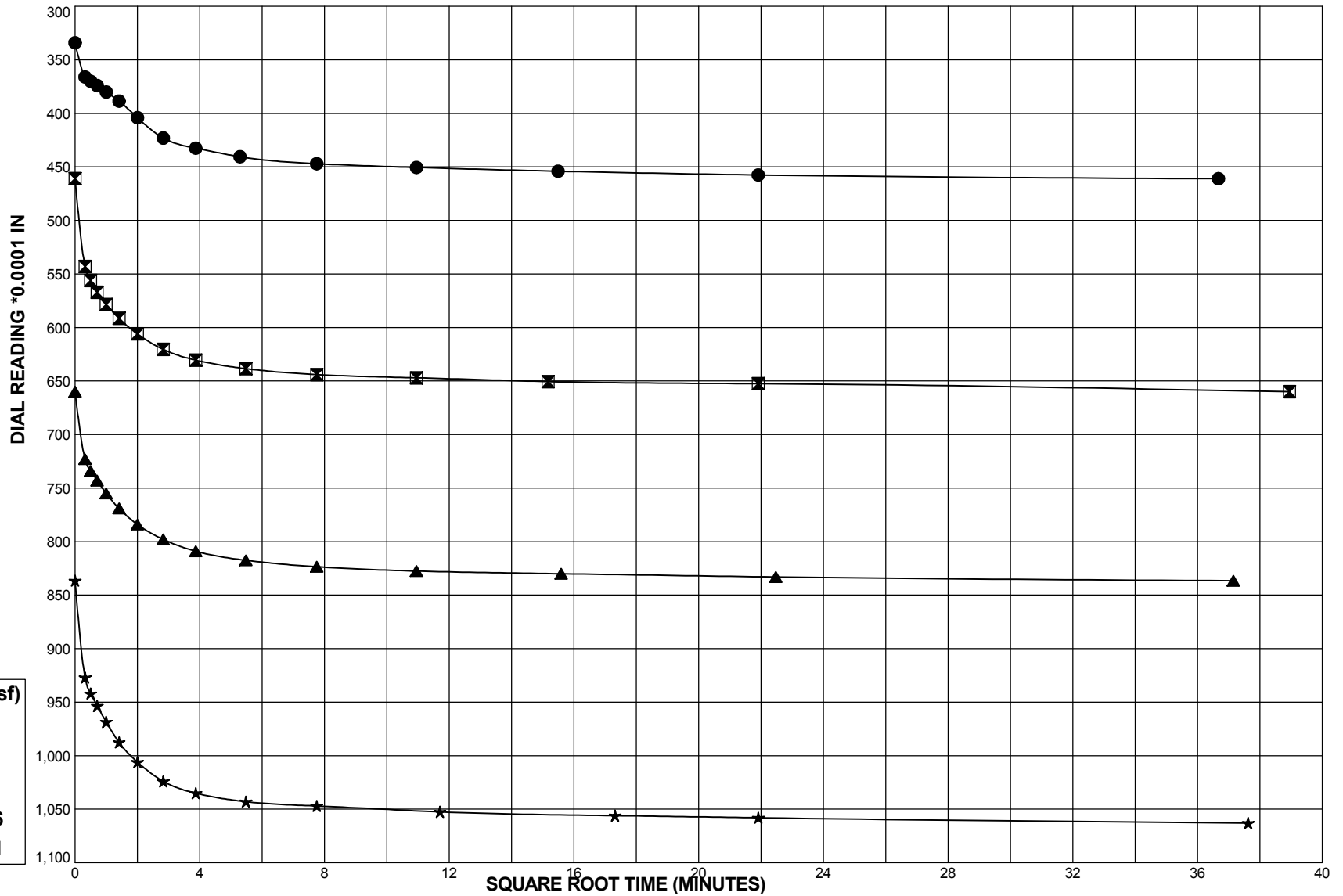
Boring	Sample ID	Depth	Visual Description/Classification								P. S. (psf)	Cc	Cr
B-017-0-11	ST-4	10	Brown SANDY SILT, little clay, little fine gravel / ODOT A-4a								2600	0.154	0.014
Diam.(in)	H (in)	SG	MC	LL	PL	PI	Gravel	Sand	Silt	Clay	DD (pcf)	WD (pcf)	Eo
2.5	0.754	2.67	15	24	15	9	8.8	38.6	38.1	14.5	113.2	129.8	0.494



CONSOLIDATION TEST
Resource International Inc.

PROJECT HAM-75-7.85 JOB NO. B-10-020 DATE 4/12/12

CONSOLIDATION TIME - CURVES



LOADS (psf)

- 4657
- ☒ 8730
- ▲ 16896
- ★ 33771

Boring	Sample ID	Depth	Visual Description/Classification
B-017-0-11	ST-4	10	Brown SANDY SILT, little clay, little fine gravel / ODOT A-4a

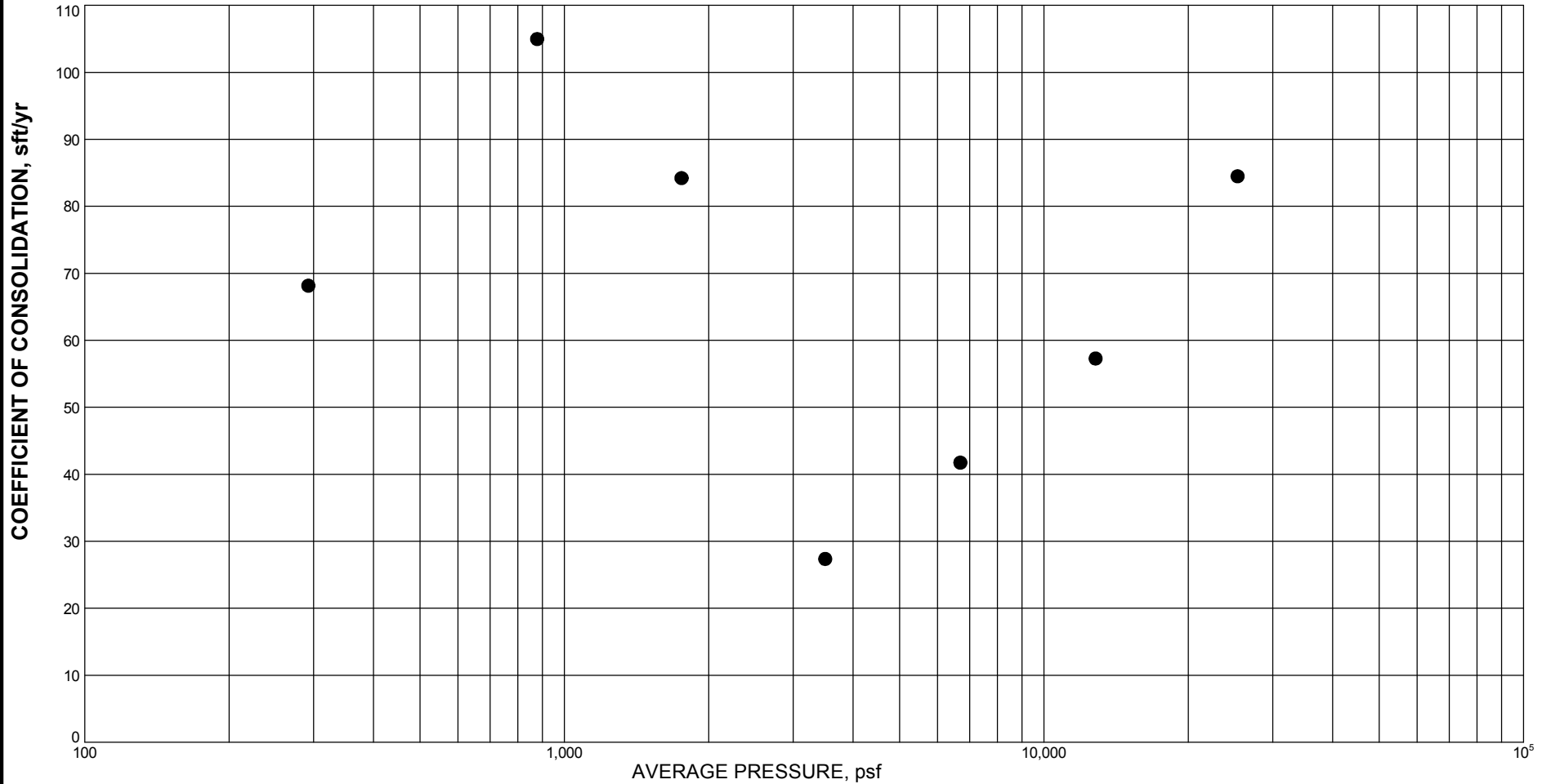


CONSOLIDATION TEST

Resource International Inc.

PROJECT HAM-75-7.85 JOB NO. B-10-020 DATE 4/12/12

COEFFICIENT OF CONSOLIDATION



Boring	Sample ID	Depth	Visual Description/Classification								P. S. (psf)	Cc	Cr
B-017-0-11	ST-4	10	Brown SANDY SILT, little clay, little fine gravel / ODOT A-4a								2600	0.154	0.014
Diam.(in)	H (in)	SG	MC	LL	PL	PI	Gravel	Sand	Silt	Clay	DD (pcf)	WD (pcf)	EO
2.5	0.754	2.67	15	24	15	9	8.8	38.6	38.1	14.5	113.2	129.8	0.494



CONSOLIDATION TEST

Resource International Inc.

PROJECT HAM-75-7.85 JOB NO. B-10-020 DATE 4/12/12

APPENDIX V

DRIVEN ANALYSIS OUTPUT

DRIVEN 1.2
GENERAL PROJECT INFORMATION

Filename: J:\GEOTECH\ANALYSIS\D2BZEP~U.2\B-181.DVN
Project Name: HAM-75-0857 - B-181 Project Date: 04/12/2012
Project Client: EMHI
Computed By: Brian Trenner
Project Manager: Jonathan Sterenberg

PILE INFORMATION

Pile Type: Pipe Pile - Closed End
Top of Pile: 0.00 ft
Diameter of Pile: 12.00 in

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	31.00 ft
	- Driving/Restrike:	31.00 ft
	- Ultimate:	31.00 ft
Ultimate Considerations:	- Local Scour:	0.00 ft
	- Long Term Scour:	0.00 ft
	- Soft Soil:	0.00 ft

ULTIMATE PROFILE

Layer	Type	Thickness	Driving Loss	Unit Weight	Strength	Ultimate Curve
1	Cohesive	7.00 ft	0.00%	115.00 pcf	1250.00 psf	T-79 Steel
2	Cohesive	2.50 ft	0.00%	120.00 pcf	3000.00 psf	T-79 Steel
3	Cohesive	3.50 ft	0.00%	125.00 pcf	4000.00 psf	T-79 Steel
4	Cohesionless	5.00 ft	0.00%	130.00 pcf	33.0/33.0	Nordlund
5	Cohesionless	14.00 ft	0.00%	135.00 pcf	35.0/35.0	Nordlund
6	Cohesionless	6.00 ft	0.00%	130.00 pcf	34.0/34.0	Nordlund
7	Cohesionless	5.00 ft	0.00%	135.00 pcf	35.0/35.0	Nordlund
8	Cohesionless	6.50 ft	0.00%	130.00 pcf	33.0/33.0	Nordlund
9	Cohesionless	1.50 ft	0.00%	135.00 pcf	35.0/35.0	Nordlund

RESTRIKE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesive	N/A	N/A	930.00 psf	0.03 Kips
6.99 ft	Cohesive	N/A	N/A	930.00 psf	20.42 Kips
7.01 ft	Cohesive	N/A	N/A	790.00 psf	20.48 Kips
9.49 ft	Cohesive	N/A	N/A	790.00 psf	26.63 Kips
9.51 ft	Cohesive	N/A	N/A	770.00 psf	26.68 Kips
12.99 ft	Cohesive	N/A	N/A	818.84 psf	35.63 Kips
13.01 ft	Cohesionless	1543.15 psf	19.41	N/A	35.68 Kips
17.99 ft	Cohesionless	1866.85 psf	19.41	N/A	46.65 Kips
18.01 ft	Cohesionless	2193.18 psf	20.58	N/A	46.71 Kips
27.01 ft	Cohesionless	2800.68 psf	20.58	N/A	81.88 Kips
30.99 ft	Cohesionless	3069.32 psf	20.58	N/A	102.30 Kips
31.01 ft	Cohesionless	3947.86 psf	20.58	N/A	102.41 Kips
31.99 ft	Cohesionless	3983.44 psf	20.58	N/A	107.86 Kips
32.01 ft	Cohesionless	4020.44 psf	19.99	N/A	107.97 Kips
37.99 ft	Cohesionless	4222.56 psf	19.99	N/A	140.47 Kips
38.01 ft	Cohesionless	4426.06 psf	20.58	N/A	140.59 Kips
42.99 ft	Cohesionless	4606.84 psf	20.58	N/A	172.60 Kips
43.01 ft	Cohesionless	4789.04 psf	19.41	N/A	172.72 Kips
49.49 ft	Cohesionless	5008.06 psf	19.41	N/A	211.01 Kips
49.51 ft	Cohesionless	5228.46 psf	20.58	N/A	211.14 Kips
50.99 ft	Cohesionless	5282.19 psf	20.58	N/A	222.05 Kips

RESTRIKE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesive	N/A	N/A	N/A	8.84 Kips
6.99 ft	Cohesive	N/A	N/A	N/A	8.84 Kips
7.01 ft	Cohesive	N/A	N/A	N/A	21.21 Kips
9.49 ft	Cohesive	N/A	N/A	N/A	21.21 Kips
9.51 ft	Cohesive	N/A	N/A	N/A	28.27 Kips
12.99 ft	Cohesive	N/A	N/A	N/A	28.27 Kips
13.01 ft	Cohesionless	1543.80 psf	47.20	39.27 Kips	36.95 Kips
17.99 ft	Cohesionless	2191.20 psf	47.20	39.27 Kips	39.27 Kips
18.01 ft	Cohesionless	2193.85 psf	64.00	84.51 Kips	74.99 Kips
27.01 ft	Cohesionless	3408.85 psf	64.00	84.51 Kips	84.51 Kips
30.99 ft	Cohesionless	3946.15 psf	64.00	84.51 Kips	84.51 Kips
31.01 ft	Cohesionless	3948.23 psf	64.00	84.51 Kips	84.51 Kips
31.99 ft	Cohesionless	4019.37 psf	64.00	84.51 Kips	84.51 Kips
32.01 ft	Cohesionless	4020.78 psf	55.60	57.74 Kips	57.74 Kips
37.99 ft	Cohesionless	4425.02 psf	55.60	57.74 Kips	57.74 Kips
38.01 ft	Cohesionless	4426.43 psf	64.00	84.51 Kips	84.51 Kips
42.99 ft	Cohesionless	4787.97 psf	64.00	84.51 Kips	84.51 Kips
43.01 ft	Cohesionless	4789.38 psf	47.20	39.27 Kips	39.27 Kips
49.49 ft	Cohesionless	5227.42 psf	47.20	39.27 Kips	39.27 Kips
49.51 ft	Cohesionless	5228.83 psf	64.00	84.51 Kips	84.51 Kips
50.99 ft	Cohesionless	5336.27 psf	64.00	84.51 Kips	84.51 Kips

RESTRIKE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.03 Kips	8.84 Kips	8.86 Kips
6.99 ft	20.42 Kips	8.84 Kips	29.26 Kips
7.01 ft	20.48 Kips	21.21 Kips	41.68 Kips
9.49 ft	26.63 Kips	21.21 Kips	47.84 Kips
9.51 ft	26.68 Kips	28.27 Kips	54.95 Kips
12.99 ft	35.63 Kips	28.27 Kips	63.91 Kips
13.01 ft	35.68 Kips	36.95 Kips	72.63 Kips
17.99 ft	46.65 Kips	39.27 Kips	85.92 Kips
18.01 ft	46.71 Kips	74.99 Kips	121.69 Kips
27.01 ft	81.88 Kips	84.51 Kips	166.39 Kips
30.99 ft	102.30 Kips	84.51 Kips	186.81 Kips
31.01 ft	102.41 Kips	84.51 Kips	186.92 Kips
31.99 ft	107.86 Kips	84.51 Kips	192.37 Kips
32.01 ft	107.97 Kips	57.74 Kips	165.71 Kips
37.99 ft	140.47 Kips	57.74 Kips	198.21 Kips
38.01 ft	140.59 Kips	84.51 Kips	225.10 Kips
42.99 ft	172.60 Kips	84.51 Kips	257.11 Kips
43.01 ft	172.72 Kips	39.27 Kips	211.99 Kips
49.49 ft	211.01 Kips	39.27 Kips	250.28 Kips
49.51 ft	211.14 Kips	84.51 Kips	295.65 Kips
50.99 ft	222.05 Kips	84.51 Kips	306.56 Kips

DRIVING - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesive	N/A	N/A	930.00 psf	0.03 Kips
6.99 ft	Cohesive	N/A	N/A	930.00 psf	20.42 Kips
7.01 ft	Cohesive	N/A	N/A	790.00 psf	20.48 Kips
9.49 ft	Cohesive	N/A	N/A	790.00 psf	26.63 Kips
9.51 ft	Cohesive	N/A	N/A	770.00 psf	26.68 Kips
12.99 ft	Cohesive	N/A	N/A	818.84 psf	35.63 Kips
13.01 ft	Cohesionless	1543.15 psf	19.41	N/A	35.68 Kips
17.99 ft	Cohesionless	1866.85 psf	19.41	N/A	46.65 Kips
18.01 ft	Cohesionless	2193.18 psf	20.58	N/A	46.71 Kips
27.01 ft	Cohesionless	2800.68 psf	20.58	N/A	81.88 Kips
30.99 ft	Cohesionless	3069.32 psf	20.58	N/A	102.30 Kips
31.01 ft	Cohesionless	3947.86 psf	20.58	N/A	102.41 Kips
31.99 ft	Cohesionless	3983.44 psf	20.58	N/A	107.86 Kips
32.01 ft	Cohesionless	4020.44 psf	19.99	N/A	107.97 Kips
37.99 ft	Cohesionless	4222.56 psf	19.99	N/A	140.47 Kips
38.01 ft	Cohesionless	4426.06 psf	20.58	N/A	140.59 Kips
42.99 ft	Cohesionless	4606.84 psf	20.58	N/A	172.60 Kips
43.01 ft	Cohesionless	4789.04 psf	19.41	N/A	172.72 Kips
49.49 ft	Cohesionless	5008.06 psf	19.41	N/A	211.01 Kips
49.51 ft	Cohesionless	5228.46 psf	20.58	N/A	211.14 Kips
50.99 ft	Cohesionless	5282.19 psf	20.58	N/A	222.05 Kips

DRIVING - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesive	N/A	N/A	N/A	8.84 Kips
6.99 ft	Cohesive	N/A	N/A	N/A	8.84 Kips
7.01 ft	Cohesive	N/A	N/A	N/A	21.21 Kips
9.49 ft	Cohesive	N/A	N/A	N/A	21.21 Kips
9.51 ft	Cohesive	N/A	N/A	N/A	28.27 Kips
12.99 ft	Cohesive	N/A	N/A	N/A	28.27 Kips
13.01 ft	Cohesionless	1543.80 psf	47.20	39.27 Kips	36.95 Kips
17.99 ft	Cohesionless	2191.20 psf	47.20	39.27 Kips	39.27 Kips
18.01 ft	Cohesionless	2193.85 psf	64.00	84.51 Kips	74.99 Kips
27.01 ft	Cohesionless	3408.85 psf	64.00	84.51 Kips	84.51 Kips
30.99 ft	Cohesionless	3946.15 psf	64.00	84.51 Kips	84.51 Kips
31.01 ft	Cohesionless	3948.23 psf	64.00	84.51 Kips	84.51 Kips
31.99 ft	Cohesionless	4019.37 psf	64.00	84.51 Kips	84.51 Kips
32.01 ft	Cohesionless	4020.78 psf	55.60	57.74 Kips	57.74 Kips
37.99 ft	Cohesionless	4425.02 psf	55.60	57.74 Kips	57.74 Kips
38.01 ft	Cohesionless	4426.43 psf	64.00	84.51 Kips	84.51 Kips
42.99 ft	Cohesionless	4787.97 psf	64.00	84.51 Kips	84.51 Kips
43.01 ft	Cohesionless	4789.38 psf	47.20	39.27 Kips	39.27 Kips
49.49 ft	Cohesionless	5227.42 psf	47.20	39.27 Kips	39.27 Kips
49.51 ft	Cohesionless	5228.83 psf	64.00	84.51 Kips	84.51 Kips
50.99 ft	Cohesionless	5336.27 psf	64.00	84.51 Kips	84.51 Kips

DRIVING - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.03 Kips	8.84 Kips	8.86 Kips
6.99 ft	20.42 Kips	8.84 Kips	29.26 Kips
7.01 ft	20.48 Kips	21.21 Kips	41.68 Kips
9.49 ft	26.63 Kips	21.21 Kips	47.84 Kips
9.51 ft	26.68 Kips	28.27 Kips	54.95 Kips
12.99 ft	35.63 Kips	28.27 Kips	63.91 Kips
13.01 ft	35.68 Kips	36.95 Kips	72.63 Kips
17.99 ft	46.65 Kips	39.27 Kips	85.92 Kips
18.01 ft	46.71 Kips	74.99 Kips	121.69 Kips
27.01 ft	81.88 Kips	84.51 Kips	166.39 Kips
30.99 ft	102.30 Kips	84.51 Kips	186.81 Kips
31.01 ft	102.41 Kips	84.51 Kips	186.92 Kips
31.99 ft	107.86 Kips	84.51 Kips	192.37 Kips
32.01 ft	107.97 Kips	57.74 Kips	165.71 Kips
37.99 ft	140.47 Kips	57.74 Kips	198.21 Kips
38.01 ft	140.59 Kips	84.51 Kips	225.10 Kips
42.99 ft	172.60 Kips	84.51 Kips	257.11 Kips
43.01 ft	172.72 Kips	39.27 Kips	211.99 Kips
49.49 ft	211.01 Kips	39.27 Kips	250.28 Kips
49.51 ft	211.14 Kips	84.51 Kips	295.65 Kips
50.99 ft	222.05 Kips	84.51 Kips	306.56 Kips

ULTIMATE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesive	N/A	N/A	930.00 psf	0.03 Kips
6.99 ft	Cohesive	N/A	N/A	930.00 psf	20.42 Kips
7.01 ft	Cohesive	N/A	N/A	790.00 psf	20.48 Kips
9.49 ft	Cohesive	N/A	N/A	790.00 psf	26.63 Kips
9.51 ft	Cohesive	N/A	N/A	770.00 psf	26.68 Kips
12.99 ft	Cohesive	N/A	N/A	818.84 psf	35.63 Kips
13.01 ft	Cohesionless	1543.15 psf	19.41	N/A	35.68 Kips
17.99 ft	Cohesionless	1866.85 psf	19.41	N/A	46.65 Kips
18.01 ft	Cohesionless	2193.18 psf	20.58	N/A	46.71 Kips
27.01 ft	Cohesionless	2800.68 psf	20.58	N/A	81.88 Kips
30.99 ft	Cohesionless	3069.32 psf	20.58	N/A	102.30 Kips
31.01 ft	Cohesionless	3947.86 psf	20.58	N/A	102.41 Kips
31.99 ft	Cohesionless	3983.44 psf	20.58	N/A	107.86 Kips
32.01 ft	Cohesionless	4020.44 psf	19.99	N/A	107.97 Kips
37.99 ft	Cohesionless	4222.56 psf	19.99	N/A	140.47 Kips
38.01 ft	Cohesionless	4426.06 psf	20.58	N/A	140.59 Kips
42.99 ft	Cohesionless	4606.84 psf	20.58	N/A	172.60 Kips
43.01 ft	Cohesionless	4789.04 psf	19.41	N/A	172.72 Kips
49.49 ft	Cohesionless	5008.06 psf	19.41	N/A	211.01 Kips
49.51 ft	Cohesionless	5228.46 psf	20.58	N/A	211.14 Kips
50.99 ft	Cohesionless	5282.19 psf	20.58	N/A	222.05 Kips

ULTIMATE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesive	N/A	N/A	N/A	8.84 Kips
6.99 ft	Cohesive	N/A	N/A	N/A	8.84 Kips
7.01 ft	Cohesive	N/A	N/A	N/A	21.21 Kips
9.49 ft	Cohesive	N/A	N/A	N/A	21.21 Kips
9.51 ft	Cohesive	N/A	N/A	N/A	28.27 Kips
12.99 ft	Cohesive	N/A	N/A	N/A	28.27 Kips
13.01 ft	Cohesionless	1543.80 psf	47.20	39.27 Kips	36.95 Kips
17.99 ft	Cohesionless	2191.20 psf	47.20	39.27 Kips	39.27 Kips
18.01 ft	Cohesionless	2193.85 psf	64.00	84.51 Kips	74.99 Kips
27.01 ft	Cohesionless	3408.85 psf	64.00	84.51 Kips	84.51 Kips
30.99 ft	Cohesionless	3946.15 psf	64.00	84.51 Kips	84.51 Kips
31.01 ft	Cohesionless	3948.23 psf	64.00	84.51 Kips	84.51 Kips
31.99 ft	Cohesionless	4019.37 psf	64.00	84.51 Kips	84.51 Kips
32.01 ft	Cohesionless	4020.78 psf	55.60	57.74 Kips	57.74 Kips
37.99 ft	Cohesionless	4425.02 psf	55.60	57.74 Kips	57.74 Kips
38.01 ft	Cohesionless	4426.43 psf	64.00	84.51 Kips	84.51 Kips
42.99 ft	Cohesionless	4787.97 psf	64.00	84.51 Kips	84.51 Kips
43.01 ft	Cohesionless	4789.38 psf	47.20	39.27 Kips	39.27 Kips
49.49 ft	Cohesionless	5227.42 psf	47.20	39.27 Kips	39.27 Kips
49.51 ft	Cohesionless	5228.83 psf	64.00	84.51 Kips	84.51 Kips
50.99 ft	Cohesionless	5336.27 psf	64.00	84.51 Kips	84.51 Kips

ULTIMATE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.03 Kips	8.84 Kips	8.86 Kips
6.99 ft	20.42 Kips	8.84 Kips	29.26 Kips
7.01 ft	20.48 Kips	21.21 Kips	41.68 Kips
9.49 ft	26.63 Kips	21.21 Kips	47.84 Kips
9.51 ft	26.68 Kips	28.27 Kips	54.95 Kips
12.99 ft	35.63 Kips	28.27 Kips	63.91 Kips
13.01 ft	35.68 Kips	36.95 Kips	72.63 Kips
17.99 ft	46.65 Kips	39.27 Kips	85.92 Kips
18.01 ft	46.71 Kips	74.99 Kips	121.69 Kips
27.01 ft	81.88 Kips	84.51 Kips	166.39 Kips
30.99 ft	102.30 Kips	84.51 Kips	186.81 Kips
31.01 ft	102.41 Kips	84.51 Kips	186.92 Kips
31.99 ft	107.86 Kips	84.51 Kips	192.37 Kips
32.01 ft	107.97 Kips	57.74 Kips	165.71 Kips
37.99 ft	140.47 Kips	57.74 Kips	198.21 Kips
38.01 ft	140.59 Kips	84.51 Kips	225.10 Kips
42.99 ft	172.60 Kips	84.51 Kips	257.11 Kips
43.01 ft	172.72 Kips	39.27 Kips	211.99 Kips
49.49 ft	211.01 Kips	39.27 Kips	250.28 Kips
49.51 ft	211.14 Kips	84.51 Kips	295.65 Kips
50.99 ft	222.05 Kips	84.51 Kips	306.56 Kips

DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename: J:\GEOTECH\ANALYSIS\D2BZEP~U.2\B-182.DVN

Project Name: HAM-75-0857 - B-182

Project Date: 04/12/2012

Project Client: EMHI

Computed By: Brian Trenner

Project Manager: Jonathan Sterenberg

PILE INFORMATION

Pile Type: Pipe Pile - Closed End

Top of Pile: 0.00 ft

Diameter of Pile: 12.00 in

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	34.00 ft
	- Driving/Restrike:	34.00 ft
	- Ultimate:	34.00 ft
Ultimate Considerations:	- Local Scour:	0.00 ft
	- Long Term Scour:	0.00 ft
	- Soft Soil:	0.00 ft

ULTIMATE PROFILE

Layer	Type	Thickness	Driving Loss	Unit Weight	Strength	Ultimate Curve
1	Cohesive	7.50 ft	0.00%	110.00 pcf	500.00 psf	T-79 Steel
2	Cohesionless	5.50 ft	0.00%	120.00 pcf	27.0/27.0	Nordlund
3	Cohesive	2.00 ft	0.00%	115.00 pcf	1000.00 psf	T-79 Steel
4	Cohesionless	6.00 ft	0.00%	120.00 pcf	28.0/28.0	Nordlund
5	Cohesionless	16.00 ft	0.00%	125.00 pcf	29.0/29.0	Nordlund
6	Cohesionless	5.00 ft	0.00%	130.00 pcf	33.0/33.0	Nordlund
7	Cohesionless	5.00 ft	0.00%	135.00 pcf	35.0/35.0	Nordlund
8	Cohesionless	5.00 ft	0.00%	135.00 pcf	35.0/35.0	Nordlund
9	Cohesionless	20.00 ft	0.00%	125.00 pcf	30.0/30.0	Nordlund
10	Cohesionless	5.00 ft	0.00%	130.00 pcf	32.0/32.0	Nordlund
11	Cohesionless	5.00 ft	0.00%	135.00 pcf	34.0/34.0	Nordlund
12	Cohesionless	23.00 ft	0.00%	135.00 pcf	35.0/35.0	Nordlund

RESTRIKE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesive	N/A	N/A	410.00 psf	0.01 Kips
7.49 ft	Cohesive	N/A	N/A	410.00 psf	9.65 Kips
7.51 ft	Cohesionless	825.60 psf	15.88	N/A	9.67 Kips
12.99 ft	Cohesionless	1154.40 psf	15.88	N/A	13.98 Kips
13.01 ft	Cohesive	N/A	N/A	815.05 psf	14.01 Kips
14.99 ft	Cohesive	N/A	N/A	824.95 psf	19.14 Kips
15.01 ft	Cohesionless	1715.60 psf	16.46	N/A	19.18 Kips
20.99 ft	Cohesionless	2074.40 psf	16.46	N/A	28.37 Kips
21.01 ft	Cohesionless	2435.63 psf	17.05	N/A	28.41 Kips
30.01 ft	Cohesionless	2998.13 psf	17.05	N/A	50.06 Kips
33.99 ft	Cohesionless	3246.88 psf	17.05	N/A	62.22 Kips
34.01 ft	Cohesionless	4060.31 psf	17.05	N/A	62.28 Kips
36.99 ft	Cohesionless	4153.59 psf	17.05	N/A	72.21 Kips
37.01 ft	Cohesionless	4248.14 psf	19.41	N/A	72.30 Kips
41.99 ft	Cohesionless	4416.46 psf	19.41	N/A	98.24 Kips
42.01 ft	Cohesionless	4586.16 psf	20.58	N/A	98.36 Kips
46.99 ft	Cohesionless	4766.94 psf	20.58	N/A	131.48 Kips
47.01 ft	Cohesionless	4949.16 psf	20.58	N/A	131.62 Kips
51.99 ft	Cohesionless	5129.94 psf	20.58	N/A	167.27 Kips
52.01 ft	Cohesionless	5312.11 psf	17.64	N/A	167.39 Kips
61.01 ft	Cohesionless	5593.81 psf	17.64	N/A	210.94 Kips
70.01 ft	Cohesionless	5875.51 psf	17.64	N/A	258.87 Kips
71.99 ft	Cohesionless	5937.49 psf	17.64	N/A	270.00 Kips
72.01 ft	Cohesionless	6564.14 psf	18.82	N/A	270.13 Kips
76.99 ft	Cohesionless	6732.46 psf	18.82	N/A	306.12 Kips
77.01 ft	Cohesionless	6902.16 psf	19.99	N/A	306.28 Kips
81.99 ft	Cohesionless	7082.94 psf	19.99	N/A	351.68 Kips
82.01 ft	Cohesionless	7265.16 psf	20.58	N/A	351.88 Kips
91.01 ft	Cohesionless	7591.86 psf	20.58	N/A	447.21 Kips
100.01 ft	Cohesionless	7918.56 psf	20.58	N/A	550.75 Kips
104.99 ft	Cohesionless	8099.34 psf	20.58	N/A	611.56 Kips

RESTRIKE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesive	N/A	N/A	N/A	3.53 Kips
7.49 ft	Cohesive	N/A	N/A	N/A	3.53 Kips
7.51 ft	Cohesionless	826.20 psf	19.80	10.46 Kips	6.60 Kips
12.99 ft	Cohesionless	1483.80 psf	19.80	10.46 Kips	10.46 Kips
13.01 ft	Cohesive	N/A	N/A	N/A	7.07 Kips
14.99 ft	Cohesive	N/A	N/A	N/A	7.07 Kips
15.01 ft	Cohesionless	1716.20 psf	22.80	10.46 Kips	10.46 Kips
20.99 ft	Cohesionless	2433.80 psf	22.80	10.46 Kips	10.46 Kips
21.01 ft	Cohesionless	2436.25 psf	26.40	10.46 Kips	10.46 Kips
30.01 ft	Cohesionless	3561.25 psf	26.40	10.46 Kips	10.46 Kips
33.99 ft	Cohesionless	4058.75 psf	26.40	10.46 Kips	10.46 Kips
34.01 ft	Cohesionless	4060.63 psf	26.40	10.46 Kips	10.46 Kips
36.99 ft	Cohesionless	4247.17 psf	26.40	10.46 Kips	10.46 Kips
37.01 ft	Cohesionless	4248.48 psf	47.20	39.27 Kips	39.27 Kips
41.99 ft	Cohesionless	4585.12 psf	47.20	39.27 Kips	39.27 Kips
42.01 ft	Cohesionless	4586.53 psf	64.00	84.51 Kips	84.51 Kips
46.99 ft	Cohesionless	4948.07 psf	64.00	84.51 Kips	84.51 Kips
47.01 ft	Cohesionless	4949.53 psf	64.00	84.51 Kips	84.51 Kips
51.99 ft	Cohesionless	5311.07 psf	64.00	84.51 Kips	84.51 Kips
52.01 ft	Cohesionless	5312.43 psf	30.00	10.46 Kips	10.46 Kips
61.01 ft	Cohesionless	5875.83 psf	30.00	10.46 Kips	10.46 Kips
70.01 ft	Cohesionless	6439.23 psf	30.00	10.46 Kips	10.46 Kips
71.99 ft	Cohesionless	6563.17 psf	30.00	10.46 Kips	10.46 Kips
72.01 ft	Cohesionless	6564.48 psf	40.40	25.92 Kips	25.92 Kips
76.99 ft	Cohesionless	6901.12 psf	40.40	25.92 Kips	25.92 Kips
77.01 ft	Cohesionless	6902.53 psf	55.60	57.74 Kips	57.74 Kips
81.99 ft	Cohesionless	7264.07 psf	55.60	57.74 Kips	57.74 Kips
82.01 ft	Cohesionless	7265.53 psf	64.00	84.51 Kips	84.51 Kips
91.01 ft	Cohesionless	7918.93 psf	64.00	84.51 Kips	84.51 Kips
100.01 ft	Cohesionless	8572.33 psf	64.00	84.51 Kips	84.51 Kips
104.99 ft	Cohesionless	8933.87 psf	64.00	84.51 Kips	84.51 Kips

RESTRIKE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.01 Kips	3.53 Kips	3.55 Kips
7.49 ft	9.65 Kips	3.53 Kips	13.18 Kips
7.51 ft	9.67 Kips	6.60 Kips	16.27 Kips
12.99 ft	13.98 Kips	10.46 Kips	24.44 Kips
13.01 ft	14.01 Kips	7.07 Kips	21.08 Kips
14.99 ft	19.14 Kips	7.07 Kips	26.21 Kips
15.01 ft	19.18 Kips	10.46 Kips	29.64 Kips
20.99 ft	28.37 Kips	10.46 Kips	38.83 Kips
21.01 ft	28.41 Kips	10.46 Kips	38.87 Kips
30.01 ft	50.06 Kips	10.46 Kips	60.52 Kips
33.99 ft	62.22 Kips	10.46 Kips	72.68 Kips
34.01 ft	62.28 Kips	10.46 Kips	72.75 Kips
36.99 ft	72.21 Kips	10.46 Kips	82.67 Kips
37.01 ft	72.30 Kips	39.27 Kips	111.57 Kips
41.99 ft	98.24 Kips	39.27 Kips	137.51 Kips
42.01 ft	98.36 Kips	84.51 Kips	182.87 Kips
46.99 ft	131.48 Kips	84.51 Kips	215.99 Kips
47.01 ft	131.62 Kips	84.51 Kips	216.13 Kips
51.99 ft	167.27 Kips	84.51 Kips	251.78 Kips
52.01 ft	167.39 Kips	10.46 Kips	177.85 Kips
61.01 ft	210.94 Kips	10.46 Kips	221.40 Kips
70.01 ft	258.87 Kips	10.46 Kips	269.33 Kips
71.99 ft	270.00 Kips	10.46 Kips	280.46 Kips
72.01 ft	270.13 Kips	25.92 Kips	296.05 Kips
76.99 ft	306.12 Kips	25.92 Kips	332.03 Kips
77.01 ft	306.28 Kips	57.74 Kips	364.02 Kips
81.99 ft	351.68 Kips	57.74 Kips	409.42 Kips
82.01 ft	351.88 Kips	84.51 Kips	436.39 Kips
91.01 ft	447.21 Kips	84.51 Kips	531.72 Kips
100.01 ft	550.75 Kips	84.51 Kips	635.25 Kips
104.99 ft	611.56 Kips	84.51 Kips	696.07 Kips

DRIVING - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesive	N/A	N/A	410.00 psf	0.01 Kips
7.49 ft	Cohesive	N/A	N/A	410.00 psf	9.65 Kips
7.51 ft	Cohesionless	825.60 psf	15.88	N/A	9.67 Kips
12.99 ft	Cohesionless	1154.40 psf	15.88	N/A	13.98 Kips
13.01 ft	Cohesive	N/A	N/A	815.05 psf	14.01 Kips
14.99 ft	Cohesive	N/A	N/A	824.95 psf	19.14 Kips
15.01 ft	Cohesionless	1715.60 psf	16.46	N/A	19.18 Kips
20.99 ft	Cohesionless	2074.40 psf	16.46	N/A	28.37 Kips
21.01 ft	Cohesionless	2435.63 psf	17.05	N/A	28.41 Kips
30.01 ft	Cohesionless	2998.13 psf	17.05	N/A	50.06 Kips
33.99 ft	Cohesionless	3246.88 psf	17.05	N/A	62.22 Kips
34.01 ft	Cohesionless	4060.31 psf	17.05	N/A	62.28 Kips
36.99 ft	Cohesionless	4153.59 psf	17.05	N/A	72.21 Kips
37.01 ft	Cohesionless	4248.14 psf	19.41	N/A	72.30 Kips
41.99 ft	Cohesionless	4416.46 psf	19.41	N/A	98.24 Kips
42.01 ft	Cohesionless	4586.16 psf	20.58	N/A	98.36 Kips
46.99 ft	Cohesionless	4766.94 psf	20.58	N/A	131.48 Kips
47.01 ft	Cohesionless	4949.16 psf	20.58	N/A	131.62 Kips
51.99 ft	Cohesionless	5129.94 psf	20.58	N/A	167.27 Kips
52.01 ft	Cohesionless	5312.11 psf	17.64	N/A	167.39 Kips
61.01 ft	Cohesionless	5593.81 psf	17.64	N/A	210.94 Kips
70.01 ft	Cohesionless	5875.51 psf	17.64	N/A	258.87 Kips
71.99 ft	Cohesionless	5937.49 psf	17.64	N/A	270.00 Kips
72.01 ft	Cohesionless	6564.14 psf	18.82	N/A	270.13 Kips
76.99 ft	Cohesionless	6732.46 psf	18.82	N/A	306.12 Kips
77.01 ft	Cohesionless	6902.16 psf	19.99	N/A	306.28 Kips
81.99 ft	Cohesionless	7082.94 psf	19.99	N/A	351.68 Kips
82.01 ft	Cohesionless	7265.16 psf	20.58	N/A	351.88 Kips
91.01 ft	Cohesionless	7591.86 psf	20.58	N/A	447.21 Kips
100.01 ft	Cohesionless	7918.56 psf	20.58	N/A	550.75 Kips
104.99 ft	Cohesionless	8099.34 psf	20.58	N/A	611.56 Kips

DRIVING - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesive	N/A	N/A	N/A	3.53 Kips
7.49 ft	Cohesive	N/A	N/A	N/A	3.53 Kips
7.51 ft	Cohesionless	826.20 psf	19.80	10.46 Kips	6.60 Kips
12.99 ft	Cohesionless	1483.80 psf	19.80	10.46 Kips	10.46 Kips
13.01 ft	Cohesive	N/A	N/A	N/A	7.07 Kips
14.99 ft	Cohesive	N/A	N/A	N/A	7.07 Kips
15.01 ft	Cohesionless	1716.20 psf	22.80	10.46 Kips	10.46 Kips
20.99 ft	Cohesionless	2433.80 psf	22.80	10.46 Kips	10.46 Kips
21.01 ft	Cohesionless	2436.25 psf	26.40	10.46 Kips	10.46 Kips
30.01 ft	Cohesionless	3561.25 psf	26.40	10.46 Kips	10.46 Kips
33.99 ft	Cohesionless	4058.75 psf	26.40	10.46 Kips	10.46 Kips
34.01 ft	Cohesionless	4060.63 psf	26.40	10.46 Kips	10.46 Kips
36.99 ft	Cohesionless	4247.17 psf	26.40	10.46 Kips	10.46 Kips
37.01 ft	Cohesionless	4248.48 psf	47.20	39.27 Kips	39.27 Kips
41.99 ft	Cohesionless	4585.12 psf	47.20	39.27 Kips	39.27 Kips
42.01 ft	Cohesionless	4586.53 psf	64.00	84.51 Kips	84.51 Kips
46.99 ft	Cohesionless	4948.07 psf	64.00	84.51 Kips	84.51 Kips
47.01 ft	Cohesionless	4949.53 psf	64.00	84.51 Kips	84.51 Kips
51.99 ft	Cohesionless	5311.07 psf	64.00	84.51 Kips	84.51 Kips
52.01 ft	Cohesionless	5312.43 psf	30.00	10.46 Kips	10.46 Kips
61.01 ft	Cohesionless	5875.83 psf	30.00	10.46 Kips	10.46 Kips
70.01 ft	Cohesionless	6439.23 psf	30.00	10.46 Kips	10.46 Kips
71.99 ft	Cohesionless	6563.17 psf	30.00	10.46 Kips	10.46 Kips
72.01 ft	Cohesionless	6564.48 psf	40.40	25.92 Kips	25.92 Kips
76.99 ft	Cohesionless	6901.12 psf	40.40	25.92 Kips	25.92 Kips
77.01 ft	Cohesionless	6902.53 psf	55.60	57.74 Kips	57.74 Kips
81.99 ft	Cohesionless	7264.07 psf	55.60	57.74 Kips	57.74 Kips
82.01 ft	Cohesionless	7265.53 psf	64.00	84.51 Kips	84.51 Kips
91.01 ft	Cohesionless	7918.93 psf	64.00	84.51 Kips	84.51 Kips
100.01 ft	Cohesionless	8572.33 psf	64.00	84.51 Kips	84.51 Kips
104.99 ft	Cohesionless	8933.87 psf	64.00	84.51 Kips	84.51 Kips

DRIVING - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.01 Kips	3.53 Kips	3.55 Kips
7.49 ft	9.65 Kips	3.53 Kips	13.18 Kips
7.51 ft	9.67 Kips	6.60 Kips	16.27 Kips
12.99 ft	13.98 Kips	10.46 Kips	24.44 Kips
13.01 ft	14.01 Kips	7.07 Kips	21.08 Kips
14.99 ft	19.14 Kips	7.07 Kips	26.21 Kips
15.01 ft	19.18 Kips	10.46 Kips	29.64 Kips
20.99 ft	28.37 Kips	10.46 Kips	38.83 Kips
21.01 ft	28.41 Kips	10.46 Kips	38.87 Kips
30.01 ft	50.06 Kips	10.46 Kips	60.52 Kips
33.99 ft	62.22 Kips	10.46 Kips	72.68 Kips
34.01 ft	62.28 Kips	10.46 Kips	72.75 Kips
36.99 ft	72.21 Kips	10.46 Kips	82.67 Kips
37.01 ft	72.30 Kips	39.27 Kips	111.57 Kips
41.99 ft	98.24 Kips	39.27 Kips	137.51 Kips
42.01 ft	98.36 Kips	84.51 Kips	182.87 Kips
46.99 ft	131.48 Kips	84.51 Kips	215.99 Kips
47.01 ft	131.62 Kips	84.51 Kips	216.13 Kips
51.99 ft	167.27 Kips	84.51 Kips	251.78 Kips
52.01 ft	167.39 Kips	10.46 Kips	177.85 Kips
61.01 ft	210.94 Kips	10.46 Kips	221.40 Kips
70.01 ft	258.87 Kips	10.46 Kips	269.33 Kips
71.99 ft	270.00 Kips	10.46 Kips	280.46 Kips
72.01 ft	270.13 Kips	25.92 Kips	296.05 Kips
76.99 ft	306.12 Kips	25.92 Kips	332.03 Kips
77.01 ft	306.28 Kips	57.74 Kips	364.02 Kips
81.99 ft	351.68 Kips	57.74 Kips	409.42 Kips
82.01 ft	351.88 Kips	84.51 Kips	436.39 Kips
91.01 ft	447.21 Kips	84.51 Kips	531.72 Kips
100.01 ft	550.75 Kips	84.51 Kips	635.25 Kips
104.99 ft	611.56 Kips	84.51 Kips	696.07 Kips

ULTIMATE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesive	N/A	N/A	410.00 psf	0.01 Kips
7.49 ft	Cohesive	N/A	N/A	410.00 psf	9.65 Kips
7.51 ft	Cohesionless	825.60 psf	15.88	N/A	9.67 Kips
12.99 ft	Cohesionless	1154.40 psf	15.88	N/A	13.98 Kips
13.01 ft	Cohesive	N/A	N/A	815.05 psf	14.01 Kips
14.99 ft	Cohesive	N/A	N/A	824.95 psf	19.14 Kips
15.01 ft	Cohesionless	1715.60 psf	16.46	N/A	19.18 Kips
20.99 ft	Cohesionless	2074.40 psf	16.46	N/A	28.37 Kips
21.01 ft	Cohesionless	2435.63 psf	17.05	N/A	28.41 Kips
30.01 ft	Cohesionless	2998.13 psf	17.05	N/A	50.06 Kips
33.99 ft	Cohesionless	3246.88 psf	17.05	N/A	62.22 Kips
34.01 ft	Cohesionless	4060.31 psf	17.05	N/A	62.28 Kips
36.99 ft	Cohesionless	4153.59 psf	17.05	N/A	72.21 Kips
37.01 ft	Cohesionless	4248.14 psf	19.41	N/A	72.30 Kips
41.99 ft	Cohesionless	4416.46 psf	19.41	N/A	98.24 Kips
42.01 ft	Cohesionless	4586.16 psf	20.58	N/A	98.36 Kips
46.99 ft	Cohesionless	4766.94 psf	20.58	N/A	131.48 Kips
47.01 ft	Cohesionless	4949.16 psf	20.58	N/A	131.62 Kips
51.99 ft	Cohesionless	5129.94 psf	20.58	N/A	167.27 Kips
52.01 ft	Cohesionless	5312.11 psf	17.64	N/A	167.39 Kips
61.01 ft	Cohesionless	5593.81 psf	17.64	N/A	210.94 Kips
70.01 ft	Cohesionless	5875.51 psf	17.64	N/A	258.87 Kips
71.99 ft	Cohesionless	5937.49 psf	17.64	N/A	270.00 Kips
72.01 ft	Cohesionless	6564.14 psf	18.82	N/A	270.13 Kips
76.99 ft	Cohesionless	6732.46 psf	18.82	N/A	306.12 Kips
77.01 ft	Cohesionless	6902.16 psf	19.99	N/A	306.28 Kips
81.99 ft	Cohesionless	7082.94 psf	19.99	N/A	351.68 Kips
82.01 ft	Cohesionless	7265.16 psf	20.58	N/A	351.88 Kips
91.01 ft	Cohesionless	7591.86 psf	20.58	N/A	447.21 Kips
100.01 ft	Cohesionless	7918.56 psf	20.58	N/A	550.75 Kips
104.99 ft	Cohesionless	8099.34 psf	20.58	N/A	611.56 Kips

ULTIMATE - END BEARING

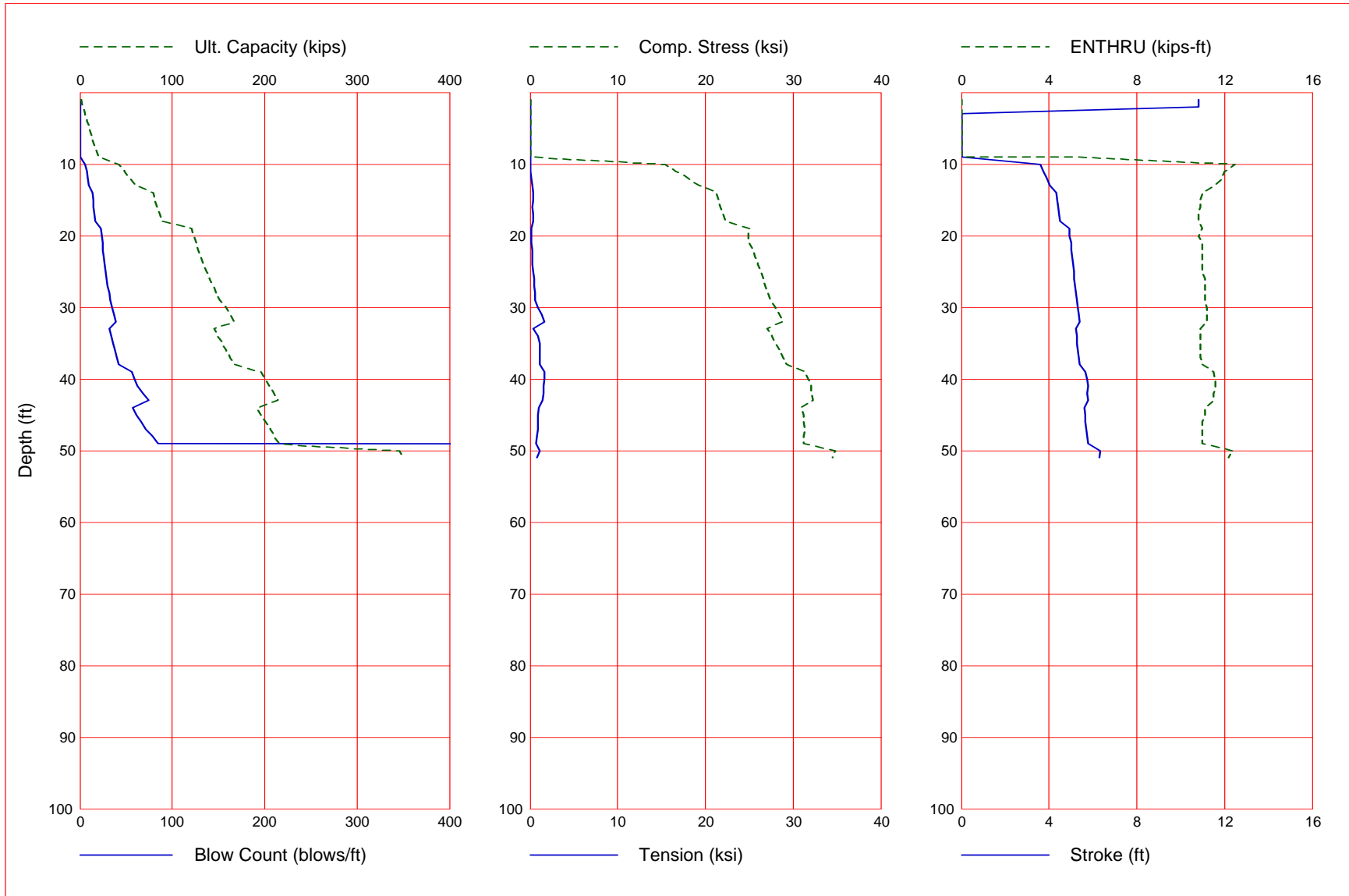
Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesive	N/A	N/A	N/A	3.53 Kips
7.49 ft	Cohesive	N/A	N/A	N/A	3.53 Kips
7.51 ft	Cohesionless	826.20 psf	19.80	10.46 Kips	6.60 Kips
12.99 ft	Cohesionless	1483.80 psf	19.80	10.46 Kips	10.46 Kips
13.01 ft	Cohesive	N/A	N/A	N/A	7.07 Kips
14.99 ft	Cohesive	N/A	N/A	N/A	7.07 Kips
15.01 ft	Cohesionless	1716.20 psf	22.80	10.46 Kips	10.46 Kips
20.99 ft	Cohesionless	2433.80 psf	22.80	10.46 Kips	10.46 Kips
21.01 ft	Cohesionless	2436.25 psf	26.40	10.46 Kips	10.46 Kips
30.01 ft	Cohesionless	3561.25 psf	26.40	10.46 Kips	10.46 Kips
33.99 ft	Cohesionless	4058.75 psf	26.40	10.46 Kips	10.46 Kips
34.01 ft	Cohesionless	4060.63 psf	26.40	10.46 Kips	10.46 Kips
36.99 ft	Cohesionless	4247.17 psf	26.40	10.46 Kips	10.46 Kips
37.01 ft	Cohesionless	4248.48 psf	47.20	39.27 Kips	39.27 Kips
41.99 ft	Cohesionless	4585.12 psf	47.20	39.27 Kips	39.27 Kips
42.01 ft	Cohesionless	4586.53 psf	64.00	84.51 Kips	84.51 Kips
46.99 ft	Cohesionless	4948.07 psf	64.00	84.51 Kips	84.51 Kips
47.01 ft	Cohesionless	4949.53 psf	64.00	84.51 Kips	84.51 Kips
51.99 ft	Cohesionless	5311.07 psf	64.00	84.51 Kips	84.51 Kips
52.01 ft	Cohesionless	5312.43 psf	30.00	10.46 Kips	10.46 Kips
61.01 ft	Cohesionless	5875.83 psf	30.00	10.46 Kips	10.46 Kips
70.01 ft	Cohesionless	6439.23 psf	30.00	10.46 Kips	10.46 Kips
71.99 ft	Cohesionless	6563.17 psf	30.00	10.46 Kips	10.46 Kips
72.01 ft	Cohesionless	6564.48 psf	40.40	25.92 Kips	25.92 Kips
76.99 ft	Cohesionless	6901.12 psf	40.40	25.92 Kips	25.92 Kips
77.01 ft	Cohesionless	6902.53 psf	55.60	57.74 Kips	57.74 Kips
81.99 ft	Cohesionless	7264.07 psf	55.60	57.74 Kips	57.74 Kips
82.01 ft	Cohesionless	7265.53 psf	64.00	84.51 Kips	84.51 Kips
91.01 ft	Cohesionless	7918.93 psf	64.00	84.51 Kips	84.51 Kips
100.01 ft	Cohesionless	8572.33 psf	64.00	84.51 Kips	84.51 Kips
104.99 ft	Cohesionless	8933.87 psf	64.00	84.51 Kips	84.51 Kips

ULTIMATE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.01 Kips	3.53 Kips	3.55 Kips
7.49 ft	9.65 Kips	3.53 Kips	13.18 Kips
7.51 ft	9.67 Kips	6.60 Kips	16.27 Kips
12.99 ft	13.98 Kips	10.46 Kips	24.44 Kips
13.01 ft	14.01 Kips	7.07 Kips	21.08 Kips
14.99 ft	19.14 Kips	7.07 Kips	26.21 Kips
15.01 ft	19.18 Kips	10.46 Kips	29.64 Kips
20.99 ft	28.37 Kips	10.46 Kips	38.83 Kips
21.01 ft	28.41 Kips	10.46 Kips	38.87 Kips
30.01 ft	50.06 Kips	10.46 Kips	60.52 Kips
33.99 ft	62.22 Kips	10.46 Kips	72.68 Kips
34.01 ft	62.28 Kips	10.46 Kips	72.75 Kips
36.99 ft	72.21 Kips	10.46 Kips	82.67 Kips
37.01 ft	72.30 Kips	39.27 Kips	111.57 Kips
41.99 ft	98.24 Kips	39.27 Kips	137.51 Kips
42.01 ft	98.36 Kips	84.51 Kips	182.87 Kips
46.99 ft	131.48 Kips	84.51 Kips	215.99 Kips
47.01 ft	131.62 Kips	84.51 Kips	216.13 Kips
51.99 ft	167.27 Kips	84.51 Kips	251.78 Kips
52.01 ft	167.39 Kips	10.46 Kips	177.85 Kips
61.01 ft	210.94 Kips	10.46 Kips	221.40 Kips
70.01 ft	258.87 Kips	10.46 Kips	269.33 Kips
71.99 ft	270.00 Kips	10.46 Kips	280.46 Kips
72.01 ft	270.13 Kips	25.92 Kips	296.05 Kips
76.99 ft	306.12 Kips	25.92 Kips	332.03 Kips
77.01 ft	306.28 Kips	57.74 Kips	364.02 Kips
81.99 ft	351.68 Kips	57.74 Kips	409.42 Kips
82.01 ft	351.88 Kips	84.51 Kips	436.39 Kips
91.01 ft	447.21 Kips	84.51 Kips	531.72 Kips
100.01 ft	550.75 Kips	84.51 Kips	635.25 Kips
104.99 ft	611.56 Kips	84.51 Kips	696.07 Kips

APPENDIX VI

GRLWEAP DRIVEABILITY ANALYSIS



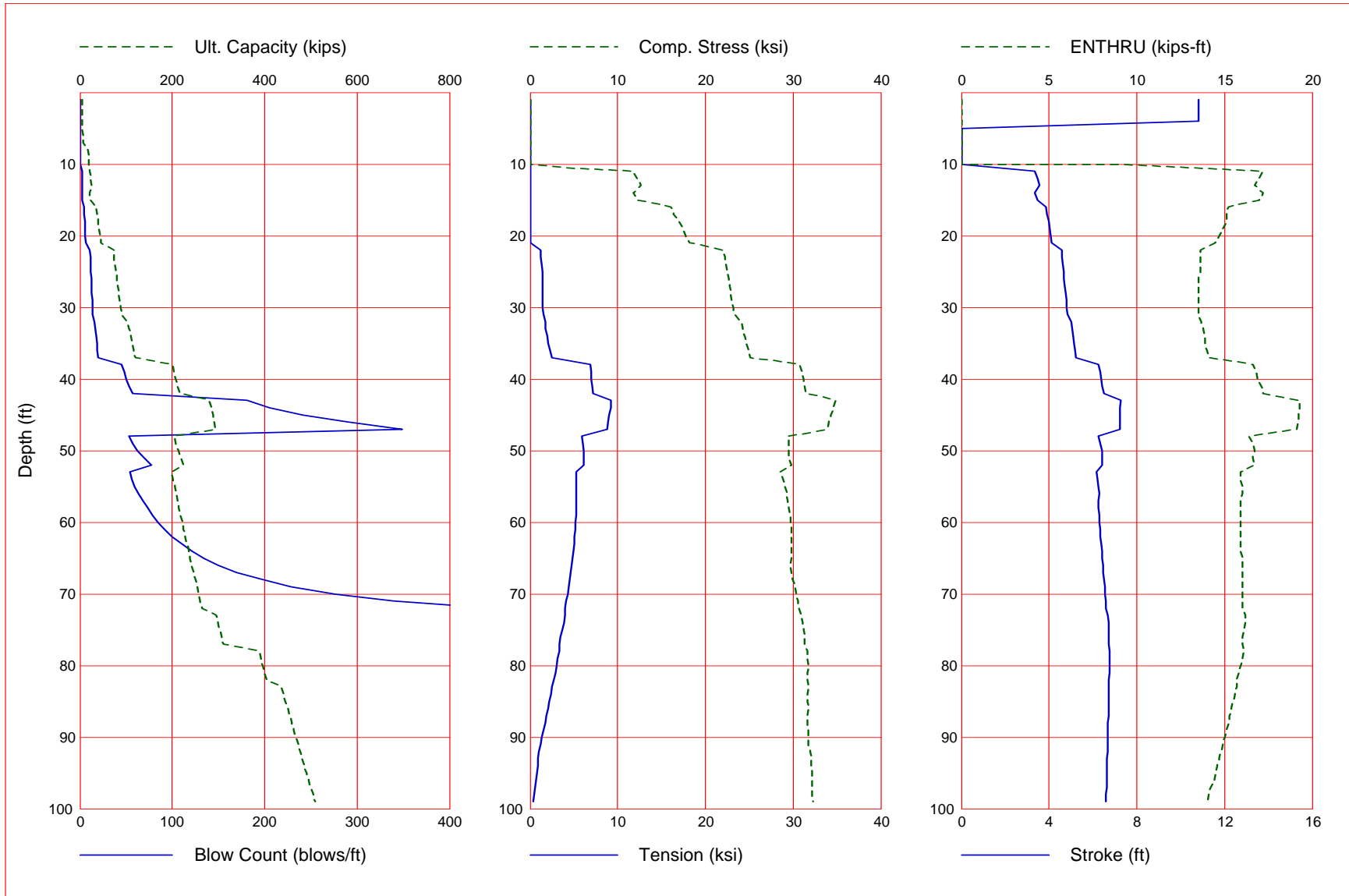
Gain/Loss 1 at Shaft and Toe 1.000 / 1.000

Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
1.0	1.9	0.0	1.8	0.0	0.000	0.000	10.81	0.0
2.0	3.8	0.2	3.6	0.0	0.000	0.000	10.81	0.0
3.0	5.9	0.4	5.4	-1.0	0.000	0.000	0.00	0.0
4.0	8.0	0.8	7.2	-1.0	0.000	0.000	0.00	0.0
5.0	10.3	1.2	9.0	-1.0	0.000	0.000	0.00	0.0
6.0	12.6	1.8	10.8	-1.0	0.000	0.000	0.00	0.0
7.0	15.0	2.4	12.7	-1.0	0.000	0.000	0.00	0.0
8.0	17.7	3.1	14.5	-1.0	0.000	0.000	0.00	0.0
9.0	20.4	4.0	16.4	-1.0	0.000	0.000	0.00	0.0
10.0	42.0	5.3	36.7	6.0	15.410	0.000	3.62	12.5
11.0	47.8	7.2	40.6	7.2	16.581	0.000	3.73	12.0
12.0	53.9	9.4	44.5	8.4	18.118	-0.201	3.92	11.9
13.0	60.1	11.7	48.5	9.7	19.288	-0.303	4.04	11.6
14.0	79.3	13.7	65.6	13.8	21.275	-0.383	4.35	11.0
15.0	81.4	15.8	65.6	14.4	21.511	-0.352	4.39	10.9
16.0	83.7	18.1	65.6	15.0	21.740	-0.315	4.42	10.9
17.0	86.2	20.6	65.6	15.6	21.996	-0.346	4.46	10.8
18.0	88.8	23.2	65.6	16.3	22.254	-0.374	4.50	10.8
19.0	120.6	25.5	95.1	23.1	25.017	-0.187	4.94	11.0
20.0	123.1	27.9	95.1	24.1	24.862	-0.213	4.92	10.8
21.0	125.7	30.5	95.1	24.6	25.042	-0.187	5.00	11.0
22.0	128.4	33.3	95.1	25.3	25.430	-0.220	5.03	11.0
23.0	131.3	36.1	95.1	26.2	25.700	-0.227	5.06	11.0
24.0	134.3	39.1	95.1	27.1	25.972	-0.269	5.09	11.0
25.0	137.4	42.3	95.1	28.0	26.301	-0.347	5.12	11.0
26.0	140.7	45.5	95.1	29.1	26.626	-0.439	5.15	11.1
27.0	144.1	48.9	95.1	30.3	26.871	-0.480	5.18	11.1
28.0	147.6	52.5	95.1	31.5	27.198	-0.546	5.21	11.1
29.0	151.3	56.2	95.1	32.9	27.418	-0.602	5.25	11.1
30.0	158.3	59.9	98.4	35.4	28.041	-0.892	5.31	11.2
31.0	162.2	63.8	98.4	37.1	28.431	-1.371	5.34	11.2
32.0	166.2	67.7	98.4	38.8	28.868	-1.618	5.38	11.2
33.0	145.6	71.8	73.8	32.4	27.051	-0.387	5.22	10.9
34.0	149.8	76.0	73.8	33.9	27.574	-0.886	5.25	10.9
35.0	154.0	80.2	73.8	35.7	28.025	-1.119	5.29	10.9
36.0	158.4	84.5	73.8	37.5	28.466	-1.133	5.33	10.9
37.0	162.7	88.9	73.8	39.7	28.832	-1.133	5.36	10.9
38.0	167.2	93.3	73.8	41.8	29.290	-1.158	5.40	11.0
39.0	196.2	97.8	98.4	55.7	31.466	-1.639	5.67	11.5
40.0	200.7	102.3	98.4	59.0	31.761	-1.615	5.73	11.6
41.0	205.3	106.9	98.4	62.7	32.041	-1.580	5.78	11.6
42.0	209.9	111.5	98.4	68.7	32.048	-1.513	5.75	11.5
43.0	214.6	116.2	98.4	74.0	32.216	-1.451	5.79	11.5
44.0	191.4	120.9	70.5	57.4	30.921	-1.012	5.62	11.1
45.0	196.1	125.6	70.5	61.1	31.156	-0.958	5.67	11.1
46.0	200.9	130.3	70.5	66.8	31.155	-0.894	5.66	11.0

Gain/Loss 1 at Shaft and Toe 1.000 / 1.000 (Continued)

Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
47.0	205.7	135.1	70.5	71.4	31.354	-0.855	5.70	11.0
48.0	210.6	140.0	70.5	78.0	31.232	-0.774	5.73	11.0
49.0	215.5	145.0	70.5	84.6	31.181	-0.697	5.76	11.0
50.0	345.8	149.0	196.9	9999.0	34.826	-1.088	6.35	12.4
51.0	348.8	151.9	196.9	9999.0	34.479	-0.851	6.31	12.2

Refusal occurred; no driving time output possible



Gain/Loss 1 at Shaft and Toe 1.000 / 1.000

Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
1.0	4.5	0.1	4.4	0.0	0.000	0.000	10.81	0.0
2.0	4.7	0.2	4.4	0.0	0.000	0.000	10.81	0.0
3.0	5.0	0.6	4.4	0.0	0.000	0.000	10.81	0.0
4.0	5.4	1.0	4.4	0.0	0.000	0.000	10.81	0.0
5.0	6.0	1.5	4.4	-1.0	0.000	0.000	0.00	0.0
6.0	6.6	2.2	4.4	-1.0	0.000	0.000	0.00	0.0
7.0	7.4	3.0	4.4	-1.0	0.000	0.000	0.00	0.0
8.0	17.1	4.0	13.1	-1.0	0.000	0.000	0.00	0.0
9.0	18.4	5.3	13.1	-1.0	0.000	0.000	0.00	0.0
10.0	19.8	6.7	13.1	-1.0	0.000	0.000	0.00	0.0
11.0	21.4	8.2	13.1	2.3	11.764	0.000	3.37	17.2
12.0	23.1	9.9	13.1	2.6	12.249	0.000	3.48	17.0
13.0	24.9	11.8	13.1	2.8	12.651	0.000	3.55	16.7
14.0	20.5	13.4	7.1	2.3	11.746	0.000	3.37	17.2
15.0	22.3	15.2	7.1	2.5	12.224	0.000	3.48	17.0
16.0	36.4	16.7	19.7	4.6	16.003	0.000	3.87	15.2
17.0	38.0	18.3	19.7	4.9	16.412	0.000	3.92	15.1
18.0	39.7	20.1	19.7	5.1	17.014	0.000	4.00	15.1
19.0	41.6	21.9	19.7	5.5	17.395	0.000	4.03	14.9
20.0	43.5	23.8	19.7	5.9	17.792	0.000	4.08	14.7
21.0	45.5	25.8	19.7	6.3	18.143	0.000	4.10	14.5
22.0	73.2	27.3	45.9	11.0	22.063	-1.180	4.57	13.6
23.0	74.7	28.8	45.9	11.3	22.227	-1.278	4.60	13.6
24.0	76.3	30.4	45.9	11.6	22.392	-1.358	4.63	13.6
25.0	78.0	32.0	45.9	11.9	22.488	-1.405	4.66	13.6
26.0	79.7	33.8	45.9	12.2	22.633	-1.435	4.69	13.5
27.0	81.5	35.6	45.9	12.6	22.773	-1.444	4.71	13.5
28.0	83.4	37.5	45.9	12.9	22.926	-1.417	4.75	13.5
29.0	85.4	39.4	45.9	13.3	23.029	-1.414	4.78	13.5
30.0	87.4	41.5	45.9	13.7	23.174	-1.483	4.80	13.5
31.0	89.5	43.6	45.9	14.1	23.328	-1.548	4.83	13.5
32.0	102.7	47.0	55.8	16.2	24.094	-1.712	5.00	13.7
33.0	106.2	50.4	55.8	16.9	24.274	-1.781	5.04	13.8
34.0	109.8	54.0	55.8	17.6	24.478	-1.920	5.09	13.9
35.0	113.4	57.7	55.8	18.3	24.690	-2.053	5.14	13.9
36.0	117.2	61.4	55.8	19.1	24.870	-2.260	5.19	14.0
37.0	121.0	65.2	55.8	20.0	25.083	-2.508	5.24	14.1
38.0	200.1	68.9	131.2	45.1	30.808	-6.843	6.26	16.6
39.0	203.8	72.6	131.2	47.7	30.979	-6.950	6.32	16.8
40.0	207.5	76.3	131.2	50.3	31.159	-7.030	6.38	16.9
41.0	211.3	80.1	131.2	53.4	31.288	-7.078	6.43	17.1
42.0	215.2	84.0	131.2	56.8	31.417	-7.159	6.49	17.2
43.0	280.9	87.3	193.6	180.7	34.827	-9.278	7.26	19.3
44.0	284.3	90.8	193.6	205.3	34.626	-9.190	7.25	19.3
45.0	287.8	94.2	193.6	241.1	34.342	-9.054	7.24	19.2
46.0	291.3	97.8	193.6	288.9	34.058	-8.907	7.24	19.2

Gain/Loss 1 at Shaft and Toe 1.000 / 1.000 (Continued)

Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
47.0	294.9	101.4	193.6	349.1	33.877	-8.823	7.23	19.1
48.0	203.0	106.2	96.8	53.4	29.369	-5.949	6.26	16.4
49.0	207.9	111.1	96.8	57.3	29.490	-6.036	6.34	16.6
50.0	212.9	116.1	96.8	62.0	29.541	-6.100	6.41	16.7
51.0	218.0	121.2	96.8	69.8	29.491	-6.121	6.40	16.6
52.0	223.1	126.4	96.8	77.0	29.836	-6.165	6.43	16.7
53.0	198.4	129.5	68.9	53.7	28.559	-5.269	6.17	15.9
54.0	201.6	132.7	68.9	56.6	28.825	-5.272	6.20	15.9
55.0	204.8	135.9	68.9	59.5	29.101	-5.330	6.23	16.0
56.0	208.0	139.1	68.9	63.0	29.306	-5.311	6.28	16.0
57.0	211.3	142.4	68.9	68.4	29.382	-5.282	6.24	15.9
58.0	214.6	145.7	68.9	73.4	29.504	-5.236	6.27	15.9
59.0	217.9	149.0	68.9	78.1	29.656	-5.257	6.29	15.9
60.0	221.3	152.4	68.9	84.5	29.740	-5.218	6.31	15.9
61.0	224.7	155.8	68.9	91.6	29.799	-5.163	6.33	15.9
62.0	228.2	159.3	68.9	99.8	29.831	-5.101	6.35	15.9
63.0	231.7	162.8	68.9	109.4	29.847	-5.047	6.38	15.9
64.0	235.2	166.3	68.9	121.0	29.827	-4.986	6.40	15.9
65.0	238.8	169.9	68.9	134.1	29.786	-4.900	6.44	16.0
66.0	242.4	173.5	68.9	149.1	29.735	-4.794	6.46	16.0
67.0	246.0	177.1	68.9	169.2	29.768	-4.685	6.48	16.0
68.0	249.7	180.8	68.9	196.8	29.955	-4.558	6.51	16.0
69.0	253.5	184.6	68.9	228.2	30.195	-4.447	6.53	16.0
70.0	257.2	188.3	68.9	276.5	30.342	-4.268	6.56	16.0
71.0	261.0	192.1	68.9	339.3	30.511	-4.157	6.58	16.0
72.0	264.8	195.9	68.9	450.3	30.670	-4.011	6.59	16.0
73.0	294.9	199.8	95.1	9999.0	30.999	-3.959	6.69	16.2
74.0	298.8	203.7	95.1	9999.0	31.107	-3.859	6.70	16.2
75.0	302.7	207.6	95.1	9999.0	31.187	-3.674	6.71	16.1
76.0	306.7	211.6	95.1	9999.0	31.274	-3.508	6.70	16.0
77.0	310.7	215.6	95.1	9999.0	31.341	-3.407	6.70	16.0
78.0	386.9	219.6	167.3	9999.0	31.635	-3.390	6.78	16.1
79.0	390.9	223.6	167.3	9999.0	31.642	-3.186	6.77	16.0
80.0	395.0	227.6	167.3	9999.0	31.692	-3.049	6.76	15.9
81.0	399.1	231.8	167.3	9999.0	31.645	-2.895	6.75	15.8
82.0	403.2	235.9	167.3	9999.0	31.674	-2.706	6.74	15.7
83.0	436.9	240.1	196.9	9999.0	31.717	-2.546	6.74	15.7
84.0	441.2	244.3	196.9	9999.0	31.671	-2.402	6.73	15.6
85.0	445.4	248.6	196.9	9999.0	31.676	-2.231	6.72	15.5
86.0	449.7	252.9	196.9	9999.0	31.695	-2.061	6.71	15.4
87.0	454.1	257.2	196.9	9999.0	31.656	-1.893	6.70	15.3
88.0	458.5	261.6	196.9	9999.0	31.659	-1.711	6.69	15.2
89.0	462.9	266.0	196.9	9999.0	31.740	-1.527	6.68	15.1
90.0	467.4	270.5	196.9	9999.0	31.773	-1.370	6.67	15.0
91.0	471.9	275.0	196.9	9999.0	31.782	-1.212	6.67	14.9
92.0	476.4	279.6	196.9	9999.0	31.941	-1.066	6.66	14.8

Gain/Loss 1 at Shaft and Toe 1.000 / 1.000 (Continued)

Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
93.0	481.0	284.2	196.9	9999.0	32.002	-0.959	6.65	14.7
94.0	485.7	288.8	196.9	9999.0	32.040	-0.856	6.64	14.6
95.0	490.3	293.5	196.9	9999.0	32.125	-0.775	6.64	14.5
96.0	495.1	298.2	196.9	9999.0	32.177	-0.668	6.63	14.4
97.0	499.8	303.0	196.9	9999.0	32.187	-0.555	6.62	14.2
98.0	504.6	307.8	196.9	9999.0	32.189	-0.459	6.61	14.1
99.0	509.5	312.6	196.9	9999.0	32.226	-0.336	6.61	14.0

Refusal occurred; no driving time output possible

APPENDIX VII

SETTLEMENT CALCULATIONS

B-10-020 HAM-75-7.85 (HAM-75-0857 Bridge Structure)
MSE Wall - Consolidation Settlement

Calculated By: BRT Date: 8/8/2013
Checked By: NCK Date: 8/8/2013

Boring B-181 (HAM-75-0857 Rear Abutment)

23.2' net embankment height considered - Total wall height is 28.2' - Bottom of wall at 531.0, existing grade is at 536.0, and proposed profile grade is at 559.2 for a net embankment height of 23.2'

H= 23.2 ft
B= 19.7 ft
 γ_{eff} = 120 pcf
 D_w = 31.0 ft depth from ground surface
 γ_w = 62.4 pcf
 ΔP = 2784 psf at surface

Layer	Soil Type	Depth		Thickness	Depth to Midpoint	γ	LL	C_c	C_r	e_o	σ'_v	σ_{v0} Bottom	σ_{v0} Midpoint	σ_{v0}' Midpoint	Z_f/B	Total Settlement at Center of Reinforced Soil Mass					Total Settlement at Facing of Wall								
																I	$\Delta\sigma_v$	σ_{v0}' Midpoint	S_c (ft)	S_c (in)	I	$\Delta\sigma_v$	σ_{v0}' Midpoint	S_c (ft)	S_c (in)				
1	A-4a (Granular)	0.0	7.0	7.0	3.5	115	Calculated Separately					402.5	402.5	402.5	0.18	Calculated Separately					0.034	0.409	Calculated Separately					0.017	0.198
2	A-4a (Cohesive)	7.0	9.0	2.0	8.0	115	23	0.154	0.014	0.494	1918	632.5	517.5	517.5	0.41	0.906	2522	3039	0.052	0.623	0.476	1325	1843	0.010	0.124				
		9.0	11.0	2.0	10.0	115	23	0.154	0.014	0.494	2148	862.5	747.5	747.5	0.51	0.840	2339	3086	0.041	0.493	0.460	1281	2028	0.008	0.097				
		11.0	13.0	2.0	12.0	120	23	0.154	0.014	0.494	2383	1102.5	982.5	982.5	0.61	0.767	2134	3117	0.031	0.375	0.444	1236	2219	0.007	0.080				
3	Granular	13.0	50.0	37.0	31.5	130	Calculated Separately					5912.5	3507.5	3476.3	1.60	Calculated Separately					0.044	0.529	Calculated Separately					0.020	0.245

Settlement at Center of Reinforced Soil Mass: 2.429 in

Settlement at Facing of Wall: 0.745 in

B-10-020 HAM-75-7.85 (HAM-75-0857 Bridge Structure)
MSE Wall - Consolidation Settlement

Calculated By: BRT Date: 8/8/2013
Checked By: NCK Date: 8/8/2013

Boring B-182 (HAM-75-0857 Forward Abutment)

23.2' net embankment height considered - Total wall height is 28.2' - Bottom of wall at 531.6, existing grade is at 536.6, and proposed profile grade is at 559.8 for a net embankment height of 23.2'

H= 23.2 ft
B= 19.7 ft
 γ_{sf} = 120 pcf
 D_w = 34.0 ft depth below bottom of footing
 γ_w = 62.4 pcf
 ΔP = 2784 psf at surface

Layer	Soil Type	Depth		Thickness	Depth to Midpoint	γ	LL	C_c	C_r	e_o	σ_p'	σ_{10} Bottom	σ_{10} Midpoint	σ_{10}' Midpoint	Z_f/B	Total Settlement at Center of Reinforced Soil Mass					Total Settlement at Facing of Wall				
		I	$\Delta\sigma_v$													σ_{sf}' Midpoint	S_c (ft)	S_c (in)	I	$\Delta\sigma_v$	σ_{sf}' Midpoint	S_c (ft)	S_c (in)		
1	Controlled Fill	0.0	1.5	1.5	0.8	120	N/A	0.100	0.008	0.437	N/A	180	90	90	0.04	0.988	2751.25	2841.25	0.012	0.141	0.500	1392.0	1482.0	0.010	0.114
		1.5	3.0	1.5	2.3	120	N/A	0.100	0.008	0.437	N/A	360	270	270	0.11	0.971	2702.12	2972.12	0.008	0.098	0.500	1392.0	1662.0	0.006	0.074
		3.0	4.5	1.5	3.8	120	N/A	0.100	0.008	0.437	N/A	540	450	450	0.19	0.953	2652.99	3102.99	0.007	0.079	0.500	1392.0	1842.0	0.005	0.058
		4.5	6.0	1.5	5.3	120	N/A	0.100	0.008	0.437	N/A	720	630	630	0.27	0.935	2603.86	3233.86	0.006	0.067	0.496	1380.9	2010.9	0.004	0.047
		6.0	7.5	1.5	6.8	120	N/A	0.100	0.008	0.437	N/A	900	810	810	0.34	0.918	2554.73	3364.73	0.005	0.058	0.484	1347.5	2157.5	0.003	0.040
2	Granular	7.5	75.0	67.5	41.3	130	Calculated Separately					9675	5287.5	4835.1	2.09	Calculated Separately			0.101	1.209	Calculated Separately		0.047	0.561	

Settlement at Center of Reinforced Soil Mass: 1.651 in

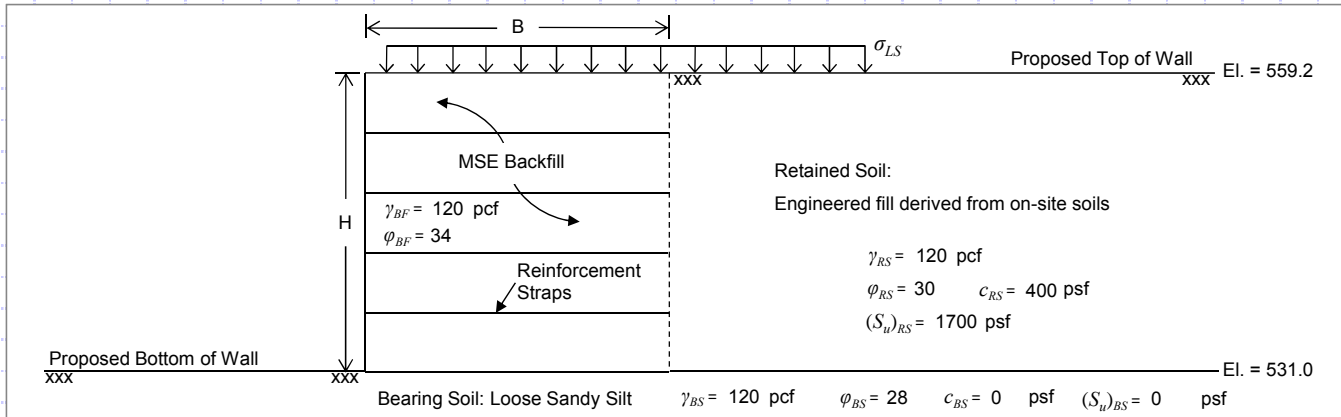
Settlement at Facing of Wall: 0.895 in

APPENDIX VIII

MSE WALL CALCULATIONS



MSE Wall - Rear Abutment - B-181 - (28.2 ft. Wall Height)



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	28.2 ft
MSE Wall Width (Reinforcement Length), (B) =	19.7 ft
Live Surcharge Load, (σ _{LS}) =	240 psf
Retained Soil Unit Weight, (γ _{RS}) =	120 pcf
Retained Soil Friction Angle, (φ _{RS}) =	30°
Retained Soil Drained Cohesion, (c _{BS}) =	400 psf
Retained Soil Undrained Shear Strength, [(S _u) _{RS}] =	1700 psf
Retained Soil Active Earth Pressure Coeff., (K _a) =	0.333
MSE Backfill Unit Weight, (γ _{BF}) =	120 pcf
MSE Backfill Friction Angle, (φ _{BF}) =	34°

Bearing Soil Properties:

Bearing Soil Unit Weight, (γ _{BS}) =	120 pcf
Bearing Soil Friction Angle, (φ _{BS}) =	28°
Bearing Soil Drained Cohesion, (c _{BS}) =	0 psf
Bearing Soil Undrained Shear Strength, [(S _u) _{BS}] =	0 psf
Embedment Depth, (D) =	5.0 ft

LRFD Load Factors

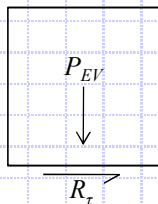
	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

Check Sliding (Loading Case - Strength Ia) - AASHTO LRFD BDM Sections 11.6.3.6 and 11.10.5.3

Nominal Sliding Resistance:

$$R_{\tau} = P_{EV} \cdot \tan \delta$$



$$P_{EV} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = (120 \text{ pcf})(28.2 \text{ ft})(19.74 \text{ ft})(1.00) = 66.8 \text{ kip/ft}$$

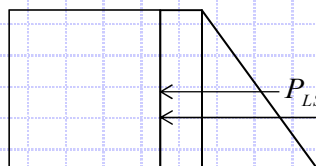
$$\tan \delta = (\tan \phi_{BS} \leq \tan \phi_{BF})$$

$$\tan \delta = \tan(28) \leq \tan(34) \rightarrow 0.53 \leq 0.67 \rightarrow \tan \delta = 0.53$$

$$R_{\tau} = (66.8 \text{ kip/ft})(0.53) = 35.40 \text{ kip/ft}$$

Sliding Force:

$$P_H = P_{EH} + P_{LS_h}$$



$$P_{EH} = \frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(28.2 \text{ ft})^2(0.333)(1.5) = 23.83 \text{ kip/ft}$$

$$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS} = (240 \text{ psf})(28.2 \text{ ft})(0.333)(1.75) = 3.94 \text{ kip/ft}$$

$$P_H = 23.83 \text{ kip/ft} + 3.94 \text{ kip/ft} = 27.77 \text{ kip/ft}$$

Check Sliding Resistance

$$P_H \leq R_{\tau} \cdot \phi_{\tau} \rightarrow 27.77 \text{ kip/ft} \leq (35.40 \text{ kip/ft})(1.0) = 35.40 \text{ kip/ft} \rightarrow 27.77 \text{ kip/ft} \leq 35.40 \text{ kip/ft} \quad \text{OK}$$

Use φ_τ = 1.0 (Per AASHTO LRFD BDM Table 11.5.6-1)



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	28.2 ft
MSE Wall Width (Reinforcement Length), (B) =	19.74 ft
Live Surcharge Load, (σ_{LS}) =	240 psf
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf
Retained Soil Friction Angle, (ϕ_{RS}) =	30°
Retained Soil Drained Cohesion, (c_{BS}) =	400 psf
Retained Soil Undrained Shear Strength, [$(S_u)_{RS}$] =	1700 psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.333
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Backfill Friction Angle, (ϕ_{BF}) =	34°

Bearing Soil Properties:

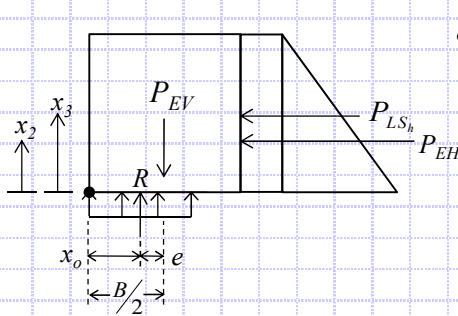
Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	28°
Bearing Soil Drained Cohesion, (c_{BS}) =	0 psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	0 psf
Embedment Depth, (D) =	5.0 ft

LRFD Load Factors

	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

Check Eccentricity (Loading Case - Strength Ia) - AASHTO LRFD BDM Section 11.6.3.3



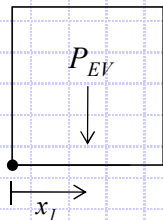
$$e = B/2 - x_o$$

$$x_o = \frac{M_{EV} - M_H}{P_{EV}} = (659.32 \text{ kip-ft/ft} - 279.56 \text{ kip-ft/ft}) / (66.8 \text{ kip/ft}) = 5.69 \text{ ft}$$

$$\begin{aligned} M_{EV} &= 659.32 \text{ kip-ft/ft} \\ M_H &= 279.56 \text{ kip-ft/ft} \\ P_{EV} &= 66.80 \text{ kip/ft} \end{aligned} \quad \left. \begin{array}{l} \\ \\ \end{array} \right\} \text{Defined below}$$

$$e = (19.74 \text{ ft})/2 - 5.69 \text{ ft} = 4.18 \text{ ft}$$

Resisting Moment, M_{EV} :



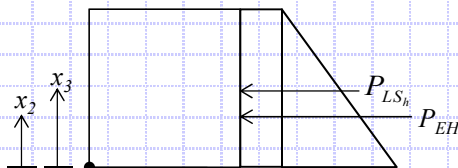
$$M_{EV} = P_{EV}(x_1)$$

$$P_{EV} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = (120 \text{ pcf})(28.2 \text{ ft})(19.74 \text{ ft})(1.00) = 66.80 \text{ kip/ft}$$

$$x_1 = B/2 = (19.74 \text{ ft})/2 = 9.87 \text{ ft}$$

$$M_{EV} = (66.8 \text{ kip/ft})(9.87 \text{ ft}) = 659.32 \text{ kip-ft/ft}$$

Overturning Moment, M_H :



$$M_H = P_{EH}(x_2) + P_{LS_h}(x_3)$$

$$P_{EH} = \frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(28.2 \text{ ft})^2(0.333)(1.5) = 23.83 \text{ kip/ft}$$

$$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS} = (240 \text{ psf})(28.2 \text{ ft})(0.333)(1.75) = 3.94 \text{ kip/ft}$$

$$x_2 = H/3 = (28.2 \text{ ft})/3 = 9.40 \text{ ft}$$

$$x_3 = H/2 = (28.2 \text{ ft})/2 = 14.10 \text{ ft}$$

$$M_H = (23.83 \text{ kip/ft})(9.4 \text{ ft}) + (3.94 \text{ kip/ft})(14.1 \text{ ft}) = 279.56 \text{ kip-ft/ft}$$

Limiting Eccentricity:

$$e_{\max} = B/4 \rightarrow e_{\max} = (19.74 \text{ ft})/4 = 4.94 \text{ ft}$$

Check Eccentricity

$$e < e_{\max} \rightarrow 4.18 \text{ ft} < 4.94 \text{ ft} \quad \text{OK}$$



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	28.2 ft
MSE Wall Width (Reinforcement Length), (B) =	19.74 ft
Live Surcharge Load, (σ_{LS}) =	240 psf
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf
Retained Soil Friction Angle, (ϕ_{RS}) =	30°
Retained Soil Drained Cohesion, (c_{BS}) =	400 psf
Retained Soil Undrained Shear Strength, [$(S_u)_{RS}$] =	1700 psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.333
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Backfill Friction Angle, (ϕ_{BF}) =	34°

Bearing Soil Properties:

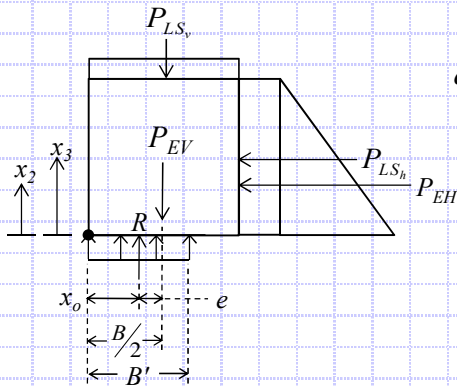
Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	28°
Bearing Soil Drained Cohesion, (c_{BS}) =	0 psf
Bearing Soil Undrained Shear Strength, [$(s_u)_{BS}$] =	0 psf
Embedment Depth, (D) =	5.0 ft

LRFD Load Factors

	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

Check Bearing Capacity (Loading Case - Strength Ib) - AASHTO LRFD BDM Section 11.6.3.2



$$q_{eq} = P_V / B'$$

$$B' = B - 2e = 19.74 \text{ ft} - 2(2.84 \text{ ft}) = 14.06 \text{ ft}$$

$$e = B/2 - x_o = (19.74 \text{ ft}) / 2 - 7.03 \text{ ft} = 2.84 \text{ ft}$$

$$x_o = \frac{M_V - M_H}{P_V} = (971.91 \text{ kip-ft/ft} - 279.64 \text{ kip-ft/ft}) / 98.47 \text{ kip/ft} = 7.03 \text{ ft}$$

$$q_{eq} = (98.47 \text{ kip/ft}) / (14.06 \text{ ft}) = 7.00 \text{ ksf}$$

$$M_V = P_{EV}(x_1) + P_{LS_v}(x_1) = (\gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV})(x_1) + (\sigma_{LS} \cdot B \cdot \gamma_{LS})(x_1)$$

$$M_V = [(120 \text{ pcf})(28.2 \text{ ft})(19.74 \text{ ft})(1.35)](9.87 \text{ ft}) + [(240 \text{ psf})(19.74 \text{ ft})(1.75)](9.87 \text{ ft}) = 971.91 \text{ kip-ft/ft}$$

$$M_H = P_{EH}(x_2) + P_{LS_h}(x_3) = (\frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH})(x_2) + (\sigma_{LS} H K_a \gamma_{LS})(x_3)$$

$$M_H = [\frac{1}{2}(120 \text{ pcf})(28.2 \text{ ft})^2(0.333)(1.5)](9.4 \text{ ft}) + [(240 \text{ psf})(28.2 \text{ ft})(0.333)(1.75)](14.1 \text{ ft}) = 279.64 \text{ kip-ft/ft}$$

$$P_V = P_{EV} + P_{LS_v} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} + \sigma_{LS} \cdot B \cdot \gamma_{LS}$$

$$P_V = (120 \text{ pcf})(28.2 \text{ ft})(19.74 \text{ ft})(1.35) + (240 \text{ psf})(19.74 \text{ ft})(1.75) = 98.47 \text{ kip/ft}$$

Nominal Bearing Resistance:

$$q_n = cN_c + \gamma DN_q + \frac{1}{2} \gamma BN_\gamma = (0 \text{ psf})(31.6) + (120 \text{ pcf})(5 \text{ ft})(17.8) + \frac{1}{2}(120 \text{ pcf})(19.74 \text{ ft})(14.6) = 28.0 \text{ ksf}$$

$$N_c = 31.6 \quad N_q = 17.8 \quad N_\gamma = 14.6$$

Check Bearing Capacity

$$q_{eq} \leq q_n \cdot \phi_b \rightarrow 7.00 \text{ ksf} \leq (28.0 \text{ ksf})(0.65) = 18.20 \text{ ksf} \rightarrow 7.00 \text{ ksf} \leq 18.20 \text{ ksf} \quad \text{OK}$$

Use $\phi_b = 0.65$ (Per AASHTO LRFD BDM Table 11.5.6-1)



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	28.2 ft
MSE Wall Width (Reinforcement Length), (B) =	19.74 ft
Live Surcharge Load, (σ_{LS}) =	240 psf
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf
Retained Soil Friction Angle, (ϕ_{RS}) =	30°
Retained Soil Drained Cohesion, (c_{RS}) =	400 psf
Retained Soil Undrained Shear Strength, [$(S_u)_{RS}$] =	1700 psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.333
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Backfill Friction Angle, (ϕ_{BF}) =	34°

Bearing Soil Properties:

Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	28°
Bearing Soil Drained Cohesion, (c_{BS}) =	0 psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	0 psf
Embedment Depth, (D) =	5.0 ft

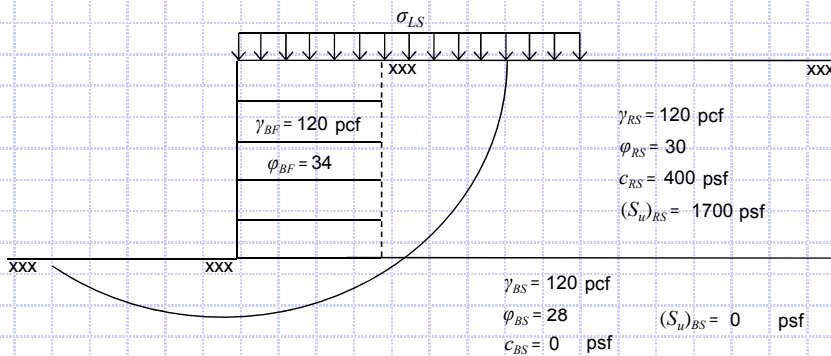
LRFD Load Factors

	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

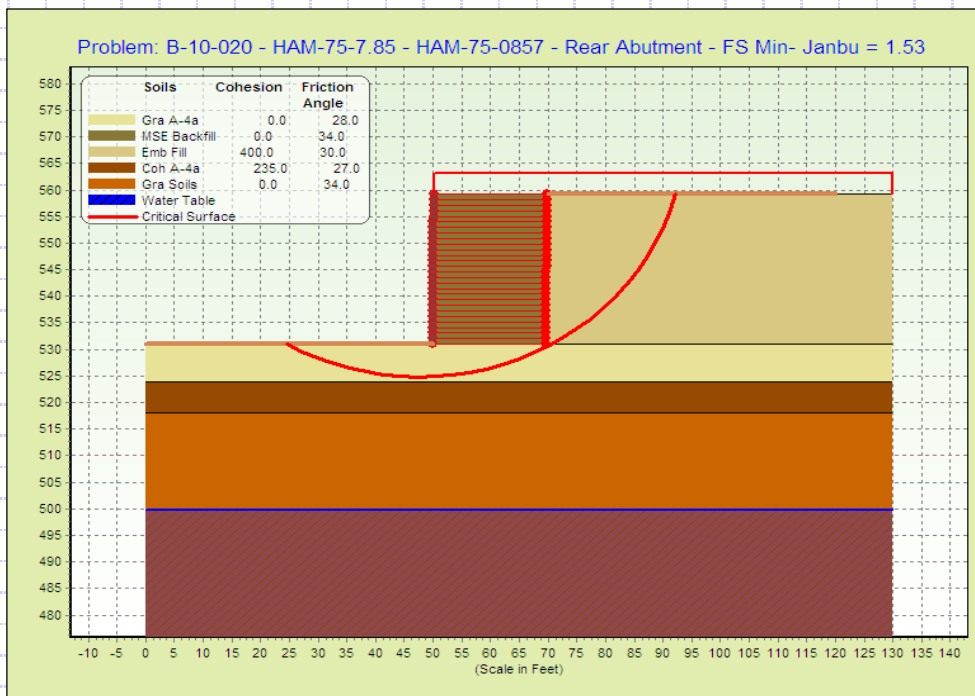
Check Overall (Global) Stability (Loading Case - Service I) - AASHTO LRFD BDM Sections 11.6.2.3 and 11.10.5.2

Long Term Stability - Drained Conditions



Loading scenario modeled as shown to the left and analyzed for slope stability using STABL for Windows software.

Graphical output shown below and tabular output results are provided as a separate attachment.



Check Overall (Global) Stability

$1.0 \leq FS \cdot \phi_{GS} \rightarrow 1.0 \leq (1.530)(0.65) = 1.0 \rightarrow 1.0 \leq 1.0$ **OK**

$FS = 1.530$ (From STABL Slope Stability Analysis)

Use $\phi_{GS} = 0.65$ (Per AASHTO LRFD BDM Section 11.6.2.3)



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	28.2 ft
MSE Wall Width (Reinforcement Length), (B) =	19.74 ft
Live Surcharge Load, (σ_{LS}) =	240 psf
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf
Retained Soil Friction Angle, (ϕ_{RS}) =	30°
Retained Soil Drained Cohesion, (c_{RS}) =	400 psf
Retained Soil Undrained Shear Strength, [$(S_u)_{RS}$] =	1700 psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.333
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Backfill Friction Angle, (ϕ_{BF}) =	34°

Bearing Soil Properties:

Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	28°
Bearing Soil Drained Cohesion, (c_{BS}) =	0 psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	0 psf
Embedment Depth, (D) =	5.0 ft

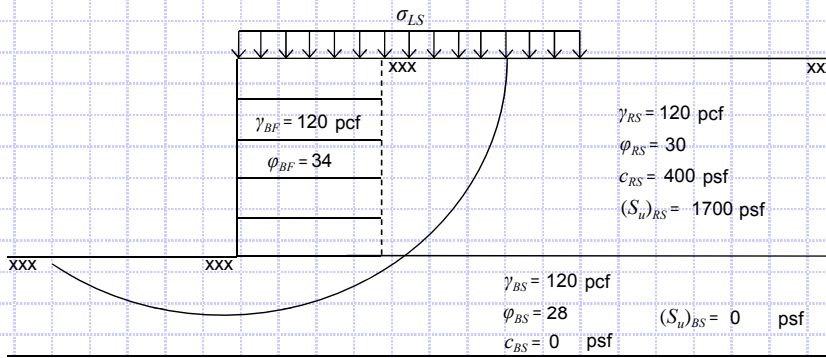
LRFD Load Factors

	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

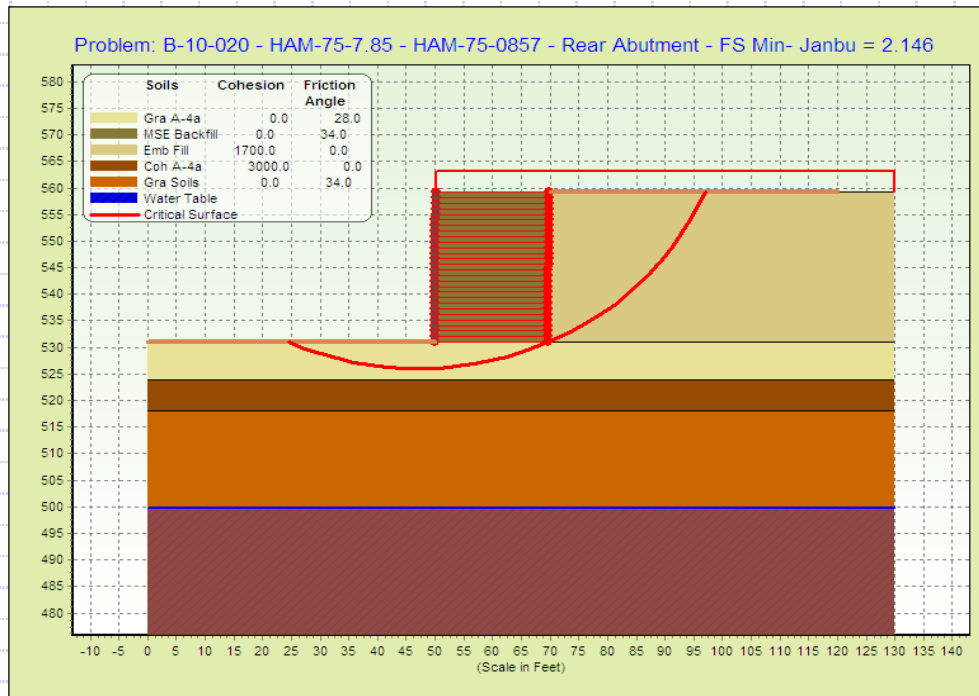
Check Overall (Global) Stability (Loading Case - Service I) - AASHTO LRFD BDM Sections 11.6.2.3 and 11.10.5.2 (Cont'd)

Short Term Stability - Undrained Conditions



Loading scenario modeled as shown to the left and analyzed for slope stability using STABL for Windows software.

Graphical output shown below and tabular output results are provided as a separate attachment.



Check Overall (Global) Stability

$1.0 \leq FS \cdot \phi_{GS} \rightarrow 1.00 \leq (2.146)(0.65) = 1.39 \rightarrow 1.00 \leq 1.39$ **OK**

$FS = 2.146$ (From STABL Slope Stability Analysis)

Use $\phi_{GS} = 0.65$ (Per AASHTO LRFD BDM Section 11.6.2.3)

result.out
 ** STABL for WINDOWS **
 by
 Geotechnical Software Solutions

1

--Slope Stability Analysis--
 Simplified Janbu, Simplified Bishop
 or Spencer's Method of Slices

Run Date:
 Time of Run:
 Run By:
 Input Data Filename: run.in
 Output Filename: result.out
 Unit: U.S.C.
 Plotted Output Filename: result.plt

PROBLEM DESCRIPTION B-10-020 - HAM-75-7.85 - HAM-75-0857 - Rear Abutment

BOUNDARY COORDINATES

4 Top Boundaries
 9 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	531.00	50.00	531.00	3
2	50.00	531.00	50.10	559.20	1
3	50.10	559.20	69.80	559.20	1
4	69.80	559.20	130.00	559.20	2
5	50.00	531.00	69.70	531.00	3
6	69.70	531.00	69.80	559.20	2
7	69.70	531.00	130.00	531.00	3
8	0.00	524.00	130.00	524.00	4
9	0.00	518.00	130.00	518.00	5

1

ISOTROPIC SOIL PARAMETERS

5 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	120.0	125.0	0.0	34.0	0.00	0.0	1
2	120.0	130.0	400.0	30.0	0.00	0.0	1
3	120.0	125.0	0.0	28.0	0.00	0.0	1
4	125.0	135.0	235.0	27.0	0.00	0.0	1
5	130.0	135.0	0.0	34.0	0.00	0.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
-----------	--------------	--------------

result.out

1	0.00	499.80
2	130.00	499.80

1

BOUNDARY LOAD(S)

1 Load(s) Specified

Load No.	X-Left (ft)	X-Right (ft)	Intensity (psf)	Deflection (deg)
1	50.10	130.00	240.0	0.0

NOTE - Intensity Is Specified As A Uniformly Distributed Force Acting On A Horizontally Projected Surface.

GEOSYNTHETIC DATA

1 Geosynthetics(s) group(s) specified

Ngroup no	Bnr no	Y-top (ft)	Y-bot (ft)	Levels no	Length (ft)	Spacing (ft)	Efficiency	Tallow (lbs/ft)
1	2	531.0	559.2	28	19.7	-1.04	1.0	7500.0

1

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

500 Trial Surfaces Have Been Generated.

10 Surfaces Initiate From Each Of 50 Points Equally Spaced Along The Ground Surface Between X = 0.00 ft. and X = 50.00 ft.

Each Surface Terminates Between X = 70.00 ft. and X = 120.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y =500.00 ft.

3.00 ft. Line Segments Define Each Trial Failure Surface.

Factor Of Safety Calculation Has Gone Through 30 Iterations, without convergence

The Trial Failure Surface In Question Is Defined By The Following 26 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	16.33	531.00
2	19.03	529.70
3	21.83	528.62
4	24.71	527.77
5	27.64	527.15

result.out

6	30.62	526.76
7	33.61	526.61
8	36.61	526.70
9	39.59	527.02
10	42.54	527.58
11	45.44	528.38
12	48.26	529.40
13	50.99	530.64
14	53.61	532.09
15	56.11	533.75
16	58.48	535.60
17	60.68	537.63
18	62.72	539.83
19	64.58	542.18
20	66.25	544.67
21	67.71	547.29
22	68.97	550.02
23	70.00	552.84
24	70.80	555.73
25	71.37	558.67
26	71.43	559.20

Factor Of Safety For The Preceding Specified Surface = -2.109

Factor Of Safety Calculation Has Gone Through 30 Iterations,
without convergence

The Trial Failure Surface In Question Is Defined
By The Following 26 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	19.39	531.00
2	22.08	529.69
3	24.88	528.59
4	27.75	527.72
5	30.68	527.09
6	33.65	526.69
7	36.65	526.53
8	39.65	526.61
9	42.63	526.93
10	45.58	527.49
11	48.47	528.28
12	51.29	529.30
13	54.02	530.55
14	56.65	532.01
15	59.14	533.67
16	61.50	535.53
17	63.70	537.57
18	65.72	539.78
19	67.57	542.15
20	69.22	544.65
21	70.66	547.28
22	71.89	550.02
23	72.90	552.84
24	73.67	555.74
25	74.22	558.69
26	74.27	559.20

Factor Of Safety For The Preceding Specified Surface = -4.662

Factor Of Safety Calculation Has Gone Through 30 Iterations,
without convergence

result.out

The Trial Failure Surface In Question Is Defined
By The Following 21 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	29.59	531.00
2	32.46	530.11
3	35.39	529.49
4	38.37	529.15
5	41.37	529.09
6	44.36	529.31
7	47.32	529.82
8	50.22	530.60
9	53.03	531.65
10	55.73	532.96
11	58.29	534.52
12	60.69	536.31
13	62.92	538.32
14	64.95	540.53
15	66.76	542.93
16	68.33	545.48
17	69.66	548.17
18	70.73	550.97
19	71.53	553.86
20	72.06	556.82
21	72.25	559.20

Factor Of Safety For The Preceding Specified Surface = 6.334

1

Following Are Displayed The Ten Most Critical Of The Trial
Failure Surfaces Examined. They Are Ordered - Most Critical
First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 30 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	24.49	531.00
2	27.14	529.59
3	29.87	528.35
4	32.68	527.30
5	35.55	526.42
6	38.47	525.74
7	41.43	525.25
8	44.41	524.95
9	47.41	524.84
10	50.41	524.93
11	53.40	525.22
12	56.36	525.69
13	59.28	526.36
14	62.16	527.22
15	64.97	528.26
16	67.71	529.49
17	70.37	530.88
18	72.92	532.45
19	75.38	534.18
20	77.71	536.07
21	79.92	538.10
22	81.98	540.27
23	83.91	542.57
24	85.68	544.99
25	87.29	547.53
26	88.73	550.16

result.out

27	90.00	552.88
28	91.09	555.67
29	91.99	558.53
30	92.16	559.20

*** 1.530 ***

Individual data on the 34 slices

Slice No.	Width (ft)	Weight (lbs)	Water	Water	Force Norm (lbs)	Force Tan (lbs)	Earthquake		Surcharge Load (lbs)
			Force Top (lbs)	Force Bot (lbs)			Force Hor (lbs)	Force Ver (lbs)	
1	2.6	224.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	2.7	665.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	2.8	1070.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	2.9	1426.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	2.9	1723.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	3.0	1955.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	3.0	2114.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	3.0	2196.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	2.6	1899.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.1	242.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.3	1281.2	0.0	0.0	0.0	0.0	0.0	0.0	74.8
12	3.0	12229.7	0.0	0.0	0.0	0.0	0.0	0.0	716.8
13	3.0	11992.9	0.0	0.0	0.0	0.0	0.0	0.0	710.8
14	2.9	11640.9	0.0	0.0	0.0	0.0	0.0	0.0	701.9
15	2.9	11180.3	0.0	0.0	0.0	0.0	0.0	0.0	690.0
16	2.8	10619.7	0.0	0.0	0.0	0.0	0.0	0.0	675.2
17	2.7	9969.6	0.0	0.0	0.0	0.0	0.0	0.0	657.5
18	2.0	6963.9	0.0	0.0	0.0	0.0	0.0	0.0	477.1
19	0.1	343.7	0.0	0.0	0.0	0.0	0.0	0.0	24.0
20	0.6	1934.8	0.0	0.0	0.0	0.0	0.0	0.0	135.9
21	0.2	644.9	0.0	0.0	0.0	0.0	0.0	0.0	45.6
22	2.4	7807.0	0.0	0.0	0.0	0.0	0.0	0.0	568.3
23	2.5	7613.1	0.0	0.0	0.0	0.0	0.0	0.0	588.2
24	2.3	6742.0	0.0	0.0	0.0	0.0	0.0	0.0	560.0
25	2.2	5855.5	0.0	0.0	0.0	0.0	0.0	0.0	529.5
26	2.1	4970.7	0.0	0.0	0.0	0.0	0.0	0.0	496.7
27	1.9	4105.1	0.0	0.0	0.0	0.0	0.0	0.0	461.8
28	1.8	3275.9	0.0	0.0	0.0	0.0	0.0	0.0	425.0
29	1.6	2499.7	0.0	0.0	0.0	0.0	0.0	0.0	386.3
30	1.4	1792.6	0.0	0.0	0.0	0.0	0.0	0.0	346.1
31	1.3	1169.5	0.0	0.0	0.0	0.0	0.0	0.0	304.4
32	1.1	643.9	0.0	0.0	0.0	0.0	0.0	0.0	261.4
33	0.9	228.1	0.0	0.0	0.0	0.0	0.0	0.0	217.3
34	0.2	6.6	0.0	0.0	0.0	0.0	0.0	0.0	39.6

Individual data on the 28 geosynthetics

Group	Level	Slice	Head Coordinates (ft)	End Coordinates (ft)	T (lbs)	Length (ft)	Tailow (lbs)	T/Tail %		
1	1	0	50.1	559.2	69.8	559.2	0.0	19.7	7500.0	0.0
1	2	0	50.1	558.2	69.8	558.2	0.0	19.7	7500.0	0.0
1	3	0	50.1	557.1	69.8	557.1	0.0	19.7	7500.0	0.0
1	4	0	50.1	556.1	69.8	556.1	0.0	19.7	7500.0	0.0
1	5	0	50.1	555.0	69.8	555.0	0.0	19.7	7500.0	0.0
1	6	0	50.1	554.0	69.8	554.0	0.0	19.7	7500.0	0.0
1	7	0	50.1	552.9	69.8	552.9	0.0	19.7	7500.0	0.0
1	8	0	50.1	551.9	69.8	551.9	0.0	19.7	7500.0	0.0
1	9	0	50.1	550.8	69.8	550.8	0.0	19.7	7500.0	0.0
1	10	0	50.1	549.8	69.8	549.8	0.0	19.7	7500.0	0.0
1	11	0	50.1	548.8	69.8	548.8	0.0	19.7	7500.0	0.0
1	12	0	50.1	547.7	69.8	547.7	0.0	19.7	7500.0	0.0
1	13	0	50.1	546.7	69.8	546.7	0.0	19.7	7500.0	0.0
1	14	0	50.1	545.6	69.8	545.6	0.0	19.7	7500.0	0.0
1	15	0	50.0	544.6	69.7	544.6	0.0	19.7	7500.0	0.0
1	16	0	50.0	543.5	69.7	543.5	0.0	19.7	7500.0	0.0
1	17	0	50.0	542.5	69.7	542.5	0.0	19.7	7500.0	0.0
1	18	0	50.0	541.4	69.7	541.4	0.0	19.7	7500.0	0.0
1	19	0	50.0	540.4	69.7	540.4	0.0	19.7	7500.0	0.0

result.out										
1	20	0	50.0	539.4	69.7	539.4	0.0	19.7	7500.0	0.0
1	21	0	50.0	538.3	69.7	538.3	0.0	19.7	7500.0	0.0
1	22	0	50.0	537.3	69.7	537.3	0.0	19.7	7500.0	0.0
1	23	0	50.0	536.2	69.7	536.2	0.0	19.7	7500.0	0.0
1	24	0	50.0	535.2	69.7	535.2	0.0	19.7	7500.0	0.0
1	25	0	50.0	534.1	69.7	534.1	0.0	19.7	7500.0	0.0
1	26	0	50.0	533.1	69.7	533.1	0.0	19.7	7500.0	0.0
1	27	0	50.0	532.0	69.7	532.0	0.0	19.7	7500.0	0.0
1	28	0	50.0	531.0	69.7	531.0	0.0	19.7	7500.0	0.0

Failure Surface Specified By 31 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	21.43	531.00
2	24.06	529.56
3	26.78	528.28
4	29.56	527.17
5	32.41	526.24
6	35.31	525.48
7	38.26	524.89
8	41.23	524.49
9	44.22	524.27
10	47.22	524.23
11	50.22	524.37
12	53.20	524.70
13	56.16	525.21
14	59.08	525.90
15	61.95	526.76
16	64.77	527.80
17	67.51	529.00
18	70.18	530.38
19	72.76	531.91
20	75.24	533.59
21	77.61	535.43
22	79.87	537.40
23	82.01	539.51
24	84.01	541.75
25	85.87	544.10
26	87.58	546.56
27	89.14	549.13
28	90.54	551.78
29	91.78	554.51
30	92.85	557.31
31	93.44	559.20

*** 1.541 ***

1

Failure Surface Specified By 32 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	15.31	531.00
2	17.72	529.22
3	20.25	527.60
4	22.88	526.17
5	25.61	524.92
6	28.42	523.87
7	31.30	523.01
8	34.22	522.35
9	37.19	521.90
10	40.18	521.66
11	43.18	521.62
12	46.17	521.79
13	49.15	522.16
14	52.09	522.74
15	54.99	523.53
16	57.82	524.51
17	60.58	525.68
18	63.26	527.05

result.out

19	65.83	528.59
20	68.28	530.32
21	70.62	532.20
22	72.81	534.24
23	74.86	536.44
24	76.76	538.76
25	78.48	541.22
26	80.04	543.78
27	81.41	546.45
28	82.59	549.21
29	83.58	552.04
30	84.38	554.93
31	84.97	557.87
32	85.14	559.20

*** 1.615 ***

Failure Surface Specified By 30 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	25.51	531.00
2	28.27	529.82
3	31.09	528.80
4	33.96	527.93
5	36.88	527.24
6	39.83	526.70
7	42.81	526.34
8	45.80	526.14
9	48.80	526.12
10	51.80	526.26
11	54.78	526.58
12	57.74	527.06
13	60.67	527.71
14	63.56	528.52
15	66.40	529.50
16	69.18	530.63
17	71.89	531.92
18	74.52	533.36
19	77.06	534.95
20	79.51	536.67
21	81.86	538.54
22	84.11	540.53
23	86.23	542.65
24	88.23	544.89
25	90.10	547.23
26	91.84	549.68
27	93.44	552.22
28	94.89	554.84
29	96.18	557.55
30	96.86	559.20

*** 1.615 ***

1

Failure Surface Specified By 24 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	36.74	531.00
2	39.41	529.63
3	42.19	528.51
4	45.06	527.64
5	48.00	527.04
6	50.98	526.70
7	53.98	526.63
8	56.97	526.83

result.out

9	59.94	527.30
10	62.84	528.03
11	65.68	529.02
12	68.41	530.26
13	71.02	531.74
14	73.48	533.45
15	75.79	535.37
16	77.91	537.49
17	79.83	539.80
18	81.53	542.27
19	83.01	544.88
20	84.25	547.61
21	85.24	550.44
22	85.96	553.35
23	86.43	556.32
24	86.62	559.20

*** 1.635 ***

Failure Surface Specified By 31 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	23.47	531.00
2	25.88	529.21
3	28.41	527.60
4	31.05	526.18
5	33.79	524.97
6	36.62	523.95
7	39.51	523.15
8	42.45	522.57
9	45.43	522.20
10	48.43	522.06
11	51.43	522.14
12	54.41	522.44
13	57.37	522.96
14	60.27	523.69
15	63.12	524.64
16	65.89	525.80
17	68.56	527.16
18	71.13	528.71
19	73.57	530.45
20	75.88	532.37
21	78.05	534.45
22	80.05	536.68
23	81.88	539.06
24	83.53	541.56
25	84.99	544.18
26	86.25	546.90
27	87.31	549.71
28	88.16	552.59
29	88.80	555.52
30	89.21	558.49
31	89.26	559.20

*** 1.635 ***

1

Failure Surface Specified By 35 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	9.18	531.00
2	11.80	529.53
3	14.49	528.20
4	17.24	527.00
5	20.05	525.95

result.out

6	22.91	525.04
7	25.81	524.28
8	28.74	523.66
9	31.71	523.20
10	34.69	522.88
11	37.69	522.72
12	40.69	522.71
13	43.68	522.85
14	46.67	523.14
15	49.64	523.59
16	52.58	524.18
17	55.48	524.93
18	58.35	525.82
19	61.16	526.85
20	63.93	528.03
21	66.62	529.34
22	69.25	530.79
23	71.80	532.37
24	74.26	534.08
25	76.64	535.91
26	78.92	537.86
27	81.10	539.92
28	83.17	542.09
29	85.13	544.36
30	86.97	546.73
31	88.69	549.19
32	90.28	551.74
33	91.74	554.36
34	93.06	557.05
35	93.99	559.20

*** 1.647 ***

Failure Surface Specified By 30 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	26.53	531.00
2	29.30	529.86
3	32.14	528.87
4	35.02	528.05
5	37.95	527.40
6	40.91	526.91
7	43.89	526.59
8	46.89	526.44
9	49.89	526.46
10	52.88	526.65
11	55.86	527.01
12	58.82	527.54
13	61.73	528.24
14	64.61	529.10
15	67.43	530.12
16	70.18	531.30
17	72.87	532.64
18	75.48	534.13
19	77.99	535.76
20	80.41	537.53
21	82.73	539.44
22	84.93	541.48
23	87.01	543.64
24	88.97	545.91
25	90.80	548.29
26	92.49	550.77
27	94.03	553.34
28	95.42	556.00
29	96.67	558.73
30	96.85	559.20

*** 1.648 ***

Failure Surface Specified By 29 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	27.55	531.00
2	29.96	529.21
3	32.50	527.62
4	35.16	526.23
5	37.93	525.07
6	40.78	524.14
7	43.70	523.44
8	46.66	522.98
9	49.65	522.76
10	52.65	522.78
11	55.64	523.04
12	58.60	523.55
13	61.51	524.29
14	64.34	525.27
15	67.09	526.47
16	69.73	527.89
17	72.25	529.52
18	74.63	531.34
19	76.86	533.36
20	78.91	535.54
21	80.78	537.89
22	82.45	540.38
23	83.92	543.00
24	85.17	545.72
25	86.20	548.54
26	86.99	551.43
27	87.55	554.38
28	87.87	557.37
29	87.92	559.20

*** 1.650 ***

Failure Surface Specified By 31 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	25.51	531.00
2	28.00	529.32
3	30.60	527.82
4	33.29	526.51
5	36.08	525.39
6	38.93	524.48
7	41.85	523.76
8	44.80	523.25
9	47.79	522.96
10	50.79	522.87
11	53.79	522.99
12	56.77	523.33
13	59.72	523.88
14	62.62	524.63
15	65.46	525.59
16	68.23	526.74
17	70.91	528.09
18	73.49	529.62
19	75.96	531.33
20	78.30	533.21
21	80.50	535.25
22	82.54	537.44
23	84.44	539.77
24	86.16	542.23
25	87.70	544.80
26	89.06	547.48
27	90.22	550.24
28	91.19	553.08
29	91.96	555.98

result.out

30	92.52	558.93
31	92.55	559.20

*** 1.658 ***

1

	Y	A	X	I	S	F	T	
	0.00	130.88	261.75	392.63	523.51	654.38		
X	0.00	+-----+-----+-----+-----+-----+-----+					W- ** ------+	
							.11	
							.1G G/1	
							.1g.g	
							..111	
	130.88	+					W : : : : *	*1/
A	261.75	+						
X	392.63	+						
I	523.51	+						
S	654.38	+						
	785.26	+						
F	916.14	+						
T	1047.01	+						

result.out
 ** STABL for WINDOWS **
 by
 Geotechnical Software Solutions

1

--Slope Stability Analysis--
 Simplified Janbu, Simplified Bishop
 or Spencer's Method of Slices

Run Date:
 Time of Run:
 Run By:
 Input Data Filename: run.in
 Output Filename: result.out
 Unit: U.S.C.
 Plotted Output Filename: result.plt

PROBLEM DESCRIPTION B-10-020 - HAM-75-7.85 - HAM-75-0857 - Rear Abutment

BOUNDARY COORDINATES

4 Top Boundaries
 9 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	531.00	50.00	531.00	3
2	50.00	531.00	50.10	559.20	1
3	50.10	559.20	69.80	559.20	1
4	69.80	559.20	130.00	559.20	2
5	50.00	531.00	69.70	531.00	3
6	69.70	531.00	69.80	559.20	2
7	69.70	531.00	130.00	531.00	3
8	0.00	524.00	130.00	524.00	4
9	0.00	518.00	130.00	518.00	5

1

ISOTROPIC SOIL PARAMETERS

5 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	120.0	125.0	0.0	34.0	0.00	0.0	1
2	120.0	130.0	1700.0	0.0	0.00	0.0	1
3	120.0	125.0	0.0	28.0	0.00	0.0	1
4	125.0	135.0	3000.0	0.0	0.00	0.0	1
5	130.0	135.0	0.0	34.0	0.00	0.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
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result.out

1	0.00	499.80
2	130.00	499.80

1

BOUNDARY LOAD(S)

1 Load(s) Specified

Load No.	X-Left (ft)	X-Right (ft)	Intensity (psf)	Deflection (deg)
1	50.10	130.00	240.0	0.0

NOTE - Intensity Is Specified As A Uniformly Distributed Force Acting On A Horizontally Projected Surface.

GEOSYNTHETIC DATA

1 Geosynthetics(s) group(s) specified

Ngroup no	Bnr no	Y-top (ft)	Y-bot (ft)	Levels no	Length (ft)	Spacing (ft)	Efficiency	Tallow (lbs/ft)
1	2	531.0	559.2	28	19.7	-1.04	1.0	7500.0

1

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

500 Trial Surfaces Have Been Generated.

10 Surfaces Initiate From Each Of 50 Points Equally Spaced Along The Ground Surface Between X = 0.00 ft. and X = 50.00 ft.

Each Surface Terminates Between X = 70.00 ft. and X = 120.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y =500.00 ft.

3.00 ft. Line Segments Define Each Trial Failure Surface.

1

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 30 Coordinate Points

Poi nt No.	X-Surf (ft)	Y-Surf (ft)
1	24.49	531.00
2	27.25	529.82
3	30.07	528.79
4	32.94	527.93

result.out

5	35.85	527.22
6	38.80	526.67
7	41.78	526.29
8	44.77	526.08
9	47.77	526.03
10	50.77	526.15
11	53.76	526.44
12	56.72	526.89
13	59.66	527.50
14	62.56	528.28
15	65.41	529.22
16	68.20	530.31
17	70.93	531.56
18	73.58	532.96
19	76.16	534.50
20	78.64	536.18
21	81.03	538.00
22	83.31	539.95
23	85.48	542.02
24	87.53	544.20
25	89.46	546.50
26	91.26	548.91
27	92.92	551.40
28	94.44	553.99
29	95.81	556.66
30	96.94	559.20

*** 2.146 ***

Individual data on the 34 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force		Force Norm (lbs)	Force Tan (lbs)	Earthquake Force		Surcharge Load (lbs)
			Top (lbs)	Bot (lbs)			Hor (lbs)	Ver (lbs)	
1	2.8	195.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	2.8	573.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	2.9	910.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	2.9	1199.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	3.0	1435.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	3.0	1612.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	3.0	1728.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	3.0	1779.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	2.2	1315.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.1	227.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.7	2658.6	0.0	0.0	0.0	0.0	0.0	0.0	160.8
12	3.0	11791.7	0.0	0.0	0.0	0.0	0.0	0.0	716.7
13	3.0	11579.8	0.0	0.0	0.0	0.0	0.0	0.0	711.8
14	2.9	11276.3	0.0	0.0	0.0	0.0	0.0	0.0	704.7
15	2.9	10885.7	0.0	0.0	0.0	0.0	0.0	0.0	695.4
16	2.8	10413.8	0.0	0.0	0.0	0.0	0.0	0.0	684.0
17	2.8	9867.4	0.0	0.0	0.0	0.0	0.0	0.0	670.5
18	1.5	5138.6	0.0	0.0	0.0	0.0	0.0	0.0	360.0
19	0.0	16.8	0.0	0.0	0.0	0.0	0.0	0.0	1.2
20	0.1	321.4	0.0	0.0	0.0	0.0	0.0	0.0	22.8
21	1.1	3777.7	0.0	0.0	0.0	0.0	0.0	0.0	270.8
22	2.7	8584.2	0.0	0.0	0.0	0.0	0.0	0.0	637.2
23	2.6	7866.6	0.0	0.0	0.0	0.0	0.0	0.0	617.6
24	2.5	7112.2	0.0	0.0	0.0	0.0	0.0	0.0	596.1
25	2.4	6332.6	0.0	0.0	0.0	0.0	0.0	0.0	572.8
26	2.3	5539.5	0.0	0.0	0.0	0.0	0.0	0.0	547.7
27	2.2	4745.2	0.0	0.0	0.0	0.0	0.0	0.0	520.9
28	2.1	3962.0	0.0	0.0	0.0	0.0	0.0	0.0	492.5
29	1.9	3202.4	0.0	0.0	0.0	0.0	0.0	0.0	462.6
30	1.8	2478.5	0.0	0.0	0.0	0.0	0.0	0.0	431.2
31	1.7	1802.4	0.0	0.0	0.0	0.0	0.0	0.0	398.5
32	1.5	1185.5	0.0	0.0	0.0	0.0	0.0	0.0	364.6
33	1.4	638.6	0.0	0.0	0.0	0.0	0.0	0.0	329.6
34	1.1	173.1	0.0	0.0	0.0	0.0	0.0	0.0	272.4

Individual data on the 28 geosynthetics

Head End

Group	Level	Slice	Coordinates (ft)		Coordinates (ft)		result.out			
							T (lbs)	Length (ft)	Tailow (lbs)	T/Tail %
1	1	0	50.1	559.2	69.8	559.2	0.0	19.7	7500.0	0.0
1	2	0	50.1	558.2	69.8	558.2	0.0	19.7	7500.0	0.0
1	3	0	50.1	557.1	69.8	557.1	0.0	19.7	7500.0	0.0
1	4	0	50.1	556.1	69.8	556.1	0.0	19.7	7500.0	0.0
1	5	0	50.1	555.0	69.8	555.0	0.0	19.7	7500.0	0.0
1	6	0	50.1	554.0	69.8	554.0	0.0	19.7	7500.0	0.0
1	7	0	50.1	552.9	69.8	552.9	0.0	19.7	7500.0	0.0
1	8	0	50.1	551.9	69.8	551.9	0.0	19.7	7500.0	0.0
1	9	0	50.1	550.8	69.8	550.8	0.0	19.7	7500.0	0.0
1	10	0	50.1	549.8	69.8	549.8	0.0	19.7	7500.0	0.0
1	11	0	50.1	548.8	69.8	548.8	0.0	19.7	7500.0	0.0
1	12	0	50.1	547.7	69.8	547.7	0.0	19.7	7500.0	0.0
1	13	0	50.1	546.7	69.8	546.7	0.0	19.7	7500.0	0.0
1	14	0	50.1	545.6	69.8	545.6	0.0	19.7	7500.0	0.0
1	15	0	50.0	544.6	69.7	544.6	0.0	19.7	7500.0	0.0
1	16	0	50.0	543.5	69.7	543.5	0.0	19.7	7500.0	0.0
1	17	0	50.0	542.5	69.7	542.5	0.0	19.7	7500.0	0.0
1	18	0	50.0	541.4	69.7	541.4	0.0	19.7	7500.0	0.0
1	19	0	50.0	540.4	69.7	540.4	0.0	19.7	7500.0	0.0
1	20	0	50.0	539.4	69.7	539.4	0.0	19.7	7500.0	0.0
1	21	0	50.0	538.3	69.7	538.3	0.0	19.7	7500.0	0.0
1	22	0	50.0	537.3	69.7	537.3	0.0	19.7	7500.0	0.0
1	23	0	50.0	536.2	69.7	536.2	0.0	19.7	7500.0	0.0
1	24	0	50.0	535.2	69.7	535.2	0.0	19.7	7500.0	0.0
1	25	0	50.0	534.1	69.7	534.1	0.0	19.7	7500.0	0.0
1	26	0	50.0	533.1	69.7	533.1	0.0	19.7	7500.0	0.0
1	27	0	50.0	532.0	69.7	532.0	0.0	19.7	7500.0	0.0
1	28	0	50.0	531.0	69.7	531.0	0.0	19.7	7500.0	0.0

Failure Surface Specified By 39 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	6.12	531.00
2	8.91	529.90
3	11.74	528.90
4	14.60	527.99
5	17.49	527.19
6	20.41	526.49
7	23.35	525.89
8	26.31	525.40
9	29.28	525.01
10	32.27	524.72
11	35.26	524.54
12	38.26	524.46
13	41.26	524.49
14	44.26	524.62
15	47.25	524.86
16	50.23	525.21
17	53.20	525.65
18	56.15	526.21
19	59.07	526.86
20	61.98	527.62
21	64.85	528.47
22	67.69	529.43
23	70.50	530.49
24	73.27	531.64
25	76.00	532.90
26	78.68	534.24
27	81.31	535.68
28	83.89	537.21
29	86.42	538.83
30	88.88	540.54
31	91.29	542.33
32	93.63	544.21
33	95.90	546.16
34	98.11	548.20
35	100.24	550.31
36	102.29	552.50
37	104.27	554.75
38	106.17	557.08
39	107.78	559.20

*** 2.172 ***

1

Failure Surface Specified By 31 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	21.43	531.00
2	24.06	529.56
3	26.78	528.28
4	29.56	527.17
5	32.41	526.24
6	35.31	525.48
7	38.26	524.89
8	41.23	524.49
9	44.22	524.27
10	47.22	524.23
11	50.22	524.37
12	53.20	524.70
13	56.16	525.21
14	59.08	525.90
15	61.95	526.76
16	64.77	527.80
17	67.51	529.00
18	70.18	530.38
19	72.76	531.91
20	75.24	533.59
21	77.61	535.43
22	79.87	537.40
23	82.01	539.51
24	84.01	541.75
25	85.87	544.10
26	87.58	546.56
27	89.14	549.13
28	90.54	551.78
29	91.78	554.51
30	92.85	557.31
31	93.44	559.20

*** 2.182 ***

Failure Surface Specified By 30 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	26.53	531.00
2	29.30	529.86
3	32.14	528.87
4	35.02	528.05
5	37.95	527.40
6	40.91	526.91
7	43.89	526.59
8	46.89	526.44
9	49.89	526.46
10	52.88	526.65
11	55.86	527.01
12	58.82	527.54
13	61.73	528.24
14	64.61	529.10
15	67.43	530.12
16	70.18	531.30
17	72.87	532.64
18	75.48	534.13
19	77.99	535.76
20	80.41	537.53
21	82.73	539.44
22	84.93	541.48
23	87.01	543.64

result.out

24	88.97	545.91
25	90.80	548.29
26	92.49	550.77
27	94.03	553.34
28	95.42	556.00
29	96.67	558.73
30	96.85	559.20

*** 2.201 ***

1

Failure Surface Specified By 36 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	18.37	531.00
2	21.14	529.87
3	23.97	528.85
4	26.83	527.95
5	29.73	527.17
6	32.65	526.51
7	35.61	525.98
8	38.58	525.57
9	41.56	525.29
10	44.56	525.13
11	47.56	525.10
12	50.56	525.19
13	53.55	525.41
14	56.53	525.75
15	59.49	526.22
16	62.44	526.81
17	65.35	527.53
18	68.23	528.36
19	71.07	529.32
20	73.88	530.39
21	76.63	531.58
22	79.33	532.88
23	81.98	534.30
24	84.56	535.83
25	87.08	537.46
26	89.52	539.19
27	91.89	541.03
28	94.19	542.97
29	96.40	545.00
30	98.52	547.12
31	100.55	549.32
32	102.49	551.61
33	104.33	553.98
34	106.07	556.43
35	107.70	558.94
36	107.85	559.20

*** 2.203 ***

Failure Surface Specified By 32 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	24.49	531.00
2	27.20	529.70
3	29.97	528.56
4	32.80	527.56
5	35.68	526.72
6	38.60	526.05
7	41.56	525.53
8	44.53	525.17
9	47.53	524.98

result.out

10	50.53	524.95
11	53.53	525.09
12	56.51	525.39
13	59.47	525.86
14	62.41	526.48
15	65.30	527.27
16	68.15	528.21
17	70.94	529.30
18	73.67	530.55
19	76.33	531.95
20	78.90	533.49
21	81.39	535.16
22	83.78	536.97
23	86.07	538.91
24	88.25	540.98
25	90.32	543.15
26	92.26	545.44
27	94.07	547.83
28	95.75	550.32
29	97.29	552.89
30	98.69	555.54
31	99.94	558.27
32	100.30	559.20

*** 2.205 ***

1

Failure Surface Specified By 39 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	9.18	531.00
2	11.98	529.92
3	14.82	528.95
4	17.69	528.07
5	20.59	527.29
6	23.51	526.61
7	26.45	526.03
8	29.41	525.56
9	32.39	525.19
10	35.38	524.92
11	38.37	524.75
12	41.37	524.69
13	44.37	524.74
14	47.37	524.88
15	50.36	525.13
16	53.34	525.49
17	56.30	525.94
18	59.25	526.50
19	62.18	527.16
20	65.08	527.93
21	67.95	528.79
22	70.79	529.75
23	73.60	530.81
24	76.37	531.96
25	79.10	533.22
26	81.78	534.56
27	84.41	536.00
28	86.99	537.52
29	89.52	539.14
30	91.99	540.84
31	94.40	542.63
32	96.75	544.50
33	99.03	546.45
34	101.24	548.47
35	103.38	550.58
36	105.45	552.75
37	107.44	555.00
38	109.35	557.31
39	110.80	559.20

*** 2.215 ***

Failure Surface Specified By 30 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	24.49	531.00
2	27.14	529.59
3	29.87	528.35
4	32.68	527.30
5	35.55	526.42
6	38.47	525.74
7	41.43	525.25
8	44.41	524.95
9	47.41	524.84
10	50.41	524.93
11	53.40	525.22
12	56.36	525.69
13	59.28	526.36
14	62.16	527.22
15	64.97	528.26
16	67.71	529.49
17	70.37	530.88
18	72.92	532.45
19	75.38	534.18
20	77.71	536.07
21	79.92	538.10
22	81.98	540.27
23	83.91	542.57
24	85.68	544.99
25	87.29	547.53
26	88.73	550.16
27	90.00	552.88
28	91.09	555.67
29	91.99	558.53
30	92.16	559.20

*** 2.236 ***

1

Failure Surface Specified By 35 Coordinate Points

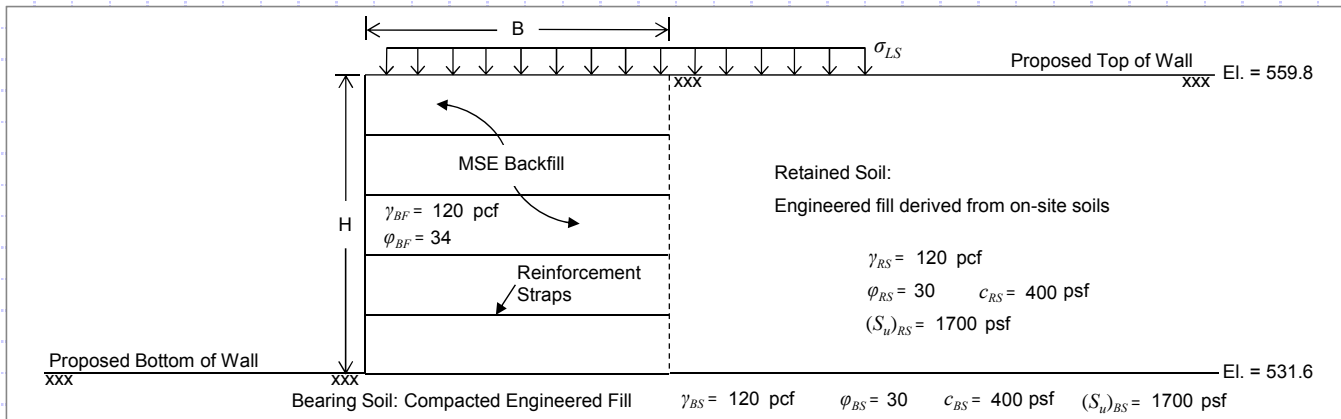
Point No.	X-Surf (ft)	Y-Surf (ft)
1	17.35	531.00
2	20.18	530.02
3	23.06	529.16
4	25.96	528.41
5	28.89	527.78
6	31.85	527.27
7	34.82	526.87
8	37.81	526.59
9	40.81	526.43
10	43.81	526.39
11	46.81	526.47
12	49.80	526.67
13	52.78	526.99
14	55.75	527.42
15	58.70	527.98
16	61.62	528.65
17	64.52	529.44
18	67.38	530.34
19	70.20	531.35
20	72.98	532.48
21	75.72	533.72
22	78.40	535.06
23	81.03	536.51
24	83.59	538.06
25	86.09	539.72

result.out

```
-  
-  
-  
A 261.75 +  
-  
-  
-  
X 392.63 +  
-  
-  
-  
I 523.51 +  
-  
-  
-  
S 654.38 +  
-  
-  
-  
785.26 +  
-  
-  
-  
F 916.14 +  
-  
-  
-  
T 1047.01 +
```



MSE Wall - Forward Abutment - B-182 - (28.2 ft. Wall Height)



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	28.2 ft
MSE Wall Width (Reinforcement Length), (B) =	21.2 ft
Live Surcharge Load, (σ _{LS}) =	240 psf
Retained Soil Unit Weight, (γ _{RS}) =	120 pcf
Retained Soil Friction Angle, (φ _{RS}) =	30°
Retained Soil Drained Cohesion, (c _{BS}) =	400 psf
Retained Soil Undrained Shear Strength, [(S _u) _{RS}] =	1700 psf
Retained Soil Active Earth Pressure Coeff., (K _a) =	0.333
MSE Backfill Unit Weight, (γ _{BF}) =	120 pcf
MSE Backfill Friction Angle, (φ _{BF}) =	34°

Bearing Soil Properties:

Bearing Soil Unit Weight, (γ _{BS}) =	120 pcf
Bearing Soil Friction Angle, (φ _{BS}) =	30°
Bearing Soil Drained Cohesion, (c _{BS}) =	400 psf
Bearing Soil Undrained Shear Strength, [(S _u) _{BS}] =	1700 psf
Embedment Depth, (D) =	5.0 ft

LRFD Load Factors

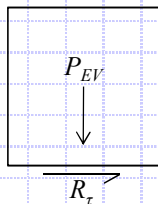
	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

Check Sliding (Loading Case - Strength Ia) - AASHTO LRFD BDM Sections 11.6.3.6 and 11.10.5.3

Nominal Sliding Resistance:

$$R_{\tau} = P_{EV} \cdot \tan \delta$$



$$P_{EV} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = (120 \text{ pcf})(28.2 \text{ ft})(21.15 \text{ ft})(1.00) = 71.57 \text{ kip/ft}$$

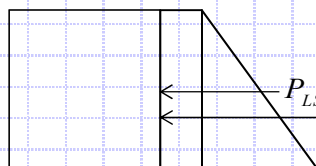
$$\tan \delta = (\tan \phi_{BS} \leq \tan \phi_{BF})$$

$$\tan \delta = \tan(30) \leq \tan(34) \rightarrow 0.58 \leq 0.67 \rightarrow \tan \delta = 0.58$$

$$R_{\tau} = (71.57 \text{ kip/ft})(0.58) = 41.51 \text{ kip/ft}$$

Sliding Force:

$$P_H = P_{EH} + P_{LS_h}$$



$$P_{EH} = \frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(28.2 \text{ ft})^2(0.333)(1.5) = 23.83 \text{ kip/ft}$$

$$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS} = (240 \text{ psf})(28.2 \text{ ft})(0.333)(1.75) = 3.94 \text{ kip/ft}$$

$$P_H = 23.83 \text{ kip/ft} + 3.94 \text{ kip/ft} = 27.77 \text{ kip/ft}$$

Check Sliding Resistance

$$P_H \leq R_{\tau} \cdot \phi_{\tau} \rightarrow 27.77 \text{ kip/ft} \leq (41.51 \text{ kip/ft})(1.0) = 41.51 \text{ kip/ft} \rightarrow 27.77 \text{ kip/ft} \leq 41.51 \text{ kip/ft} \quad \text{OK}$$

Use φ_τ = 1.0 (Per AASHTO LRFD BDM Table 11.5.6-1)



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	28.2 ft
MSE Wall Width (Reinforcement Length), (B) =	21.15 ft
Live Surcharge Load, (σ_{LS}) =	240 psf
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf
Retained Soil Friction Angle, (ϕ_{RS}) =	30°
Retained Soil Drained Cohesion, (c_{BS}) =	400 psf
Retained Soil Undrained Shear Strength, [$(S_u)_{RS}$] =	1700 psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.333
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Backfill Friction Angle, (ϕ_{BF}) =	34°

Bearing Soil Properties:

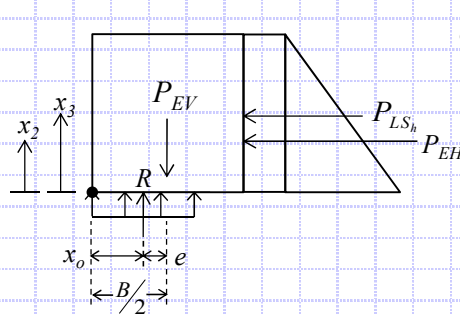
Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	30°
Bearing Soil Drained Cohesion, (c_{BS}) =	400 psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	1700 psf
Embedment Depth, (D) =	5.0 ft

LRFD Load Factors

	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

Check Eccentricity (Loading Case - Strength Ia) - AASHTO LRFD BDM Section 11.6.3.3



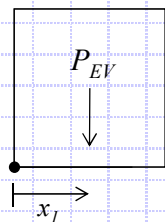
$$e = B/2 - x_o$$

$$x_o = \frac{M_{EV} - M_H}{P_{EV}} = (756.85 \text{ kip-ft/ft} - 279.56 \text{ kip-ft/ft}) / (71.57 \text{ kip/ft}) = 6.67 \text{ ft}$$

$$\begin{aligned} M_{EV} &= 756.85 \text{ kip-ft/ft} \\ M_H &= 279.56 \text{ kip-ft/ft} \\ P_{EV} &= 71.57 \text{ kip/ft} \end{aligned} \quad \left. \vphantom{\begin{aligned} M_{EV} \\ M_H \\ P_{EV} \end{aligned}} \right\} \text{ Defined below}$$

$$e = (21.15 \text{ ft})/2 - 6.67 \text{ ft} = 3.91 \text{ ft}$$

Resisting Moment, M_{EV} :



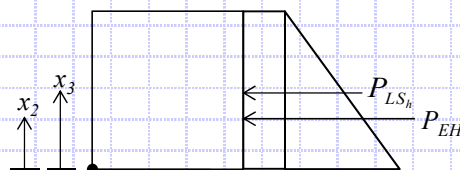
$$M_{EV} = P_{EV} (x_1)$$

$$P_{EV} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = (120 \text{ pcf})(28.2 \text{ ft})(21.15 \text{ ft})(1.00) = 71.57 \text{ kip/ft}$$

$$x_1 = B/2 = (21.15 \text{ ft}) / 2 = 10.58 \text{ ft}$$

$$M_{EV} = (71.57 \text{ kip/ft})(10.575 \text{ ft}) = 756.85 \text{ kip-ft/ft}$$

Overturning Moment, M_H :



$$M_H = P_{EH} (x_2) + P_{LS_h} (x_3)$$

$$P_{EH} = \frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH} = \frac{1}{2} (120 \text{ pcf})(28.2 \text{ ft})^2 (0.333)(1.5) = 23.83 \text{ kip/ft}$$

$$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS} = (240 \text{ psf})(28.2 \text{ ft})(0.333)(1.75) = 3.94 \text{ kip/ft}$$

$$x_2 = H/3 = (28.2 \text{ ft}) / 3 = 9.40 \text{ ft}$$

$$x_3 = H/2 = (28.2 \text{ ft}) / 2 = 14.10 \text{ ft}$$

$$M_H = (23.83 \text{ kip/ft})(9.4 \text{ ft}) + (3.94 \text{ kip/ft})(14.1 \text{ ft}) = 279.56 \text{ kip-ft/ft}$$

Limiting Eccentricity:

$$e_{\max} = B/4 \rightarrow e_{\max} = (21.15 \text{ ft}) / 4 = 5.29 \text{ ft}$$

Check Eccentricity

$$e < e_{\max} \rightarrow 3.91 \text{ ft} < 5.29 \text{ ft} \quad \text{OK}$$



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	28.2 ft
MSE Wall Width (Reinforcement Length), (B) =	21.15 ft
Live Surcharge Load, (σ_{LS}) =	240 psf
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf
Retained Soil Friction Angle, (ϕ_{RS}) =	30°
Retained Soil Drained Cohesion, (c_{BS}) =	400 psf
Retained Soil Undrained Shear Strength, [$(S_u)_{RS}$] =	1700 psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.333
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Backfill Friction Angle, (ϕ_{BF}) =	34°

Bearing Soil Properties:

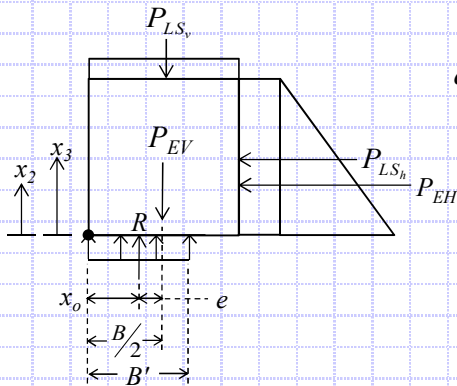
Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	30°
Bearing Soil Drained Cohesion, (c_{BS}) =	400 psf
Bearing Soil Undrained Shear Strength, [$(s_u)_{BS}$] =	1700 psf
Embedment Depth, (D) =	5.0 ft

LRFD Load Factors

	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

Check Bearing Capacity (Loading Case - Strength Ib) - AASHTO LRFD BDM Section 11.6.3.2



$$q_{eq} = P_V / B'$$

$$B' = B - 2e = 21.2 \text{ ft} - 2(2.655 \text{ ft}) = 15.84 \text{ ft}$$

$$e = B/2 - x_o = (21.2 \text{ ft}) / 2 - 7.92 \text{ ft} = 2.66 \text{ ft}$$

$$x_o = \frac{M_V - M_H}{P_V} = (1115.71 \text{ kip-ft/ft} - 279.64 \text{ kip-ft/ft}) / 105.5 \text{ kip/ft} = 7.92 \text{ ft}$$

$$q_{eq} = (105.5 \text{ kip/ft}) / (15.84 \text{ ft}) = 6.66 \text{ ksf}$$

$$M_V = P_{EV}(x_1) + P_{LS}(x_1) = (\gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV})(x_1) + (\sigma_{LS} \cdot B \cdot \gamma_{LS})(x_1)$$

$$M_V = (120 \text{ pcf})(28.2 \text{ ft})(21.15 \text{ ft})(1.35)(10.575 \text{ ft}) + [(240 \text{ psf})(21.15 \text{ ft})(1.75)(10.575 \text{ ft})] = 1115.71 \text{ kip-ft/ft}$$

$$M_H = P_{EH}(x_2) + P_{LS}(x_3) = (\frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH})(x_2) + (\sigma_{LS} H K_a \gamma_{LS})(x_3)$$

$$M_H = [\frac{1}{2}(120 \text{ pcf})(28.2 \text{ ft})^2(0.333)(1.5)](9.4 \text{ ft}) + [(240 \text{ psf})(28.2 \text{ ft})(0.333)(1.75)](14.1 \text{ ft}) = 279.64 \text{ kip-ft/ft}$$

$$P_V = P_{EV} + P_{LS} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} + \sigma_{LS} \cdot B \cdot \gamma_{LS}$$

$$P_V = (120 \text{ pcf})(28.2 \text{ ft})(21.15 \text{ ft})(1.35) + (240 \text{ psf})(21.15 \text{ ft})(1.75) = 105.5 \text{ kip/ft}$$

Nominal Bearing Resistance:

$$q_n = cN_c + \gamma DN_q + \frac{1}{2} \gamma BN_\gamma = (1700 \text{ psf})(5.7) + (120 \text{ pcf})(5 \text{ ft})(1.0) + \frac{1}{2}(120 \text{ pcf})(21.15 \text{ ft})(0.0) = 10.3 \text{ ksf}$$

$$N_c = 5.7 \quad N_q = 1.0 \quad N_\gamma = 0.0$$

Check Bearing Capacity

$$q_{eq} \leq q_n \cdot \phi_b \rightarrow 6.66 \text{ ksf} \leq (10.3 \text{ ksf})(0.65) = 6.70 \text{ ksf} \rightarrow 6.66 \text{ ksf} \leq 6.70 \text{ ksf} \quad \text{OK}$$

Use $\phi_b = 0.65$ (Per AASHTO LRFD BDM Table 11.5.6-1)



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	28.2 ft
MSE Wall Width (Reinforcement Length), (B) =	21.15 ft
Live Surcharge Load, (σ_{LS}) =	240 psf
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf
Retained Soil Friction Angle, (ϕ_{RS}) =	30°
Retained Soil Drained Cohesion, (c_{BS}) =	400 psf
Retained Soil Undrained Shear Strength, [$(S_u)_{RS}$] =	1700 psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.333
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Backfill Friction Angle, (ϕ_{BF}) =	34°

Bearing Soil Properties:

Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	30°
Bearing Soil Drained Cohesion, (c_{BS}) =	400 psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	1700 psf
Embedment Depth, (D) =	5.0 ft

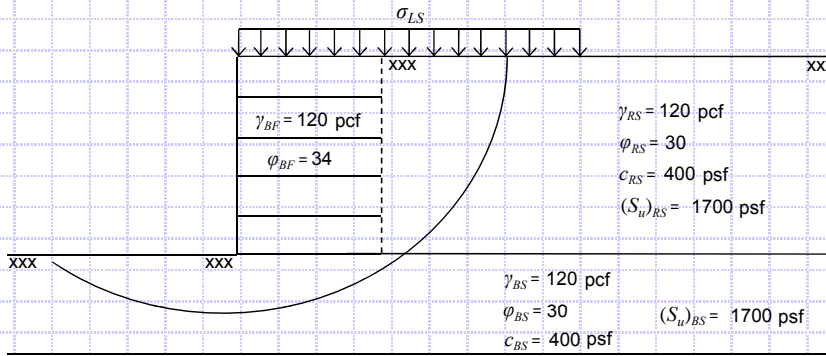
LRFD Load Factors

	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

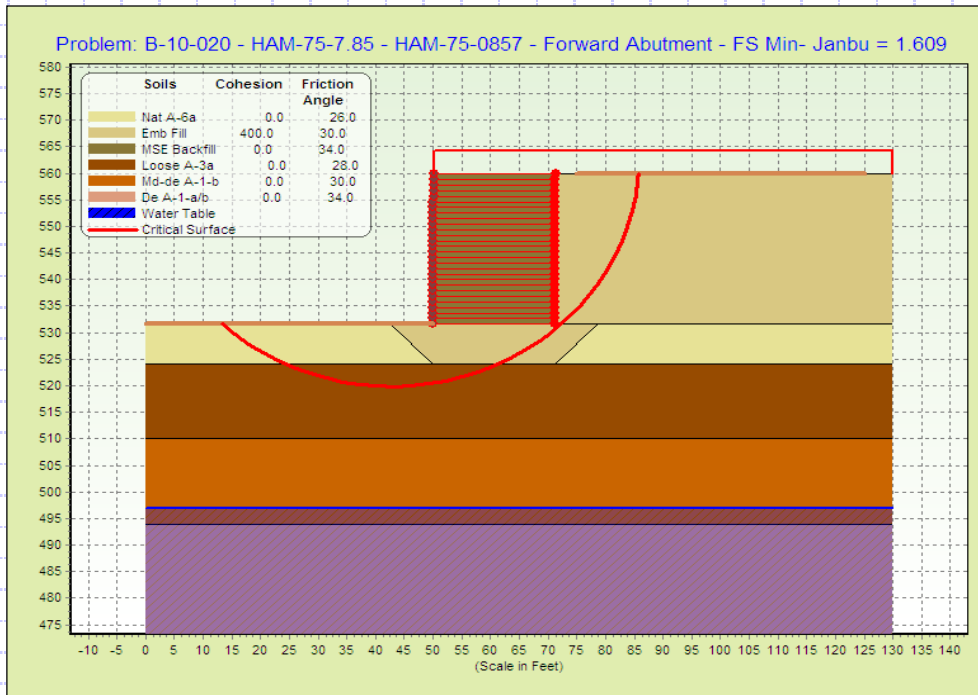
Check Overall (Global) Stability (Loading Case - Service I) - AASHTO LRFD BDM Sections 11.6.2.3 and 11.10.5.2

Long Term Stability - Drained Conditions



Loading scenario modeled as shown to the left and analyzed for slope stability using STABL for Windows software.

Graphical output shown below and tabular output results are provided as a separate attachment.



Check Overall (Global) Stability

$1.0 \leq FS \cdot \phi_{GS} \rightarrow 1.00 \leq (1.609)(0.65) = 1.05 \rightarrow 1.00 \leq 1.05$ **OK**

$FS = 1.609$ (From STABL Slope Stability Analysis)

Use $\phi_{GS} = 0.65$ (Per AASHTO LRFD BDM Section 11.6.2.3)



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	28.2 ft
MSE Wall Width (Reinforcement Length), (B) =	21.15 ft
Live Surcharge Load, (σ_{LS}) =	240 psf
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf
Retained Soil Friction Angle, (ϕ_{RS}) =	30°
Retained Soil Drained Cohesion, (c_{BS}) =	400 psf
Retained Soil Undrained Shear Strength, [$(S_u)_{RS}$] =	1700 psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.333
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Backfill Friction Angle, (ϕ_{BF}) =	34°

Bearing Soil Properties:

Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	30°
Bearing Soil Drained Cohesion, (c_{BS}) =	400 psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	1700 psf
Embedment Depth, (D) =	5.0 ft

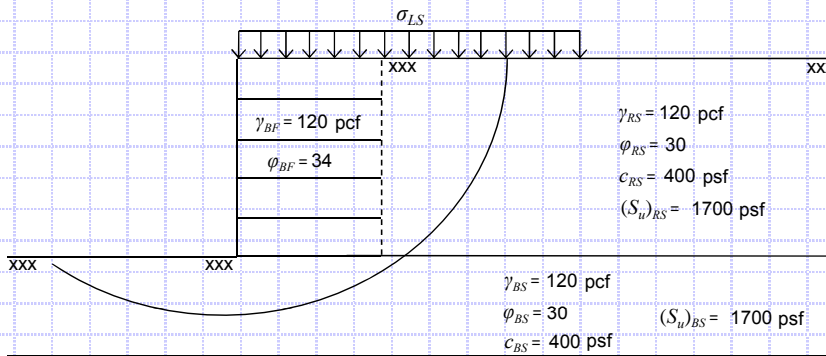
LRFD Load Factors

	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

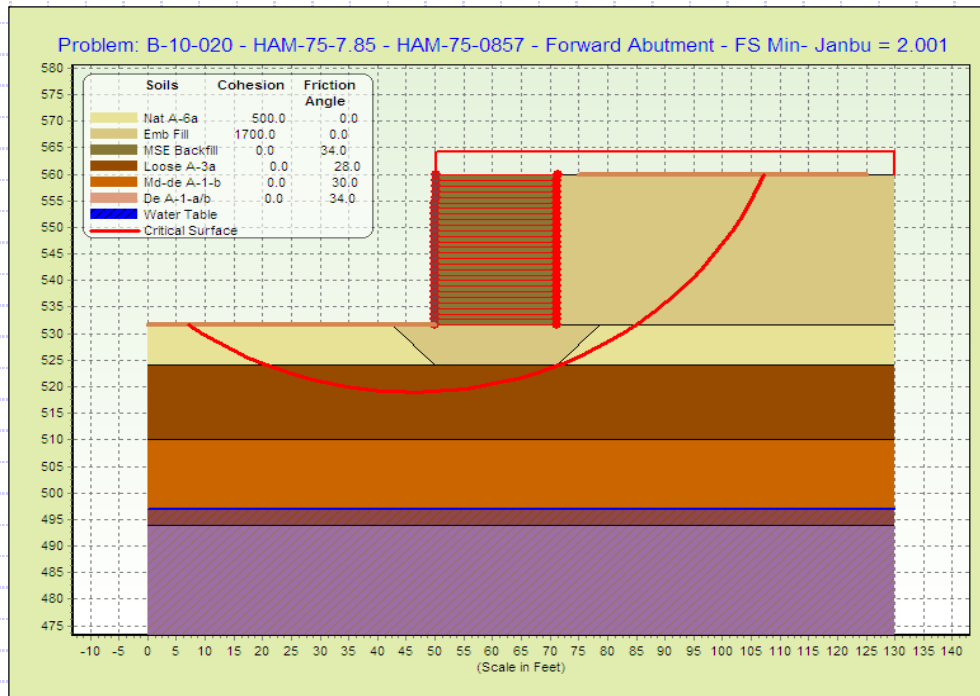
Check Overall (Global) Stability (Loading Case - Service I) - AASHTO LRFD BDM Sections 11.6.2.3 and 11.10.5.2 (Cont'd)

Short Term Stability - Undrained Conditions



Loading scenario modeled as shown to the left and analyzed for slope stability using STABL for Windows software.

Graphical output shown below and tabular output results are provided as a separate attachment.



Check Overall (Global) Stability

$1.0 \leq FS \cdot \phi_{GS} \rightarrow 1.00 \leq (2.001)(0.65) = 1.30 \rightarrow 1.00 \leq 1.30$ **OK**

$FS = 2.001$ (From STABL Slope Stability Analysis)

Use $\phi_{GS} = 0.65$ (Per AASHTO LRFD BDM Section 11.6.2.3)

result.out

** STABL for WINDOWS **
by
Geotechnical Software Solutions

1

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer's Method of Slices

Run Date:
Time of Run:
Run By:
Input Data Filename: run.in
Output Filename: result.out
Unit: U.S.C.
Plotted Output Filename: result.plt

PROBLEM DESCRIPTION B-10-020 - HAM-75-7.85 - HAM-75-0857 - Forward Abutment

BOUNDARY COORDINATES

5 Top Boundaries
16 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	531.60	42.50	531.60	3
2	42.50	531.60	50.00	531.60	2
3	50.00	531.60	50.10	559.80	1
4	50.10	559.80	71.30	559.80	1
5	71.30	559.80	130.00	559.80	2
6	50.00	531.60	71.20	531.60	2
7	71.20	531.60	71.30	559.80	2
8	71.20	531.60	78.70	531.60	2
9	78.70	531.60	130.00	531.60	3
10	42.50	531.60	50.00	524.00	3
11	50.00	524.00	71.20	524.00	4
12	71.20	524.00	78.70	531.60	3
13	0.00	524.00	50.00	524.00	4
14	71.20	524.00	130.00	524.00	4
15	0.00	510.00	130.00	510.00	5
16	0.00	494.00	130.00	494.00	6

1

ISOTROPIC SOIL PARAMETERS

6 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	120.0	125.0	0.0	34.0	0.00	0.0	1
2	120.0	130.0	400.0	30.0	0.00	0.0	1
3	110.0	120.0	0.0	26.0	0.00	0.0	1
4	120.0	125.0	0.0	28.0	0.00	0.0	1
5	125.0	130.0	0.0	30.0	0.00	0.0	1
6	130.0	135.0	0.0	34.0	0.00	0.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

result.out

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	497.00
2	130.00	497.00

1

BOUNDARY LOAD(S)

1 Load(s) Specified

Load No.	X-Left (ft)	X-Right (ft)	Intensity (psf)	Deflection (deg)
1	50.10	130.00	240.0	0.0

NOTE - Intensity Is Specified As A Uniformly Distributed Force Acting On A Horizontally Projected Surface.

GEOSYNTHETIC DATA

1 Geosynthetics(s) group(s) specified

Ngroup no	Bnr no	Y-top (ft)	Y-bot (ft)	Levels no	Length (ft)	Spacing (ft)	Efficiency	Tallow (lbs/ft)
1	3	531.6	559.8	28	21.2	-1.04	1.0	7500.0

1

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

500 Trial Surfaces Have Been Generated.

10 Surfaces Initiate From Each Of 50 Points Equally Spaced Along The Ground Surface Between X = 0.00 ft. and X = 50.00 ft.

Each Surface Terminates Between X = 75.00 ft. and X = 125.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = 500.00 ft.

3.00 ft. Line Segments Define Each Trial Failure Surface.

Factor Of Safety Calculation Has Gone Through 30 Iterations, without convergence

The Trial Failure Surface In Question Is Defined By The Following 22 Coordinate Points

result.out

Point No.	X-Surf (ft)	Y-Surf (ft)
1	28.57	531.60
2	31.43	530.69
3	34.36	530.03
4	37.33	529.61
5	40.32	529.45
6	43.32	529.55
7	46.30	529.90
8	49.24	530.50
9	52.12	531.35
10	54.91	532.44
11	57.60	533.76
12	60.17	535.31
13	62.60	537.07
14	64.87	539.03
15	66.97	541.18
16	68.88	543.49
17	70.58	545.96
18	72.07	548.57
19	73.33	551.29
20	74.35	554.11
21	75.13	557.01
22	75.64	559.80

Factor Of Safety For The Preceding Specified Surface = -4.160

Factor Of Safety Calculation Has Gone Through 30 Iterations, without convergence

The Trial Failure Surface In Question Is Defined By The Following 22 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	31.63	531.60
2	34.55	530.90
3	37.52	530.45
4	40.51	530.24
5	43.51	530.27
6	46.49	530.56
7	49.45	531.09
8	52.35	531.86
9	55.17	532.87
10	57.91	534.10
11	60.53	535.56
12	63.02	537.23
13	65.37	539.10
14	67.55	541.15
15	69.56	543.38
16	71.38	545.77
17	72.99	548.30
18	74.40	550.95
19	75.57	553.71
20	76.52	556.55
21	77.23	559.47
22	77.28	559.80

Factor Of Safety For The Preceding Specified Surface = -4.253

1

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

result.out

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 34 Coordinate Points

Poi nt No.	X-Surf (ft)	Y-Surf (ft)
1	13.27	531.60
2	15.52	529.62
3	17.91	527.80
4	20.41	526.15
5	23.03	524.69
6	25.74	523.40
7	28.54	522.31
8	31.40	521.42
9	34.32	520.73
10	37.28	520.24
11	40.27	519.96
12	43.26	519.89
13	46.26	520.03
14	49.24	520.37
15	52.19	520.93
16	55.09	521.68
17	57.94	522.64
18	60.70	523.79
19	63.39	525.14
20	65.97	526.67
21	68.44	528.37
22	70.78	530.24
23	72.99	532.27
24	75.05	534.45
25	76.96	536.77
26	78.70	539.21
27	80.26	541.77
28	81.65	544.43
29	82.84	547.19
30	83.84	550.01
31	84.64	552.91
32	85.23	555.85
33	85.62	558.82
34	85.68	559.80

*** 1.609 ***

Individual data on the 41 slices

Slice No.	Width (ft)	Weight (lbs)	Water		Force Norm (lbs)	Force Tan (lbs)	Earthquake		Surcharge Load (lbs)
			Force Top (lbs)	Force Bot (lbs)			Force Hor (lbs)	Force Ver (lbs)	
1	2.3	245.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	2.4	758.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	2.5	1274.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	2.6	1778.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	1.4	1156.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	1.3	1101.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	2.8	2719.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	2.9	3128.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	2.9	3466.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	3.0	3724.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	3.0	3895.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	2.2	2959.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.8	1018.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	3.0	4028.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	3.0	4008.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.8	1013.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.1	302.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	2.1	9796.2	0.0	0.0	0.0	0.0	0.0	0.0	501.5
19	2.9	13409.4	0.0	0.0	0.0	0.0	0.0	0.0	696.7
20	2.8	12840.5	0.0	0.0	0.0	0.0	0.0	0.0	682.3

						result. out			
21	2.8	12157.1	0.0	0.0	0.0	0.0	0.0	0.0	664.6
22	0.4	1766.4	0.0	0.0	0.0	0.0	0.0	0.0	98.4
23	2.3	9606.5	0.0	0.0	0.0	0.0	0.0	0.0	545.3
24	2.6	10503.7	0.0	0.0	0.0	0.0	0.0	0.0	619.7
25	2.5	9566.7	0.0	0.0	0.0	0.0	0.0	0.0	592.7
26	2.3	8580.9	0.0	0.0	0.0	0.0	0.0	0.0	562.8
27	0.4	1468.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
28	0.1	349.6	0.0	0.0	0.0	0.0	0.0	0.0	24.0
29	1.0	3310.0	0.0	0.0	0.0	0.0	0.0	0.0	231.1
30	0.7	2438.4	0.0	0.0	0.0	0.0	0.0	0.0	175.0
31	2.1	6542.4	0.0	0.0	0.0	0.0	0.0	0.0	494.9
32	1.9	5530.9	0.0	0.0	0.0	0.0	0.0	0.0	457.3
33	1.7	4552.0	0.0	0.0	0.0	0.0	0.0	0.0	417.4
34	1.6	3625.4	0.0	0.0	0.0	0.0	0.0	0.0	375.5
35	1.4	2770.3	0.0	0.0	0.0	0.0	0.0	0.0	331.8
36	1.2	2004.1	0.0	0.0	0.0	0.0	0.0	0.0	286.5
37	1.0	1342.8	0.0	0.0	0.0	0.0	0.0	0.0	239.8
38	0.8	800.2	0.0	0.0	0.0	0.0	0.0	0.0	191.9
39	0.6	388.1	0.0	0.0	0.0	0.0	0.0	0.0	143.1
40	0.4	115.4	0.0	0.0	0.0	0.0	0.0	0.0	93.6
41	0.1	3.5	0.0	0.0	0.0	0.0	0.0	0.0	14.3

Individual data on the 28 geosynthetics

Group	Level	Slice	Head Coordinates (ft)		End Coordinates (ft)		T (lbs)	Length (ft)	Tailow (lbs)	T/Tail %
1	1	0	50.1	559.8	71.3	559.8	0.0	21.2	7500.0	0.0
1	2	0	50.1	558.8	71.3	558.8	0.0	21.2	7500.0	0.0
1	3	0	50.1	557.7	71.3	557.7	0.0	21.2	7500.0	0.0
1	4	0	50.1	556.7	71.3	556.7	0.0	21.2	7500.0	0.0
1	5	0	50.1	555.6	71.3	555.6	0.0	21.2	7500.0	0.0
1	6	0	50.1	554.6	71.3	554.6	0.0	21.2	7500.0	0.0
1	7	0	50.1	553.5	71.3	553.5	0.0	21.2	7500.0	0.0
1	8	0	50.1	552.5	71.3	552.5	0.0	21.2	7500.0	0.0
1	9	0	50.1	551.4	71.3	551.4	0.0	21.2	7500.0	0.0
1	10	0	50.1	550.4	71.3	550.4	0.0	21.2	7500.0	0.0
1	11	0	50.1	549.4	71.3	549.4	0.0	21.2	7500.0	0.0
1	12	0	50.1	548.3	71.3	548.3	0.0	21.2	7500.0	0.0
1	13	0	50.1	547.3	71.3	547.3	0.0	21.2	7500.0	0.0
1	14	0	50.1	546.2	71.3	546.2	0.0	21.2	7500.0	0.0
1	15	0	50.0	545.2	71.2	545.2	0.0	21.2	7500.0	0.0
1	16	0	50.0	544.1	71.2	544.1	0.0	21.2	7500.0	0.0
1	17	0	50.0	543.1	71.2	543.1	0.0	21.2	7500.0	0.0
1	18	0	50.0	542.0	71.2	542.0	0.0	21.2	7500.0	0.0
1	19	0	50.0	541.0	71.2	541.0	0.0	21.2	7500.0	0.0
1	20	0	50.0	540.0	71.2	540.0	0.0	21.2	7500.0	0.0
1	21	0	50.0	538.9	71.2	538.9	0.0	21.2	7500.0	0.0
1	22	0	50.0	537.9	71.2	537.9	0.0	21.2	7500.0	0.0
1	23	0	50.0	536.8	71.2	536.8	0.0	21.2	7500.0	0.0
1	24	0	50.0	535.8	71.2	535.8	0.0	21.2	7500.0	0.0
1	25	0	50.0	534.7	71.2	534.7	0.0	21.2	7500.0	0.0
1	26	0	50.0	533.7	71.2	533.7	0.0	21.2	7500.0	0.0
1	27	0	50.0	532.6	71.2	532.6	0.0	21.2	7500.0	0.0
1	28	0	50.0	531.6	71.2	531.6	0.0	21.2	7500.0	0.0

Failure Surface Specified By 33 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	15.31	531.60
2	17.81	529.94
3	20.40	528.44
4	23.09	527.10
5	25.85	525.93
6	28.68	524.93
7	31.56	524.11
8	34.49	523.47
9	37.46	523.01
10	40.45	522.73
11	43.44	522.64
12	46.44	522.74
13	49.43	523.02
14	52.39	523.48
15	55.32	524.13

result.out

16	58.21	524.96
17	61.03	525.96
18	63.79	527.14
19	66.47	528.49
20	69.07	529.99
21	71.56	531.66
22	73.95	533.48
23	76.22	535.44
24	78.36	537.54
25	80.38	539.76
26	82.25	542.11
27	83.97	544.56
28	85.53	547.12
29	86.94	549.77
30	88.17	552.51
31	89.24	555.31
32	90.13	558.18
33	90.53	559.80

*** 1.627 ***

1

Failure Surface Specified By 34 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	15.31	531.60
2	17.72	529.82
3	20.24	528.19
4	22.86	526.73
5	25.57	525.44
6	28.36	524.33
7	31.21	523.40
8	34.11	522.65
9	37.06	522.09
10	40.04	521.72
11	43.03	521.54
12	46.03	521.55
13	49.02	521.75
14	52.00	522.15
15	54.94	522.73
16	57.84	523.51
17	60.68	524.46
18	63.46	525.60
19	66.16	526.91
20	68.76	528.40
21	71.27	530.04
22	73.67	531.85
23	75.95	533.80
24	78.09	535.89
25	80.10	538.12
26	81.96	540.48
27	83.67	542.94
28	85.22	545.51
29	86.59	548.18
30	87.80	550.93
31	88.82	553.75
32	89.67	556.62
33	90.33	559.55
34	90.36	559.80

*** 1.629 ***

Failure Surface Specified By 30 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
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result.out

1	23.47	531.60
2	25.85	529.78
3	28.37	528.15
4	31.01	526.72
5	33.75	525.49
6	36.57	524.48
7	39.47	523.69
8	42.41	523.13
9	45.39	522.79
10	48.39	522.69
11	51.39	522.82
12	54.37	523.18
13	57.31	523.76
14	60.20	524.58
15	63.01	525.61
16	65.74	526.85
17	68.37	528.31
18	70.87	529.96
19	73.24	531.80
20	75.46	533.82
21	77.52	536.00
22	79.41	538.33
23	81.11	540.80
24	82.61	543.40
25	83.91	546.10
26	84.99	548.90
27	85.86	551.77
28	86.51	554.70
29	86.92	557.67
30	87.05	559.80

*** 1.649 ***

1

Failure Surface Specified By 37 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	7.14	531.60
2	9.60	529.88
3	12.15	528.30
4	14.78	526.86
5	17.49	525.57
6	20.26	524.42
7	23.09	523.42
8	25.97	522.58
9	28.89	521.90
10	31.85	521.38
11	34.83	521.01
12	37.82	520.81
13	40.82	520.77
14	43.82	520.90
15	46.80	521.19
16	49.77	521.64
17	52.71	522.24
18	55.61	523.01
19	58.46	523.93
20	61.26	525.01
21	64.00	526.24
22	66.67	527.61
23	69.25	529.13
24	71.76	530.78
25	74.17	532.57
26	76.47	534.48
27	78.68	536.52
28	80.76	538.68
29	82.73	540.94
30	84.57	543.31
31	86.29	545.77
32	87.86	548.33
33	89.29	550.96
34	90.58	553.67
35	91.72	556.44

result.out

36	92.71	559.28
37	92.86	559.80

*** 1.663 ***

Failure Surface Specified By 34 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	15.31	531.60
2	17.46	529.52
3	19.77	527.59
4	22.20	525.84
5	24.76	524.27
6	27.42	522.88
7	30.17	521.69
8	33.00	520.70
9	35.90	519.92
10	38.84	519.35
11	41.82	518.99
12	44.82	518.85
13	47.82	518.93
14	50.81	519.22
15	53.76	519.72
16	56.68	520.44
17	59.53	521.36
18	62.31	522.49
19	65.00	523.82
20	67.59	525.33
21	70.06	527.03
22	72.41	528.90
23	74.61	530.94
24	76.66	533.13
25	78.55	535.46
26	80.27	537.92
27	81.80	540.50
28	83.14	543.18
29	84.29	545.95
30	85.23	548.80
31	85.97	551.71
32	86.50	554.66
33	86.81	557.64
34	86.88	559.80

*** 1.673 ***

1

Failure Surface Specified By 37 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	7.14	531.60
2	9.27	529.48
3	11.53	527.51
4	13.91	525.69
5	16.41	524.03
6	19.01	522.54
7	21.71	521.22
8	24.48	520.08
9	27.33	519.12
10	30.23	518.36
11	33.17	517.79
12	36.15	517.41
13	39.14	517.22
14	42.14	517.24
15	45.14	517.45
16	48.11	517.86

result.out

17	51.05	518.46
18	53.94	519.25
19	56.78	520.24
20	59.54	521.40
21	62.22	522.75
22	64.81	524.27
23	67.29	525.95
24	69.66	527.79
25	71.90	529.79
26	74.00	531.93
27	75.96	534.20
28	77.77	536.59
29	79.41	539.10
30	80.89	541.72
31	82.19	544.42
32	83.31	547.20
33	84.25	550.05
34	85.00	552.96
35	85.55	555.90
36	85.91	558.88
37	85.96	559.80

*** 1.679 ***

Failure Surface Specified By 36 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	15.31	531.60
2	17.44	529.49
3	19.71	527.53
4	22.12	525.74
5	24.63	524.10
6	27.25	522.65
7	29.97	521.37
8	32.77	520.28
9	35.63	519.39
10	38.55	518.69
11	41.50	518.19
12	44.49	517.89
13	47.49	517.80
14	50.49	517.91
15	53.47	518.22
16	56.43	518.74
17	59.34	519.45
18	62.20	520.36
19	64.99	521.47
20	67.70	522.76
21	70.31	524.23
22	72.82	525.87
23	75.21	527.69
24	77.47	529.66
25	79.59	531.78
26	81.57	534.03
27	83.38	536.42
28	85.03	538.93
29	86.51	541.54
30	87.81	544.25
31	88.91	547.03
32	89.83	549.89
33	90.55	552.80
34	91.07	555.76
35	91.39	558.74
36	91.43	559.80

*** 1.680 ***

result.out

Poi nt No.	X-Surf (ft)	Y-Surf (ft)
1	11.22	531.60
2	13.36	529.49
3	15.63	527.53
4	18.01	525.71
5	20.51	524.04
6	23.10	522.54
7	25.79	521.21
8	28.56	520.05
9	31.39	519.07
10	34.29	518.27
11	37.22	517.66
12	40.19	517.23
13	43.18	516.99
14	46.18	516.95
15	49.18	517.10
16	52.16	517.43
17	55.11	517.96
18	58.03	518.67
19	60.89	519.57
20	63.69	520.64
21	66.42	521.89
22	69.06	523.32
23	71.60	524.91
24	74.04	526.65
25	76.37	528.55
26	78.56	530.59
27	80.63	532.77
28	82.55	535.08
29	84.32	537.50
30	85.93	540.03
31	87.38	542.66
32	88.65	545.37
33	89.76	548.16
34	90.68	551.01
35	91.42	553.92
36	91.97	556.87
37	92.33	559.80

*** 1.681 ***

Failure Surface Specified By 37 Coordinate Points

Poi nt No.	X-Surf (ft)	Y-Surf (ft)
1	12.25	531.60
2	14.38	529.49
3	16.65	527.53
4	19.03	525.71
5	21.54	524.06
6	24.14	522.57
7	26.84	521.25
8	29.61	520.11
9	32.45	519.15
10	35.35	518.38
11	38.30	517.80
12	41.27	517.41
13	44.26	517.22
14	47.26	517.22
15	50.26	517.41
16	53.23	517.80
17	56.18	518.38
18	59.08	519.15
19	61.92	520.11
20	64.69	521.25
21	67.39	522.57
22	69.99	524.06
23	72.49	525.71
24	74.88	527.53

result.out

** STABL for WINDOWS **
by
Geotechnical Software Solutions

1

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer's Method of Slices

Run Date:
Time of Run:
Run By:
Input Data Filename: run.in
Output Filename: result.out
Unit: U.S.C.
Plotted Output Filename: result.plt

PROBLEM DESCRIPTION B-10-020 - HAM-75-7.85 - HAM-75-0857 - Forward Abutment

BOUNDARY COORDINATES

5 Top Boundaries
16 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	531.60	42.50	531.60	3
2	42.50	531.60	50.00	531.60	2
3	50.00	531.60	50.10	559.80	1
4	50.10	559.80	71.30	559.80	1
5	71.30	559.80	130.00	559.80	2
6	50.00	531.60	71.20	531.60	2
7	71.20	531.60	71.30	559.80	2
8	71.20	531.60	78.70	531.60	2
9	78.70	531.60	130.00	531.60	3
10	42.50	531.60	50.00	524.00	3
11	50.00	524.00	71.20	524.00	4
12	71.20	524.00	78.70	531.60	3
13	0.00	524.00	50.00	524.00	4
14	71.20	524.00	130.00	524.00	4
15	0.00	510.00	130.00	510.00	5
16	0.00	494.00	130.00	494.00	6

1

ISOTROPIC SOIL PARAMETERS

6 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	120.0	125.0	0.0	34.0	0.00	0.0	1
2	120.0	130.0	1700.0	0.0	0.00	0.0	1
3	110.0	120.0	500.0	0.0	0.00	0.0	1
4	120.0	125.0	0.0	28.0	0.00	0.0	1
5	125.0	130.0	0.0	30.0	0.00	0.0	1
6	130.0	135.0	0.0	34.0	0.00	0.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

result.out

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	497.00
2	130.00	497.00

1

BOUNDARY LOAD(S)

1 Load(s) Specified

Load No.	X-Left (ft)	X-Right (ft)	Intensity (psf)	Deflection (deg)
1	50.10	130.00	240.0	0.0

NOTE - Intensity Is Specified As A Uniformly Distributed Force Acting On A Horizontally Projected Surface.

GEOSYNTHETIC DATA

1 Geosynthetics(s) group(s) specified

Ngroup no	Bnr no	Y-top (ft)	Y-bot (ft)	Levels no	Length (ft)	Spacing (ft)	Efficiency	Tallow (lbs/ft)
1	3	531.6	559.8	28	21.2	-1.04	1.0	7500.0

1

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

500 Trial Surfaces Have Been Generated.

10 Surfaces Initiate From Each Of 50 Points Equally Spaced Along The Ground Surface Between X = 0.00 ft. and X = 50.00 ft.

Each Surface Terminates Between X = 75.00 ft. and X = 125.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y =500.00 ft.

3.00 ft. Line Segments Define Each Trial Failure Surface.

1

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 41 Coordinate Points

result.out

Poi nt No.	X-Surf (ft)	Y-Surf (ft)
1	7.14	531.60
2	9.61	529.89
3	12.15	528.30
4	14.77	526.83
5	17.44	525.47
6	20.18	524.24
7	22.97	523.13
8	25.80	522.15
9	28.68	521.30
10	31.59	520.58
11	34.53	520.00
12	37.50	519.54
13	40.48	519.22
14	43.48	519.04
15	46.48	518.99
16	49.47	519.08
17	52.47	519.31
18	55.44	519.66
19	58.40	520.16
20	61.34	520.78
21	64.24	521.54
22	67.11	522.43
23	69.93	523.45
24	72.70	524.60
25	75.42	525.87
26	78.08	527.26
27	80.67	528.77
28	83.19	530.39
29	85.63	532.13
30	88.00	533.98
31	90.28	535.93
32	92.46	537.99
33	94.55	540.14
34	96.55	542.38
35	98.44	544.71
36	100.22	547.12
37	101.89	549.62
38	103.44	552.18
39	104.88	554.81
40	106.20	557.51
41	107.19	559.80

*** 2.001 ***

Individual data on the 49 slices

Slice No.	Width (ft)	Weight (lbs)	Water		Force Norm (lbs)	Force Tan (lbs)	Earthquake Force		Surcharge Load (lbs)
			Force Top (lbs)	Force Bot (lbs)			Hor (lbs)	Ver (lbs)	
1	2.5	231.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	2.5	699.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	2.6	1159.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	2.7	1604.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	2.7	2028.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.6	499.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	2.2	1936.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	2.8	2831.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	2.9	3189.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	2.9	3503.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	2.9	3769.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	3.0	3984.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	3.0	4146.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	2.0	2858.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	1.0	1398.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	3.0	4376.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	3.0	4459.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.5	786.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.1	318.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	2.4	11524.9	0.0	0.0	0.0	0.0	0.0	0.0	568.0

						result.out			
21	3.0	14409.1	0.0	0.0	0.0	0.0	0.0	0.0	714.8
22	3.0	14164.3	0.0	0.0	0.0	0.0	0.0	0.0	710.2
23	2.9	13845.6	0.0	0.0	0.0	0.0	0.0	0.0	704.1
24	2.9	13456.1	0.0	0.0	0.0	0.0	0.0	0.0	696.6
25	2.9	12999.6	0.0	0.0	0.0	0.0	0.0	0.0	687.6
26	2.8	12480.5	0.0	0.0	0.0	0.0	0.0	0.0	677.2
27	1.3	5512.1	0.0	0.0	0.0	0.0	0.0	0.0	305.5
28	0.1	228.8	0.0	0.0	0.0	0.0	0.0	0.0	12.8
29	0.0	200.8	0.0	0.0	0.0	0.0	0.0	0.0	11.2
30	1.4	5955.0	0.0	0.0	0.0	0.0	0.0	0.0	336.0
31	2.7	11230.0	0.0	0.0	0.0	0.0	0.0	0.0	652.4
32	2.7	10519.7	0.0	0.0	0.0	0.0	0.0	0.0	637.9
33	0.6	2399.4	0.0	0.0	0.0	0.0	0.0	0.0	149.8
34	2.0	7397.3	0.0	0.0	0.0	0.0	0.0	0.0	472.3
35	2.5	9091.5	0.0	0.0	0.0	0.0	0.0	0.0	605.1
36	1.7	5851.1	0.0	0.0	0.0	0.0	0.0	0.0	407.0
37	0.7	2511.3	0.0	0.0	0.0	0.0	0.0	0.0	179.8
38	2.4	7586.1	0.0	0.0	0.0	0.0	0.0	0.0	567.3
39	2.3	6790.7	0.0	0.0	0.0	0.0	0.0	0.0	546.7
40	2.2	5994.6	0.0	0.0	0.0	0.0	0.0	0.0	524.9
41	2.1	5206.0	0.0	0.0	0.0	0.0	0.0	0.0	502.1
42	2.0	4433.3	0.0	0.0	0.0	0.0	0.0	0.0	478.2
43	1.9	3684.5	0.0	0.0	0.0	0.0	0.0	0.0	453.3
44	1.8	2967.8	0.0	0.0	0.0	0.0	0.0	0.0	427.5
45	1.7	2291.1	0.0	0.0	0.0	0.0	0.0	0.0	400.9
46	1.6	1662.0	0.0	0.0	0.0	0.0	0.0	0.0	373.4
47	1.4	1087.7	0.0	0.0	0.0	0.0	0.0	0.0	345.1
48	1.3	575.3	0.0	0.0	0.0	0.0	0.0	0.0	316.2
49	1.0	136.7	0.0	0.0	0.0	0.0	0.0	0.0	238.6

Individual data on the 28 geosynthetics

Group	Level	Slice	Head Coordinates (ft)		End Coordinates (ft)		T (lbs)	Length (ft)	Tailow (lbs)	T/Tail %
1	1	0	50.1	559.8	71.3	559.8	0.0	21.2	7500.0	0.0
1	2	0	50.1	558.8	71.3	558.8	0.0	21.2	7500.0	0.0
1	3	0	50.1	557.7	71.3	557.7	0.0	21.2	7500.0	0.0
1	4	0	50.1	556.7	71.3	556.7	0.0	21.2	7500.0	0.0
1	5	0	50.1	555.6	71.3	555.6	0.0	21.2	7500.0	0.0
1	6	0	50.1	554.6	71.3	554.6	0.0	21.2	7500.0	0.0
1	7	0	50.1	553.5	71.3	553.5	0.0	21.2	7500.0	0.0
1	8	0	50.1	552.5	71.3	552.5	0.0	21.2	7500.0	0.0
1	9	0	50.1	551.4	71.3	551.4	0.0	21.2	7500.0	0.0
1	10	0	50.1	550.4	71.3	550.4	0.0	21.2	7500.0	0.0
1	11	0	50.1	549.4	71.3	549.4	0.0	21.2	7500.0	0.0
1	12	0	50.1	548.3	71.3	548.3	0.0	21.2	7500.0	0.0
1	13	0	50.1	547.3	71.3	547.3	0.0	21.2	7500.0	0.0
1	14	0	50.1	546.2	71.3	546.2	0.0	21.2	7500.0	0.0
1	15	0	50.0	545.2	71.2	545.2	0.0	21.2	7500.0	0.0
1	16	0	50.0	544.1	71.2	544.1	0.0	21.2	7500.0	0.0
1	17	0	50.0	543.1	71.2	543.1	0.0	21.2	7500.0	0.0
1	18	0	50.0	542.0	71.2	542.0	0.0	21.2	7500.0	0.0
1	19	0	50.0	541.0	71.2	541.0	0.0	21.2	7500.0	0.0
1	20	0	50.0	540.0	71.2	540.0	0.0	21.2	7500.0	0.0
1	21	0	50.0	538.9	71.2	538.9	0.0	21.2	7500.0	0.0
1	22	0	50.0	537.9	71.2	537.9	0.0	21.2	7500.0	0.0
1	23	0	50.0	536.8	71.2	536.8	0.0	21.2	7500.0	0.0
1	24	0	50.0	535.8	71.2	535.8	0.0	21.2	7500.0	0.0
1	25	0	50.0	534.7	71.2	534.7	0.0	21.2	7500.0	0.0
1	26	0	50.0	533.7	71.2	533.7	0.0	21.2	7500.0	0.0
1	27	0	50.0	532.6	71.2	532.6	0.0	21.2	7500.0	0.0
1	28	0	50.0	531.6	71.2	531.6	0.0	21.2	7500.0	0.0

Failure Surface Specified By 44 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	5.10	531.60
2	7.71	530.11
3	10.36	528.71
4	13.07	527.42
5	15.82	526.23
6	18.62	525.14
7	21.45	524.15

result.out

8	24.32	523.28
9	27.22	522.50
10	30.14	521.84
11	33.09	521.29
12	36.06	520.84
13	39.04	520.51
14	42.03	520.29
15	45.03	520.18
16	48.03	520.18
17	51.03	520.29
18	54.02	520.51
19	57.00	520.85
20	59.97	521.29
21	62.92	521.85
22	65.84	522.51
23	68.74	523.28
24	71.61	524.16
25	74.44	525.15
26	77.24	526.24
27	79.99	527.43
28	82.70	528.73
29	85.35	530.12
30	87.95	531.62
31	90.50	533.20
32	92.98	534.89
33	95.40	536.66
34	97.76	538.52
35	100.04	540.47
36	102.25	542.50
37	104.38	544.61
38	106.43	546.80
39	108.40	549.07
40	110.28	551.40
41	112.07	553.81
42	113.78	556.27
43	115.39	558.81
44	115.97	559.80

*** 2.007 ***

1

Failure Surface Specified By 40 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	9.18	531.60
2	11.64	529.88
3	14.17	528.27
4	16.78	526.79
5	19.46	525.43
6	22.19	524.20
7	24.99	523.10
8	27.83	522.14
9	30.71	521.31
10	33.63	520.62
11	36.58	520.07
12	39.55	519.66
13	42.54	519.39
14	45.54	519.26
15	48.54	519.28
16	51.53	519.43
17	54.52	519.73
18	57.48	520.17
19	60.43	520.75
20	63.34	521.47
21	66.22	522.33
22	69.05	523.32
23	71.83	524.45
24	74.55	525.70
25	77.21	527.09
26	79.81	528.60
27	82.33	530.23
28	84.76	531.97

result.out

29	87.12	533.83
30	89.38	535.81
31	91.54	537.88
32	93.61	540.06
33	95.57	542.33
34	97.42	544.69
35	99.15	547.14
36	100.77	549.66
37	102.27	552.26
38	103.64	554.93
39	104.88	557.66
40	105.73	559.80

*** 2.015 ***

Failure Surface Specified By 40 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	11.22	531.60
2	13.69	529.90
3	16.24	528.31
4	18.86	526.85
5	21.54	525.51
6	24.29	524.30
7	27.09	523.22
8	29.93	522.27
9	32.82	521.46
10	35.75	520.78
11	38.70	520.24
12	41.67	519.84
13	44.66	519.59
14	47.66	519.47
15	50.66	519.49
16	53.65	519.66
17	56.64	519.96
18	59.60	520.41
19	62.55	520.99
20	65.46	521.72
21	68.33	522.58
22	71.16	523.57
23	73.94	524.70
24	76.67	525.95
25	79.33	527.33
26	81.93	528.84
27	84.45	530.46
28	86.89	532.21
29	89.25	534.06
30	91.51	536.03
31	93.69	538.09
32	95.76	540.26
33	97.73	542.53
34	99.59	544.88
35	101.33	547.32
36	102.96	549.84
37	104.47	552.43
38	105.86	555.09
39	107.12	557.81
40	107.93	559.80

*** 2.028 ***

1

Failure Surface Specified By 41 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
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result.out

1	8.16	531.60
2	10.81	530.19
3	13.51	528.88
4	16.26	527.67
5	19.05	526.58
6	21.88	525.60
7	24.75	524.72
8	27.66	523.96
9	30.59	523.32
10	33.54	522.79
11	36.51	522.37
12	39.50	522.07
13	42.49	521.89
14	45.49	521.83
15	48.49	521.88
16	51.48	522.05
17	54.47	522.34
18	57.44	522.75
19	60.40	523.27
20	63.33	523.90
21	66.23	524.65
22	69.11	525.52
23	71.94	526.49
24	74.74	527.57
25	77.49	528.77
26	80.20	530.07
27	82.85	531.47
28	85.44	532.98
29	87.97	534.59
30	90.44	536.29
31	92.84	538.10
32	95.17	539.99
33	97.42	541.97
34	99.59	544.04
35	101.68	546.19
36	103.68	548.43
37	105.60	550.74
38	107.42	553.12
39	109.15	555.57
40	110.78	558.09
41	111.80	559.80

*** 2.052 ***

Failure Surface Specified By 40 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	17.35	531.60
2	19.99	530.17
3	22.68	528.85
4	25.43	527.65
5	28.22	526.55
6	31.06	525.57
7	33.93	524.71
8	36.83	523.96
9	39.77	523.34
10	42.73	522.83
11	45.70	522.45
12	48.69	522.18
13	51.69	522.04
14	54.69	522.02
15	57.68	522.13
16	60.68	522.35
17	63.66	522.70
18	66.62	523.17
19	69.56	523.76
20	72.48	524.47
21	75.36	525.30
22	78.21	526.24
23	81.01	527.30
24	83.77	528.47
25	86.48	529.76

result.out

26	89.14	531.15
27	91.74	532.65
28	94.27	534.26
29	96.74	535.97
30	99.13	537.78
31	101.45	539.68
32	103.69	541.68
33	105.85	543.76
34	107.91	545.94
35	109.89	548.19
36	111.78	550.53
37	113.56	552.93
38	115.25	555.41
39	116.84	557.96
40	117.88	559.80

*** 2.056 ***

1

Failure Surface Specified By 41 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	3.06	531.60
2	5.49	529.83
3	7.99	528.18
4	10.57	526.65
5	13.22	525.24
6	15.93	523.96
7	18.70	522.80
8	21.52	521.77
9	24.38	520.87
10	27.28	520.11
11	30.21	519.48
12	33.17	519.00
13	36.15	518.64
14	39.15	518.43
15	42.14	518.36
16	45.14	518.43
17	48.14	518.63
18	51.12	518.98
19	54.08	519.46
20	57.01	520.09
21	59.92	520.84
22	62.78	521.73
23	65.60	522.76
24	68.37	523.91
25	71.08	525.19
26	73.73	526.60
27	76.31	528.13
28	78.82	529.77
29	81.25	531.54
30	83.59	533.41
31	85.85	535.39
32	88.01	537.47
33	90.07	539.65
34	92.03	541.92
35	93.87	544.29
36	95.61	546.73
37	97.23	549.26
38	98.74	551.85
39	100.12	554.52
40	101.37	557.24
41	102.41	559.80

*** 2.057 ***

Failure Surface Specified By 37 Coordinate Points

result.out

Point No.	X-Surf (ft)	Y-Surf (ft)
1	9.18	531.60
2	11.80	530.13
3	14.48	528.79
4	17.23	527.58
5	20.02	526.49
6	22.87	525.54
7	25.76	524.73
8	28.68	524.05
9	31.63	523.51
10	34.60	523.11
11	37.59	522.85
12	40.59	522.74
13	43.59	522.76
14	46.59	522.93
15	49.57	523.24
16	52.54	523.69
17	55.48	524.27
18	58.39	525.00
19	61.26	525.86
20	64.09	526.86
21	66.87	527.99
22	69.59	529.25
23	72.25	530.64
24	74.84	532.15
25	77.36	533.78
26	79.80	535.53
27	82.15	537.39
28	84.41	539.37
29	86.58	541.44
30	88.64	543.62
31	90.60	545.89
32	92.45	548.25
33	94.19	550.69
34	95.81	553.22
35	97.31	555.82
36	98.69	558.49
37	99.29	559.80

*** 2.062 ***

1

Failure Surface Specified By 46 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	1.02	531.60
2	3.59	530.05
3	6.21	528.59
4	8.88	527.23
5	11.60	525.97
6	14.37	524.80
7	17.17	523.73
8	20.01	522.76
9	22.88	521.90
10	25.79	521.14
11	28.71	520.48
12	31.66	519.93
13	34.63	519.48
14	37.61	519.14
15	40.60	518.91
16	43.60	518.78
17	46.60	518.76
18	49.60	518.85
19	52.59	519.05
20	55.57	519.35
21	58.55	519.76
22	61.50	520.27
23	64.44	520.89
24	67.35	521.62

result.out

25	70.23	522.45
26	73.08	523.38
27	75.90	524.41
28	78.68	525.55
29	81.41	526.78
30	84.10	528.11
31	86.74	529.53
32	89.33	531.05
33	91.86	532.66
34	94.34	534.36
35	96.75	536.14
36	99.09	538.01
37	101.37	539.97
38	103.57	542.00
39	105.70	544.11
40	107.76	546.30
41	109.73	548.56
42	111.62	550.88
43	113.43	553.28
44	115.15	555.73
45	116.79	558.25
46	117.71	559.80

*** 2.063 ***

Failure Surface Specified By 40 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	15.31	531.60
2	17.99	530.26
3	20.73	529.03
4	23.51	527.91
5	26.34	526.90
6	29.20	526.01
7	32.10	525.23
8	35.02	524.56
9	37.97	524.01
10	40.94	523.58
11	43.92	523.27
12	46.92	523.07
13	49.92	523.00
14	52.92	523.04
15	55.91	523.20
16	58.90	523.49
17	61.87	523.89
18	64.83	524.40
19	67.76	525.04
20	70.66	525.79
21	73.54	526.65
22	76.37	527.63
23	79.17	528.72
24	81.92	529.93
25	84.61	531.23
26	87.26	532.65
27	89.85	534.17
28	92.37	535.79
29	94.83	537.51
30	97.22	539.32
31	99.53	541.23
32	101.77	543.23
33	103.92	545.32
34	105.99	547.49
35	107.98	549.74
36	109.87	552.07
37	111.67	554.47
38	113.37	556.94
39	114.97	559.48
40	115.15	559.80

*** 2.066 ***

1

	Y	A	X	I	S	F	T	
	0.00	131.02	262.04	393.05	524.07	655.09		
X	0.00	+-----+-----+-----+-----+-----+-----+					****	-----+
						.14		
						*G G/1		
						*g.g		
						.1*3.		
						.211		
	131.02	+				****	*1/	
A	262.04	+						
X	393.05	+						
I	524.07	+						
S	655.09	+						
	786.10	+						
F	917.12	+						
T	1048.14	+						