



**FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 11 AT PAN LAKE, 10.6 km NORTH OF HIGHWAY 64
STATION 14+750 TO 14+950, IN OLIVE TOWNSHIP.
WP 5578-04-00, NORTH BAY AREA
GEOCRES No. 31L-123**

**MTO NE REGION CONTRACT #5006-E-0070
ASSIGNMENT #7**

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1.0 INTRODUCTION

AMEC Earth & Environmental, a division of AMEC Americas Limited (AMEC), Consulting Geotechnical, Construction Quality Control and Environmental Engineers, was retained by the Ministry of Transportation (North East Region) to conduct a foundation investigation and detail design to assess the stability of an existing embankment on Highway 11 at Pan Lake, 10.6 km north of Highway 64, in Olive Township, Ontario. The embankment has undergone historical slope movement and settlement, e.g., tilting guiderail. The approximate site location is shown on Figure 1.

Twelve (12) boreholes, with a total drilling length of approximately 114 m, in the vicinity of the existing guiderail were specified by the MTO in the Terms of Reference. Authorization to proceed with this investigation was signed by the Regional / Branch Director of MTO dated 17th March 2008 and faxed on 18th March 2008. The work was carried out by AMEC according to the MTO Northeastern Region Terms of Reference Agreement #5006-E-0070 Assignment #7; Foundation Investigation and Design for Highway 11 at Pan Lake, 10.6 km north of Highway 64.

Subsurface information from a previous project that was available was reviewed prior to carrying out the fieldwork for this project. The following information was reviewed at the MTO Foundation Library (GEOCRE), in Downsview, and used in preparing this report wherever applicable.

- ***“Foundation Investigation Report for Culvert Replacements: Hwy 11, Sta.15+225 – Robin Creek, Site 43-363, Hwy 11, Sta.15+060 – Angus Creek, Site 43-366 and Hwy 11, Sta. 17+984 – North Mile Creek (Rabbit Creek), Site 43-365, WP 714-92-00, District 54, Sudbury”***, Jacques, Whitford Limited, Project 10993, April 14, 1998.

However, the subsoil information for the project site under this investigation was not available in the above-mentioned report.

The investigation was carried out by means of a limited number of boreholes, in-situ tests and laboratory tests on selected samples. The factual results of the soil conditions encountered in the boreholes and laboratory tests are presented in a separate report (Foundation Investigation Report – Reference No. TB7206007-I, dated 3 September 2008), and this report together with the detail design and recommendations.

2.0 SITE DESCRIPTION

The site for the foundation investigation is on Highway 11, approximately 10.6 km east of Highway 64, in Olive Township. The area under investigation on Hwy 11 is located west of the highway from MTO Stations 14+750 to 14+950. Highway 11, at this location, is a two lane road with gravel shoulders with both post and wire, and steel guiderails.

The general site limits are shown on Figure 1 – Site Location Plan and Figure 2 – Borehole Location Plan.

The area under investigation included the edge of the roadway, shoulder, the embankment and an area below the embankment adjacent to Pan Lake. At the time the fieldwork was conducted, the embankment slope comprised grass and rock fill / bedrock, and was snow-covered. There was also approximately 0.6 m thick ice covering the lake. Typical photographs can be found in Appendix C.

According to the Terms of Reference, the existing guiderail will be replaced and the shoulders will be regraded by adding 150 mm to 300 mm lift of Granular A during 2008/2009. Furthermore, future embankment widening by shifting the horizontal alignment by about 2.5 m away from the lake and raising the existing grade by about 2 m has been considered by MTO, of which the design depends on the results of this investigation.

3.0 GEOLOGY

A previous geotechnical investigation carried out approximately 250 m north of the project site indicates that the surficial soils comprise glacial sand and gravel till from the area known as Northern Upland. It also indicates the depth to bedrock to be in the order of 0.8 m to 6.1 m, with some areas of bedrock on the surface. The bedrock comprises Precambrian granite, syenite and gneiss.

4.0 INVESTIGATION PROCEDURES

4.1 Field Investigation

In accordance with the Terms of Reference for this investigation, twelve (12) borehole locations (BH 1 to BH 12) were staked and cleared of underground utilities.

These twelve boreholes were put down at the locations indicated by the MTO on the TOR. Numerous additional boreholes (using labels BH #A-E) were completed, extending to depths of between 0.6 m and 12.9 m below ground surface. These boreholes were put down in order to confirm bedrock in locations where the original boreholes had encountered shallow refusal on

possible rock fill / bedrock. Each of the boreholes encountered split spoon, cone penetration or auger refusal.

The boreholes were drilled at the locations indicated in Table 1 of the TOR, as shown below:

TABLE 1 – Field and Laboratory Testing Requirements (TOR)								
Borehole	Location & Approximate Offset	Depth (m)	SPT	FVT *	LS-701	LS-702	LS-703 *	LS-704 *
BH-1	14+750, 4m lt.	6.0	8	0	2	2		
BH-2	14+750, 12m lt.	12.0	12	2	4	4	1	1
BH-3	14+800, 4m lt.	6.0	8	0	2	2		
BH-4	14+800, 12m lt.	12.0	12	2	4	4	1	1
BH-5	14+850, 4m lt.	6.0	8	1	2	2		
BH-6	14+850, 12m lt.	12.0	12	2	4	4	2	2
BH-7	14+850, 20m lt.	12.0	12	2	4	4	2	2
BH-8	14+900, 4m lt.	6.0	8	1	2	2		
BH-9	14+900, 12m lt.	12.0	12	2	4	4	2	2
BH-10	14+900, 20m lt.	12.0	12	2	4	4	2	2
BH-11	14+950, 4m lt.	6.0	8	0	2	2		
BH-12	14+950, 12m lt.	12.0	12	2	4	4	1	1
Totals	12	114	124	16	38	38	11	11

The fieldwork was performed on March 28th, 31st and April 2nd, 2008. Prior to drilling, utility locates were carried out. The holes were drilled by Walker Drilling Ltd, using a tripod and a truck-mount drilling rig.

The borehole locations are presented on Figure 2 – Borehole Location Plan and detailed in Table 1A.

The borehole investigation was carried out under the full-time supervision of experienced geotechnical personnel from AMEC.

Soil samples were taken at 0.75 m intervals during the performance of Standard Penetration Test (SPT) in accordance with ASTM D1586. This consisted of freely dropping a 63.5 kg (140 lbs.) hammer for a vertical distance of 0.76 m (30 inches) to drive a 51 mm (2 inches) diameter O.D. split-barrel (split spoon) sampler into the ground. The number of blows of the hammer required to drive the sampler into the relatively undisturbed ground by a vertical distance of 0.30 m (12 inches) was recorded as SPT 'N' value of the soil which indicated the consistency of cohesive soils or the relative density of non-cohesive soils.

The dynamic cone penetration test (DCPT) was carried out by advancing a steel cone into the ground with a 63.5 kg (140 lbs.) hammer. The number of blows per 0.3 m required to advance the cone was recorded and presented in the Record of Boreholes (Appendix A).

Table 1A: Drilled Borehole Locations and Depths

Borehole No.	Location	Drilled Depth (m)	Depth Required by TOR* (m)	Notes*
1	Stn(14+750), 4.0m Lt of CL	1.25	6.0	
1A	Stn(14+725), 4.7m Lt of CL	1.45		
1B	Stn(14+715), 4.5m Lt of CL	1.40		
1C	Stn(14+700), 4.65m Lt of CL	1.43		
2	Stn(14+750), 12.0m Lt of CL	0.00	12.0	Visible rock fill / bedrock at surface
2A	Stn(14+750), 17.0m Lt of CL	12.90		
3	Stn(14+800), 4.0m Lt of CL	0.90	6.0	
3A	Stn(14+790), 4.0m Lt of CL	0.92		
3B	Stn(14+780), 4.0m Lt of CL	1.20		
3C	Stn(14+776), 4.0m Lt of CL	1.25		
3D	Stn(14+760), 4.0m Lt of CL	1.20		
4	Stn(14+800), 12.0m Lt of CL	0.00	12.0	Visible rock fill / bedrock at surface
4A	Stn(14+800), 14.0m Lt of CL	1.52		
4B	Stn(14+800), 18.0m Lt of CL	10.90		
5	Stn(14+850), 4.2m Lt of CL	1.10	6.0	
5A	Stn(14+840), 4.2m Lt of CL	0.91		
5B	Stn(14+830), 4.2m Lt of CL	0.76		
5C	Stn(14+820), 4.2m Lt of CL	0.66		
5D	Stn(14+810), 4.2m Lt of CL	0.60		
5E	Stn(14+805), 4.2m Lt of CL	1.10		
6	Stn(14+850), 12.0m Lt of CL	1.52	12.0	
6A	Stn(14+850), 13.0m Lt of CL	2.44		
6B	Stn(14+850), 15.0m Lt of CL	8.40		
7	Stn(14+850), 20.0m Lt of CL	8.10	12.0	
8	Stn(14+900), 4.2m Lt of CL	1.40	6.0	
8A	Stn(14+890), 4.2m Lt of CL	1.45		
8B	Stn(14+880), 4.2m Lt of CL	1.07		
8C	Stn(14+870), 4.2m Lt of CL	1.06		
8D	Stn(14+860), 4.2m Lt of CL	1.25		
8E	Stn(14+856), 4.2m Lt of CL	1.07		
9	Stn(14+900), 12.0m Lt of CL	1.52	12.0	
9A	Stn(14+900), 13.0m Lt of CL	10.00		
10	Stn(14+900), 20.0m Lt of CL	10.90	12.0	

Borehole No.	Location	Drilled Depth (m)	Depth Required by TOR* (m)	Notes*
11	Stn(14+950), 4.2m Lt of CL	1.10	6.0	
11A	Stn(14+947), 4.2m Lt of CL	1.07		
11B	Stn(14+944), 4.2m Lt of CL	1.16		
11C	Stn(14+940), 4.2m Lt of CL	1.20		
11D	Stn(14+930), 4.2m Lt of CL	1.25		
11E	Stn(14+920), 4.2m Lt of CL	1.20		
11F	Stn(14+910), 4.2m Lt of CL	1.20		
11G	Stn(14+905), 4.2m Lt of CL	1.28		
12	Stn(14+950), 12.0m Lt of CL	10.4	12.0	

* Rock coring was not required by the TOR.

Four boreholes (BH 2A, 4B, 7, 10) encountered firm to very soft clay soils through which MTO Field Vane Testing was carried out.

In Boreholes 1A, 3A-D, 4A, 6 and 6A, auger samples were taken from the boreholes to depths of between 0.9 m and 2.4 m below existing site grade. The additional boreholes were put down in order to confirm the subsurface soils as well as the depth of auger refusal.

Soil samples were normally collected from each soil layer exposed in the boreholes for laboratory inspection and testing.

Upon completion of drilling, the boreholes that were deeper than 3 m were backfilled with bentonite in accordance with the general requirements of Ministry of the Environment Regulation 903 as indicated on the Records of Boreholes.

The soil samples were transported to AMEC's Soil Laboratory in Hamilton for further examination and laboratory soil testing. The program of laboratory testing included grain size analysis, Liquid and Plastic Limits, and moisture content determination.

The results of the in-situ and laboratory tests are presented in the corresponding Records of Boreholes (Appendix A) and Laboratory Test Results (Appendix B).

AMEC will retain the soil samples for a period of one year after completion of the Project, unless otherwise advised in writing by the Ministry.

4.2 Laboratory Tests

In accordance with the Terms of Reference for this investigation, representative soil samples were subjected to laboratory testing in AMEC's Soil Laboratory in Hamilton for soil classification.

The following tests were conducted:

- In-situ water content determination (38);
- Grain size distribution analysis (38); and
- Liquid and Plastic Limits (11).

The results of the laboratory tests are included in the Record of Boreholes in Appendix A. The grain size distribution curves and Liquid / Plastic Limits are shown in Appendix B.

5.0 SUB-SURFACE CONDITIONS

The general soil profile below road at the edge of the pavement and shoulder consisted of sand and gravel over sand to sand and silt. Refusal due to the presence of rock fill was encountered in this area from depths between 0.6 m and 1.5 m below ground surface. Coring through the rock fill was not required by the MTO.

Only two boreholes (Boreholes 2A and 12) were able to be put down at deep depth within the embankment area. This was due to the large amount of rock fill / bedrock in the area which was visible on the surface throughout the embankment. Borehole 2A encountered silt to silty clay underlain by silty sand to sandy silt. Borehole 12 encountered layers of peat and silty clay fill underlain by silty clay.

The general soil profile within the lake adjacent to the road embankment consisted of a layer of peat with thickness ranging from 1.9 m to 3.9 m, underlain by silty clay to clayey silt, which was further underlain by sand or silt.

The stratigraphic units and groundwater conditions at the borehole locations are discussed in the following sections. Detailed information is provided in the Record of Boreholes (Appendix A).

The following summary is to assist the designers of the project with an understanding of the anticipated soil conditions across the site. However, it should be noted that the soil and groundwater conditions may vary between the borehole locations.

5.1 Surficial Material

In Boreholes 1A, 5, 8, and 11, 300 mm to 600 mm thick sand and gravel was encountered. This material was in a frozen state in Boreholes 5, 8 and 11.

Boreholes 1, 3, 3A, 3B, 3C, 3D that were put down along the edge of pavement on Highway 11 encountered between 170 mm and 410 mm thick asphaltic concrete. The asphaltic concrete in Boreholes 1, 3C, and 3D was underlain by 15 mm to 50 mm thick sand and gravel, which was further underlain by 200 mm to 230 mm thick asphaltic concrete.

5.2 Peat/Organic Matters

A number of the boreholes (BH's 2A, 4B, 6, 6A, 6B, 7, 10, 12) put down within the embankment and lake areas encountered peat and/or organic matters to depths between 1.5 m and 4.6 m below ground surface. The deposits in Borehole 2A and 12 were encountered at ground surface and were about 300 mm thick. The deposits in the remaining boreholes were encountered within the lake, beneath ice and/or water. The peat comprised mainly woodchips and trace rootlets with some silt. The SPT 'N' values recorded in Boreholes 4B, 7, 10, indicated a very loose relative density with values of 1 to 2 blows per 0.3 m.

5.3 Silt Fill

Underlying the surficial peat (possibly organic fill material) in Borehole 12, silt fill was encountered to a depth of 3.6 m below ground surface. The silt fill comprised trace rootlets, wood chips, sand and gravel and some organic matters.

The SPT 'N' values varied from 5 to 10 blows per 0.3 m, indicating a very loose to loose relative density.

The results of laboratory tests conducted on selected soil samples are as follows:

Plastic Limit (1 sample):	24
Liquid Limit (1 sample):	27
Plasticity Index (1 sample):	3
Grain size (5 samples):	Gravel (%): 0
	Sand (%): 2 to 9
	Silt (%): 79 to 91
	Clay (%): 7 to 16

The plasticity indices are plotted in Enclosure 39B and the grain size distribution curves are presented in Enclosures 34B to 38B in Appendix B.

5.4 Sand and Gravel to Gravely Sand

Underlying the asphaltic concrete in Boreholes 1, 3, 3A, 3B, 3C, 3D, the ice in Borehole 4A, and the frozen sand and gravel in Borehole 5, sand and gravel to gravely sand was encountered to depths between 250 mm and the maximum depths investigated. The sand and gravel in Borehole 4A contained silt and cobbles.

The SPT 'N' values recorded in Boreholes 1, 3 and 11 ranged from 17 blows to 50 blows per 0.3 m (compact to very dense relative density).

The results of laboratory tests conducted on selected soil samples are as follows:

Natural moisture content (%):	14 to 16
Grain size (6 samples):	Gravel (%): 13 to 36
	Sand (%): 62 to 70
	Silt (%): 10 to 17
	Clay (%): 3 to 4

The grain size distribution curves are presented in Enclosures 1B, 2B, 17B, 18B, 24B and 32B in Appendix B.

5.5 Sand/Silty Sand to Sandy Silt/Silt

Underlying the sand and gravel in Boreholes 3A, 3B, 3C and 11, sand to silty sand was encountered to the maximum depths investigated.

Underlying the peat in Borehole 2A, silt was encountered at a depth of 0.3 m below ground surface. Underlying the silt to silty clay in Borehole 2A, silty sand to sandy silt was encountered at a depth of 4.5 m below ground surface. Underlying the silty clay to silt in Borehole 4B, and the sand and gravel in Borehole 8, sand to silty sand was encountered to the maximum depths investigated.

SPT 'N' values of between 1 and 24 blows per 0.3 m were recorded indicating a very loose to compact consistency. In Boreholes 2A, 4B and 8, refusal to split spoon sampling occurred which was likely due to the presence of cobbles.

The results of laboratory tests conducted on selected soil samples are as follows:

Natural moisture content (%):	18 to 19
Grain size (10 samples):	Gravel (%): 0 to 19
	Sand (%): 4 to 80
	Silt (%): 14 to 93
	Clay (%): 3 to 7

The grain size distribution curves are presented in Enclosures 3B, 7B to 10B, 14B to 16B, 25B and 33B in Appendix B.

5.6 Silt to Silty Clay to Clayey Silt

Underlying the peat in Boreholes 4B, 7, and 10, and the silt in Borehole 2A, silty clay to clayey silt was encountered to depths between 0.6 m and the maximum depths investigated.

The SPT 'N' values ranged from 1 to 32 blows per 0.3 m indicating a very soft to hard consistency. Five MTO field vanes resulted in shear strengths of between 14.4 kPa and 33.5 kPa (soft to firm consistency).

The results of laboratory tests conducted on selected soil samples are as follows:

Natural moisture content (%): 19 to 30
 Plastic Limit (4 samples): 16 to 28
 Liquid Limit (4 samples): 17 to 29

Grain size (17 samples):

Gravel (%):	0 to 36
Sand (%):	1 to 38
Silt (%):	56 to 90
Clay (%):	6 to 26

The plasticity indices are plotted in Enclosure 39B and the grain size distribution curves are presented in Enclosures 4B to 6B, 11B to 13B, 19B to 23B and 26B to 31B in Appendix B.

5.7 Groundwater

The groundwater levels were observed in seven of the boreholes and measured upon completion of drilling. In each of the remaining boreholes, no groundwater level was observed upon completion. The measured groundwater levels are shown in the Record of Boreholes (Appendix A).

Groundwater levels were encountered as follows:

Borehole No.	Groundwater Depth below Existing Ground Surface, m	Groundwater Elevation, m	Notes
2A	1.1	292.7	caved at 3.2m
4B	0	289.9	caved at 4.7m
6B	0	289.8	caved to surface
7	0	289.9	caved at 0.9m
9A	0	289.9	caved to surface
10	0	289.9	caved at 4.5m
12	1.4	289.0	caved at 2.3m

It should be noted that the groundwater at the site would fluctuate seasonally and can be expected to be somewhat higher during the spring months and in response to major weather events / water levels in the lake.

6.0 DISCUSSION AND RECOMMENDATIONS

According to the information provided by MTO, the road embankment between Station 14+750 to Station 14+950 of Highway 11 at Pan Lake has experienced historical slope movement / instability and settlement. Some of the existing guiderails are currently tilting outward toward the lake. The existing guiderails are planned to be replaced and the existing shoulders would be reinstated by adding 150 mm to 300 mm thick Granular A during 2008/2009. In addition, future widening of the road embankment has been considered by shifting the horizontal alignment approximately 2.5 m from the lake and raising the existing grade by about 2 m.

Based on the results of this investigation, the existing road embankment consists of fill soils and rock fill underlain by possible bedrock. The construction of the existing road embankment is not known, although the road embankment was likely constructed by replacing the peat and soft soils under the lake water by rock fill. In the process, some peat and/or soft soils could remain underneath the rock fill which could eventually lead to embankment movements in the form of lateral movement and vertical settlement. The tilting of the guiderails indicates the lateral movement of the road embankment and the settlement of the shoulder indicates the vertical and lateral movement of the road embankment.

Due to the presence of rock fill / bedrock, boreholes drilled within the road embankment could not penetrate the rock fill / bedrock to determine the thickness of the rock fill and the soil conditions underlying the rock fill. Rock coring was not required in the Terms of Reference. The soil profiles of the road embankment and the underlying soils can not be completely established. In addition, the topographical contours of the lake bed adjacent to the road embankment are not known. The causes of the road embankment movements can not therefore be clearly identified. Nevertheless, the results of this investigation provide a possible soil profile that could explain the cause(s) of embankment movements.

Using the possible soil profile underneath the existing road embankment, slope stability analyses were carried out to determine the possible cause(s) of embankment movements. Recommendations for remedial works are subsequently provided as described in the following sections.

6.1 Slope Stability Analyses

The stability of the existing road embankment, the future widening of the existing road embankment and remedial works was analyzed using a computer program SLOPE/W with

circular slip surfaces. The soil profiles were based on the results of the borehole investigation and reasonable assumptions. In general, the existing road embankment considered in the slope stability analyses consisted mainly of rock fill underlain by a thin layer of soft clay overlying very stiff clay, loose sand and bedrock. Two modes of road embankment movement were considered, i.e., slope movement within the rock fill itself and slope movement through an assumed soft soil layer underlying the rock fill.

The minimum factor of safety against slope instability within the rock fill was determined by searching for the critical slip surface within the rock fill in order to determine whether or not the road embankment movement could be caused by the rock fill itself. It should be noted that according to the topographic profile available, the rock fill slope appeared to be steeper than 1.5H:1V such that movement within the rock fill could be possible.

In addition, the minimum factor of safety against slope instability of the rock fill due to the assumed soft clay underlying the rock fill was determined by searching for the critical slip surface through the soft clay layer. This was to determine whether or not the road embankment movement could be caused by the presence of a soft layer underlying the rock fill which could not be verified by the boreholes.

The results of the slope stability analyses are summarized in Table 2 and the figures showing the critical slip surfaces with the soil parameters used are presented in Appendix D.

Table 2 – Results of Slope Stability Analyses for Road Embankment Slope

Figure No.	Conditions of Road Embankment	Considerations for Analysis	Minimum Calculated Factor of Safety (FOS)	Remarks
Station 14 +800				
D1.1	Existing slope (~1V:1.2H)	Slip surface within rock fill	1.02	Slip surface within rock fill is possible.
D1.2	Existing slope (~1V:1.2H)	Deep seated slip surface with assumed weak layer	1.02	Deep seated slip surface is possible.
D1.3	Existing slope (~1V:1.2H)	Deep seated slip surface without assumed weak layer	1.29	Assumed weak layer in D1.2 is possible.
D2.1	Existing slope (~1V:1.2H)	Slip surface within rock fill with assumed weak layer and additional rock fill (1V:1.5H)	1.06	Slightly increase FOS in D1.1.
D2.2	Existing slope (~1V:1.2H)	Deep seated slip surface with assumed weak layer and additional rock fill (1V:1.5H)	1.13	Increase FOS in D1.2.
D2.3	Existing slope (~1V:1.2H)	Slip surface within rock fill with assumed weak layer and additional rock fill (1V:2H)	1.25	Increase FOS in D1.1 and D2.1.

Figure No.	Conditions of Road Embankment	Considerations for Analysis	Minimum Calculated Factor of Safety (FOS)	Remarks
D2.4	Existing slope (~1V:1.2H)	Deep seated slip surface with assumed weak layer and additional rock fill (1V:2H)	1.22	Increase FOS in D1.2 and D2.2.
D3.1	2m grade raise and 2.5m horizontal alignment shift	Slip surface within rock fill with assumed weak layer and additional rock fill (1V:1.5H)	1.02	Slip surface within rock fill is possible.
D3.2	2m grade raise and 2.5m horizontal alignment shift	Deep seated slip surface with assumed weak layer and additional rock fill (1V:1.5H)	1.05	Deep seated slip surface is possible.
D3.3	2m grade raise and 2.5m horizontal alignment shift	Slip surface within rock fill with assumed weak layer and additional rock fill (1V:2H)	1.28	Increase FOS in D3.1.
D3.4	2m grade raise and 2.5m horizontal alignment shift	Deep seated slip surface with assumed weak layer and additional rock fill (1V:2H)	1.15	Increase FOS in D3.2.
Station 14 +850				
D4.1	Existing slope (~1V:1.2H)	Slip surface within rock fill	1.02	Slip surface within rock fill is possible.
D4.2	Existing slope (~1V:1.2H)	Deep seated slip surface with assumed weak layer	1.18	Deep seated slip surface may be possible.
D4.3	Existing slope (~1V:1.2H)	Deep seated slip surface without assumed weak layer	1.34	Assumed weak layer in D4.2 is possible.
D5.1	Existing slope (~1V:1.2H)	Slip surface within rock fill with assumed weak layer and additional rock fill (1V:1.5H)	1.02	Shallow slip surface within rock fill is possible.
D5.2	Existing slope (~1V:1.2H)	Deep seated slip surface with assumed weak layer and additional rock fill (1V:1.5H)	1.28	Increase FOS in D4.2.
D5.3	Existing slope (~1V:1.2H)	Slip surface within rock fill with assumed weak layer and additional rock fill (1V:2H)	1.32	Increase FOS in D4.1 and D5.1.
D5.4	Existing slope (~1V:1.2H)	Deep seated slip surface with assumed weak layer and additional rock fill (1V:2H)	1.39	Increase FOS in D4.2 and D5.2.
D6.1	2m grade raise and 2.5m horizontal alignment shift	Slip surface within rock fill with assumed weak layer and additional rock fill (1V:1.5H)	1.00	Slip surface within rockfill is possible

Figure No.	Conditions of Road Embankment	Considerations for Analysis	Minimum Calculated Factor of Safety (FOS)	Remarks
D6.2	2m grade raise and 2.5m horizontal alignment shift	Deep seated slip surface with assumed weak layer and additional rock fill (1V:1.5H)	1.17	Deep seated slip surface may be possible.
D6.3	2m grade raise and 2.5m horizontal alignment shift	Slip surface within rock fill with assumed weak layer and additional rock fill (1V:2H)	1.28	Increase FOS in D6.1.
D6.4	2m grade raise and 2.5m horizontal alignment shift	Deep seated slip surface with assumed weak layer and additional rock fill (1V:2H)	1.27	Increase FOS in D6.2.
Station 14 +900				
D7.1	Existing slope (~1V:1.2H)	Slip surface within rock fill	1.24	Likely stable.
D7.2	Existing slope (~1V:1.2H)	Deep seated slip surface with assumed weak layer	1.39	Likely stable.
D7.3	Existing slope (~1V:1.2H)	Deep seated slip surface without assumed weak layer	1.70	Likely stable.
D8.1	Existing slope (~1V:1.2H)	Slip surface within rock fill with assumed weak layer and additional rock fill (1V:1.5H)	1.32	Likely stable.
D8.2	Existing slope (~1V:1.2H)	Deep seated slip surface with assumed weak layer and additional rock fill (1V:1.5H)	1.44	Likely stable.
D8.3	Existing slope (~1V:1.2H)	Slip surface within rock fill with assumed weak layer and additional rock fill (1V:2H)	1.47	Increase FOS in D7.2 and D8.2
D8.4	Existing slope (~1V:1.2H)	Deep seated slip surface with assumed weak layer and additional rock fill (1V:2H)	1.51	Increase FOS in D7.2 and D8.2.
D9.1	2m grade raise and 2.5m horizontal alignment shift	Slip surface within rock fill with assumed weak layer and additional rock fill (1V:1.5H)	1.12	Shallow slip surface within rock fill is possible.
D9.2	2m grade raise and 2.5m horizontal alignment shift	Deep seated slip surface with assumed weak layer and additional rock fill (1V:1.5H)	1.24	Likely stable.
D9.3	2m grade raise and 2.5m horizontal alignment shift	Slip surface within rock fill with assumed weak layer and additional rock fill (1V:2H)	1.37	Increase FOS in D9.1.

Figure No.	Conditions of Road Embankment	Considerations for Analysis	Minimum Calculated Factor of Safety (FOS)	Remarks
D9.4	2m grade raise and 2.5m horizontal alignment shift	Deep seated slip surface with assumed weak layer and additional rock fill (1V:2H)	1.30	Increase FOS in D9.4.

Based on the results of the slope stability analyses presented in Table 2, the following conclusions can be made:

- The cause(s) of the movement of the existing road embankment could be due to the relatively steep slope of the rock fill (steeper than 1.5H:1V above the lake water level) and/or the possible presence of a weak soil/peat layer underlying the rock fill as a result of placing the rock fill without completely removing the peat and soft soil.
- For the 2008/2009 work for replacing the guiderails and regrading the shoulders, additional rock fill should be placed on the existing road embankment slope adjacent to the lake such that the new road fill slope is 1.5H:1V or flatter to 2H:1V from the toe of the embankment slope in the lake to the top of the shoulder. The additional rock fill should be carried out prior to replacing the guiderails and regrading the shoulders.
- For the future work where the existing road alignment will be moved horizontally about 2.5 m away from the lake and the existing grade will be raised by about 2 m, the current road embankment slope should be constructed with rock fill to a 2H:1V slope prior to raising the current road grade.
- Considering the 2008/2009 work and the future work, the existing road embankment slope adjacent to the lake should be flattened by adding rock fill to form a 2H:1V slope from the toe of the embankment in the lake to the top of the current shoulder in 2008/2009. This will improve the road embankment stability and allow for slight slope movement due to the additional rock fill prior to raising the existing grade by up to 2 m.

6.2 General Construction Comments

Due to the close proximity of the lake to the existing road embankment, the existing slope should be flattened by placing additional rock fill onto the slope surface, both in and above the lake water. The rock fill should be placed according to OPSD 202.010.

If practical, all organic matters and other unsuitable soils along the toe of the existing road embankment in the lake should be removed, as per Ministry of Transportation of Ontario's current practice, with an envelope given by a gradient not steeper than 1H:1V away from the toe

of the embankment. Care should be exercised to prevent undermining and minimize disturbance to the existing road embankment during the construction of the new embankment. For under water construction, all organic matters and /or soft / loose soils should be removed and backfilled with rock fill, at least until the backfill level is above the water level. Otherwise, a coffer dam and dewatering are required for placing an engineered fill in the lake. If engineered fill is used, particularly above the lake water, the exposed surface should be protected for erosion by rip-rap or equivalent.

For an engineered fill (if used), the fill soils used for construction of the conventional earth fill embankment, or for the purposes of backfilling, should consist of approved, clean earth fill (e.g. Select Subgrade Materials – Ontario Provincial Standards Specifications Number: 1010). The fill may be imported for this purpose or the excavated soils (if any) may be reused provided that they do not contain organic matters and can be compacted to the specifications. The fill soils should be placed in accordance with Ontario Provincial Standards Specifications Number: 501. Each lift should not exceed 300 mm before compaction and each lift should be uniformly compacted to at least 95 % of the Standard Proctor Maximum Dry Density (SPMDD) of the materials. The degree of compaction within the top 0.6 m of the fill (i.e., the subgrade immediately beneath the granular sub-base) should be increased to 98 % SPMDD. The selection, placement and compaction of the fill should be carried out under a geotechnical control program.

For the fill embankment at this site, using properly compacted and acceptable inorganic fill soils, the side slopes should not be steeper than 2H:1V for earth fill embankment. Proper erosion control measures should be implemented both during construction and on a permanent basis. This can be achieved by immediate seeding or sodding (Ontario Provincial Standards Specification Number: 572) or equivalent.

No major construction difficulties in placing rock fill are foreseen but allowance should be made for possible substantial quantity of rock fill under water which could be required due to extensive peat and/or soft soils.

Additional investigation of the soil conditions in the lake along the toe of the existing road embankment may be required to provide a detail estimate of the rock fill quantity.

Small settlement of the newly-placed rock fill and road shoulder may occur after construction. If necessary, the newly-placed rock fill should be monitored for settlement prior to installing new permanent guiderails and regrading the shoulders.

6.3 Construction Staging and Detour

To place additional rock fill onto the existing road embankment slope, replace the guiderails and regrading the shoulders, the lane adjacent to the lake may have to be temporarily closed during construction. Traffic could be allowed through the remaining lane.

6.4 Construction Inspection

It is recommended that a quality control programme of inspection and testing be carried out during the construction phase of the project to confirm that the conditions encountered are consistent with design assumptions; and to confirm that the various project specifications and material requirements and handling are followed.

6.5 Non Standard Special Provisions

Non Standard Special Provision should be included in the contract documents regarding the placement of rock fill under the lake water. The following clause is suggested to alert prospective Contractors to specific conditions.

- **Based on the available site and soil conditions, the soil conditions in the lake along the existing road embankment toe have not been completely determined. There could be some peat and/or soft soils along the toe of the existing road embankment that may require a large quantity of rock fill. The Contractor should therefore carry out additional investigation, prior to tendering, to obtain sufficient information for accurate estimation of the rock fill required.**

7.0 CLOSURE

The sub-soil information and recommendations contained in this report should be used solely for the purpose of foundation/slope stability assessment of this site.

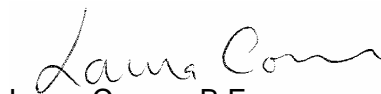
AMEC should be retained to review the recommendations provided in this report, once the details of the project are finalized and prior to the final design stage of the project.


The Limitations of Report, as quoted on the following page, is an integral part of this report.

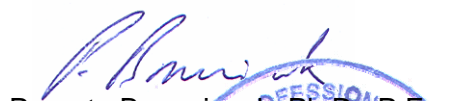
The information presented in this report is complete within the Terms of Reference. If there are any further questions concerning this report, please do not hesitate to contact the undersigned.

Sincerely,

AMEC Earth & Environmental,
A division of AMEC Americas Limited


Laura Cowan, B.Eng.
Geotechnical EIT


Siva Nadarajah, M.Eng.
Engineering Analyst


Prapote Boonsinsuk, Ph.D., P.Eng.
Geotechnical Engineer




George Chow, P.Eng.
Designated Principal Contact



LIMITATIONS OF REPORT

The conclusions and recommendations given in this report are based on information determined at the testhole locations. The information contained herein in no way reflects on the environmental aspects of the project, unless otherwise stated. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the testhole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation. It is recommended practice that the Geotechnical Engineer be retained during the construction to confirm that the subsurface conditions across the site do not deviate materially from those encountered in the testholes.

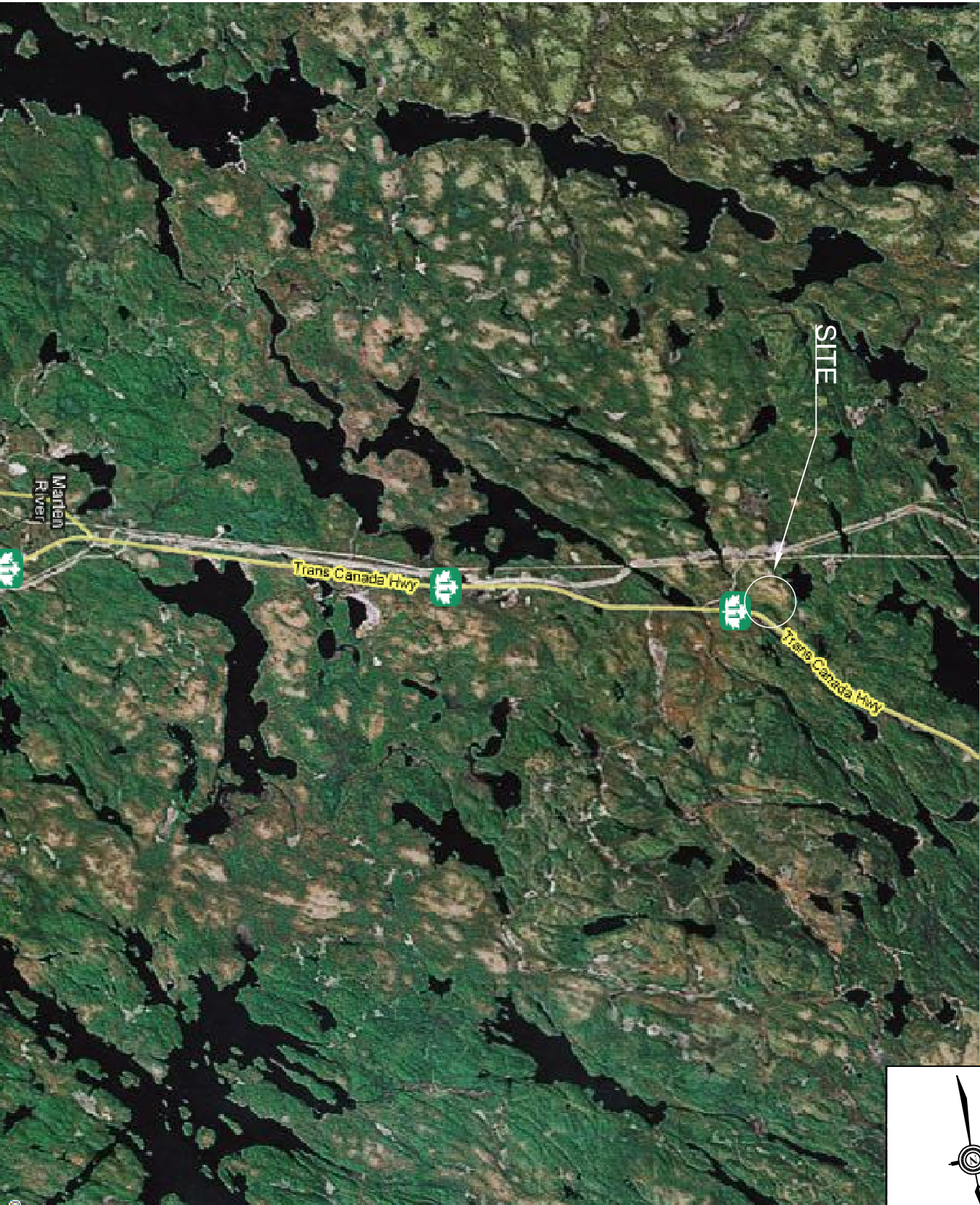
The design recommendations given in this report are applicable only to the project described in the text, and then only if constructed substantially in accordance with the details stated in this report. Since all details of the design may not be known, we recommend that we be retained during the final design stage to verify that the design is consistent with our recommendations, and that assumptions made in our analysis are valid.



The comments made in this report relating to potential construction problems and possible methods of construction are intended only for the guidance of the designer. The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work. This work has been undertaken in accordance with normally accepted geotechnical engineering practices. No other warranty is expressed or implied.

The benchmark and elevations mentioned in this report were obtained strictly for use by this office in the geotechnical design of the project. They should not be used by any other party for any other purpose.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. AMEC Earth & Environmental accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

DRAWINGS



- LEGEND
-  BOREHOLE
 -  METAL GUIDE RAIL



TITLE:

SITE LOCATION PLAN

PROJECT:

FOUNDATION INVESTIGATION &
DESIGN
HWY 11 AT PAN LAKE,
OLIVE TWP, ONTARIO

CLIENT:

Ministry of Transportation
North East Region, Engineering Office
Geotechnical Section
447 McKeown Avenue, Suite 301
North Bay, Ontario P1B 9S9

DRAWN BY:

LC

CHECKED BY:

HS

DATE:

APRIL 2008

PROJECT NO:

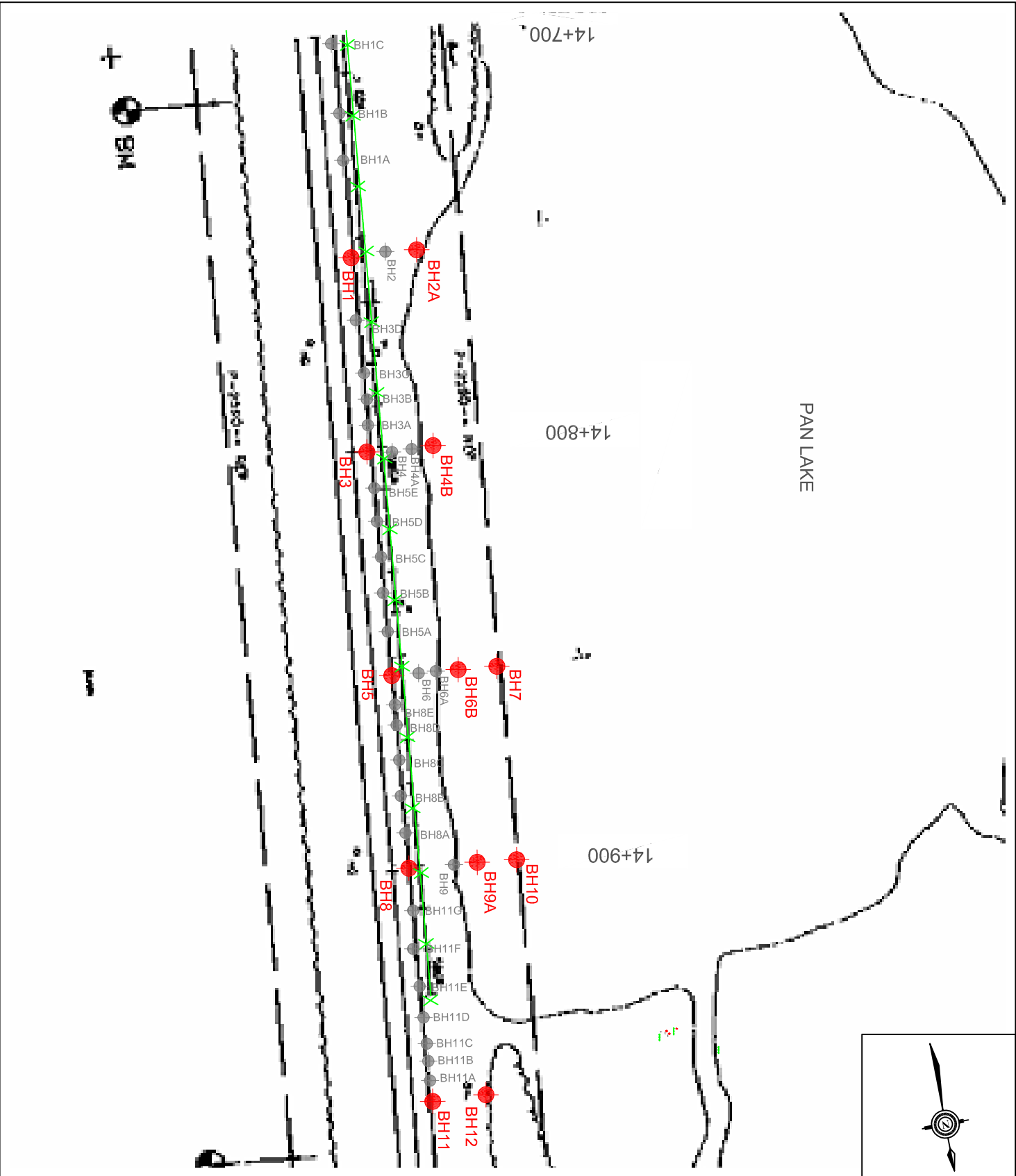
TB7206007

SCALE:

As Indicated

FIGURE NO:

1



LEGEND

 BOREHOLE (with SPT values)

 BOREHOLE

 METAL GUIDE RAIL

Note:

Figure based on Drawing WP No. 713-92-00
provided to AMEC by the MTO.

Borehole locations are approximate.



TITLE:

BOREHOLE LOCATION PLAN

PROJECT:

FOUNDATION INVESTIGATION &
DESIGN

HWY 11 AT PAN LAKE,
OLIVE TWP, ONTARIO

CLIENT:

Ministry of Transportation

North East Region, Engineering Office

Geotechnical Section

447 McKeown Avenue, Suite 301

North Bay, Ontario P1B 9S9

DRAWN BY: LC

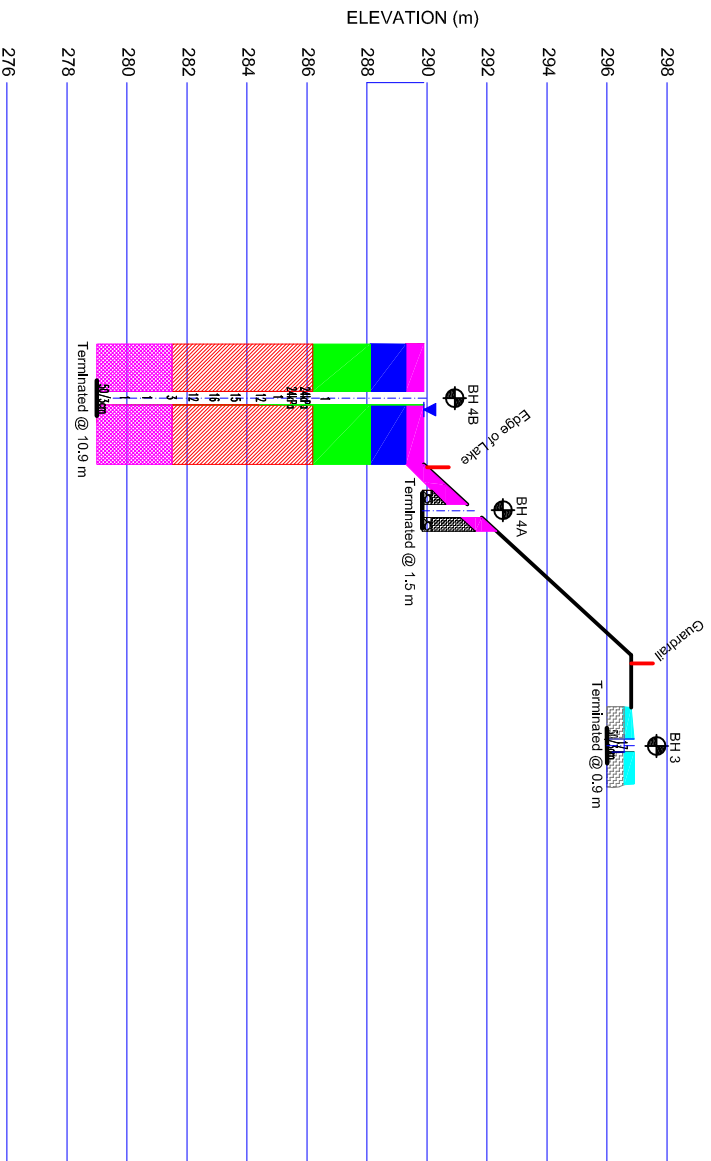
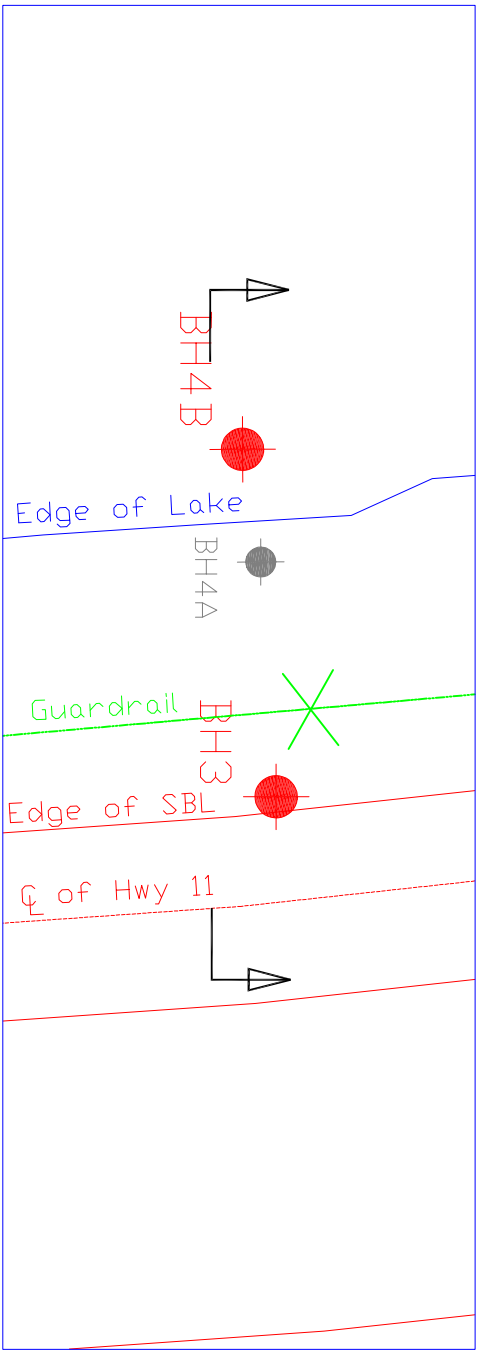
CHECKED BY: HS

DATE: APRIL 2008

PROJECT NO: TB7206007

SCALE: n.t.s

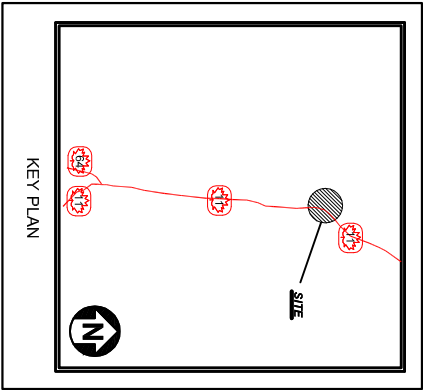
FIGURE NO:



PROFILE

AGREEMENT No.	5006-E-0070
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN	

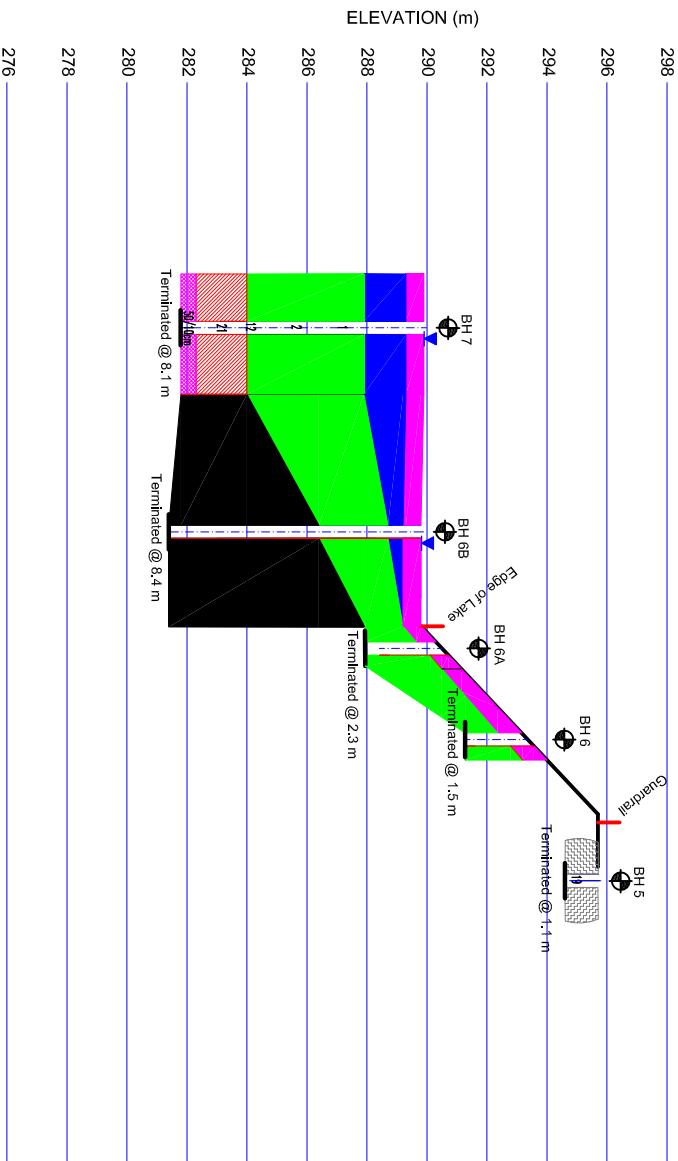
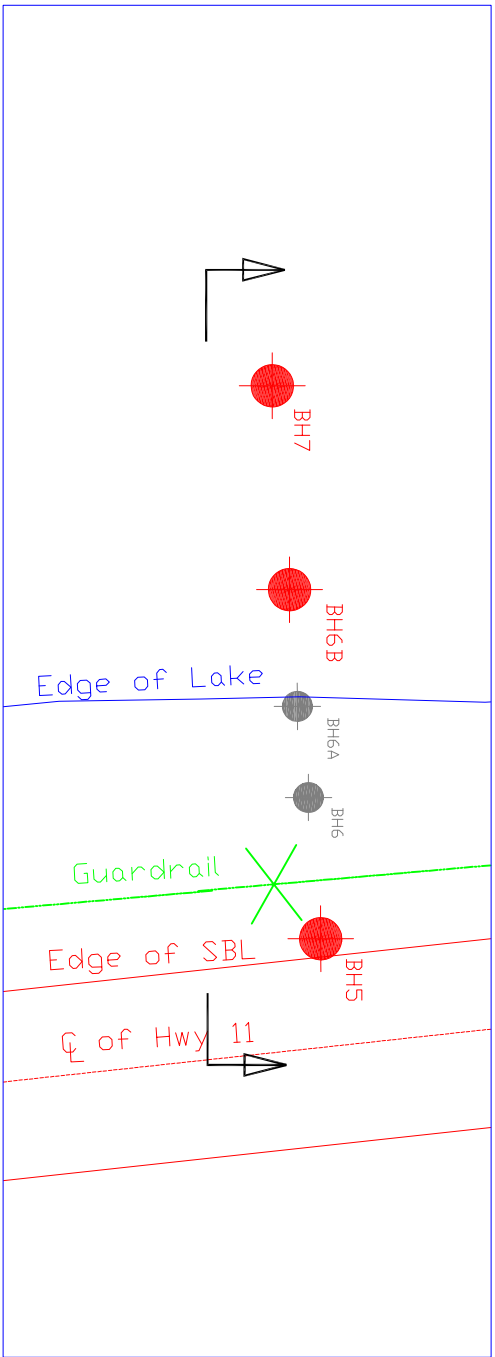
CONSTRUCTION INVESTIGATION HWY 11 AT PAUL LAKE 10.600 NORTH OF OLIVE TWP. ONTARIO ASSIGNMENT #7	Figure No. 3
Stratigraphical Cross Section BH3, BH4A, BH4B	
amec AMEC Earth & Environmental a Division of AMEC Americas Limited	



LEGEND			
BOREHOLE LOCATION		WATER LEVEL	
BOREHOLE	UTM COORDINATES (NAD83)	ELEVATION (m)	
	NORTHING	EASTING	

NOTES:
1. The boundaries between soil strata have been established only at borehole locations. Between boreholes, the boundaries are assumed from geological evidence and may be subject to considerable error.

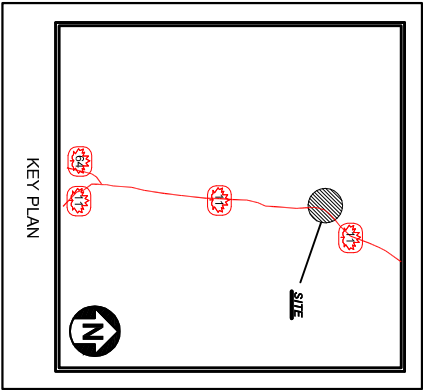
SOIL STRATIGRAPHY	
Ice	Asphalt
Water	Silt, Sand & Gravel
Pearl / Organics	Cobbles and Boulders
Silty Clay	No Data Available
Silt / Silty Sand	Borehole Terminated



PROFILE

METRIC		AGREEMENT No.	
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN		5006-E-0070	

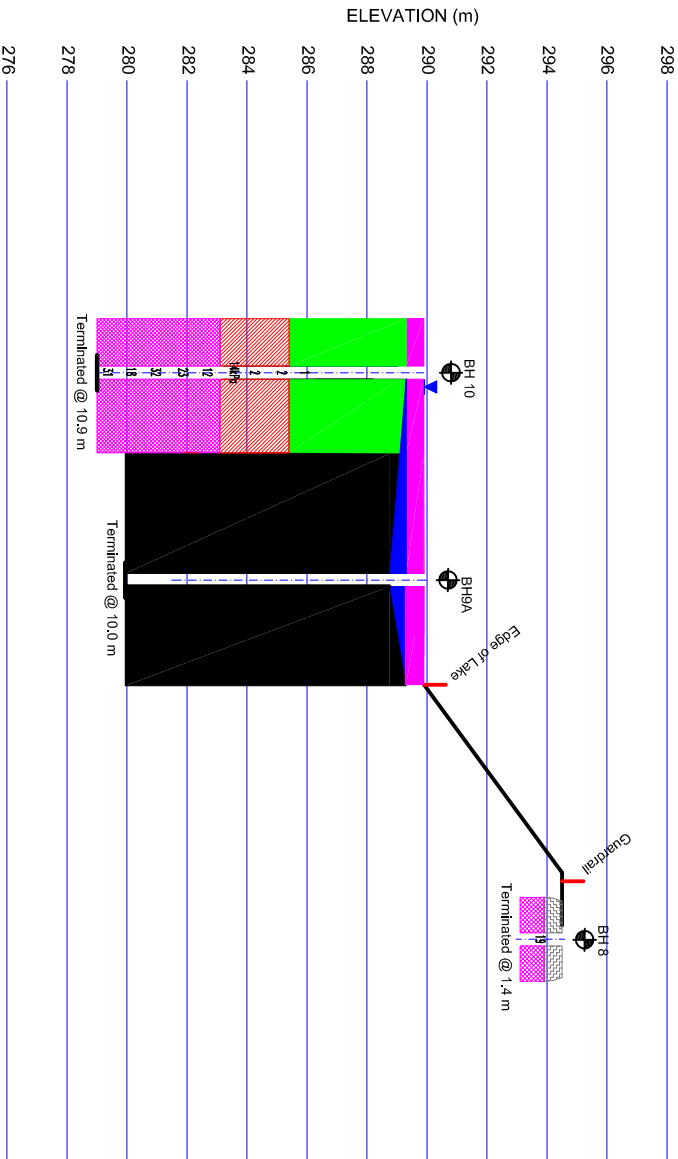
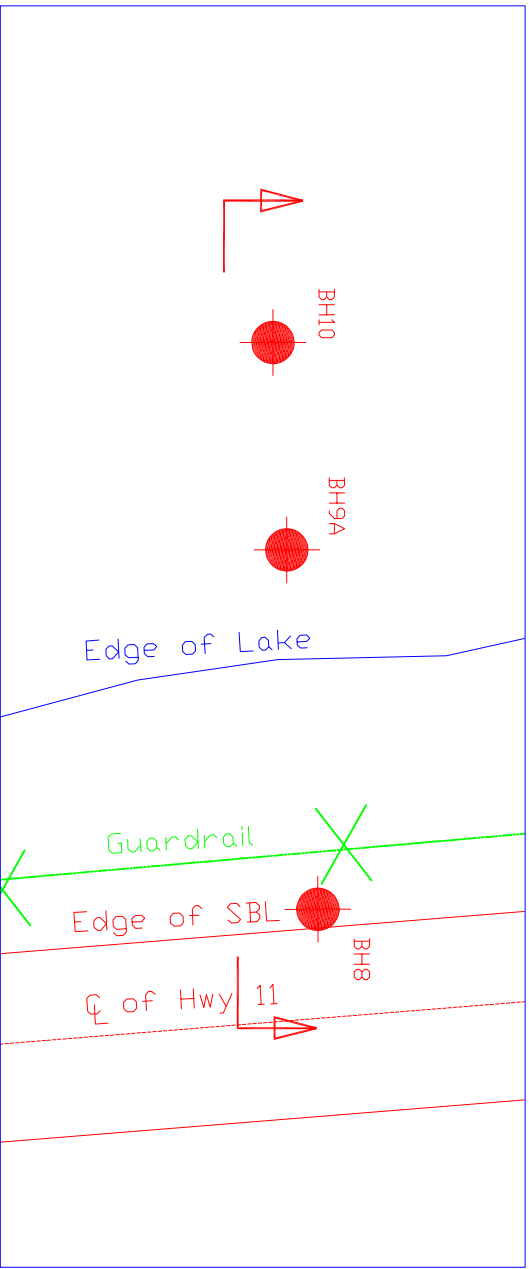
CONTOUR INVESTIGATION HWY 11 AT PAUL LAKE 10.600 NORTH OF OLIVE TWP. ONTARIO ASSIGNMENT #7		TB7206007 Figure No. 4	
Drp. Title Stratigraphical Cross Section BH 6, BH 6A, BH 6B, BH 7			
amec			



LEGEND			
BOREHOLE LOCATION		ULM COORDINATES (NAD83)	
BOREHOLE		EASTING	
NORTHING		ELEVATION (m)	

NOTES:
1. The boundaries between soil strata have been established only at borehole locations. Between boreholes, the boundaries are assumed from geological evidence and may be subject to considerable error.

SOIL STRATIGRAPHY			
Ice		Asphalt	
Water		Silt, Sand & Gravel	
Peat / Organics		Cobbles and Boulders	
Silty Clay		No Data Available	
Silt / Silty Sand		Borehole Terminated	



PROFILE

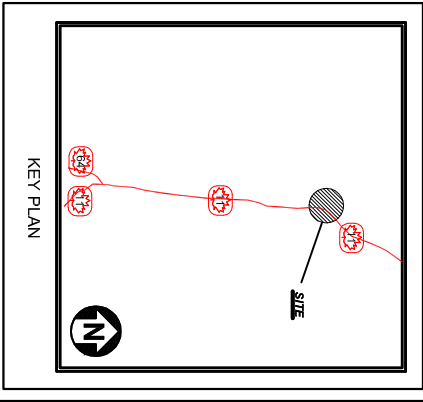
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

AGREEMENT No. **5006-E-0070**

CONSTRUCTION INVESTIGATION
HWY 11 AT PAUL LAKE 10.600 NORTH OF
OLIVE TWP. ONTARIO
ASSIGNMENT #7
Comp. Title
Stratigraphical Cross Section
BH 8, BH 9A, BH 10

Figure No. 5

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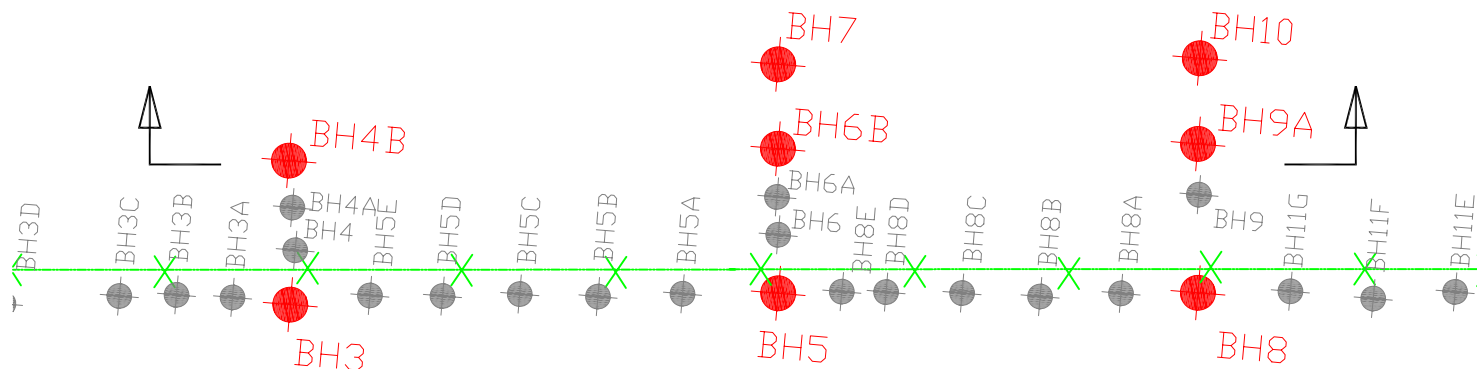
LEGEND			
BOREHOLE LOCATION		ELEVATION (m)	
BOREHOLE		ELEVATION	
NORTHING		EASTING	
UTM COORDINATES (NAD83)			

NOTES:
1. The boundaries between soil strata have been established only at borehole locations. Between boreholes, the boundaries are assumed from geological evidence and may be subject to considerable error.

SOIL STRATIGRAPHY			
	Ice		Asphalt
	Water		Silt, Sand & Gravel
	Peat / Organics		Cobbles and Boulders
	Silty Clay		No Data Available
	Silt / Silty Sand		Borehole Terminated

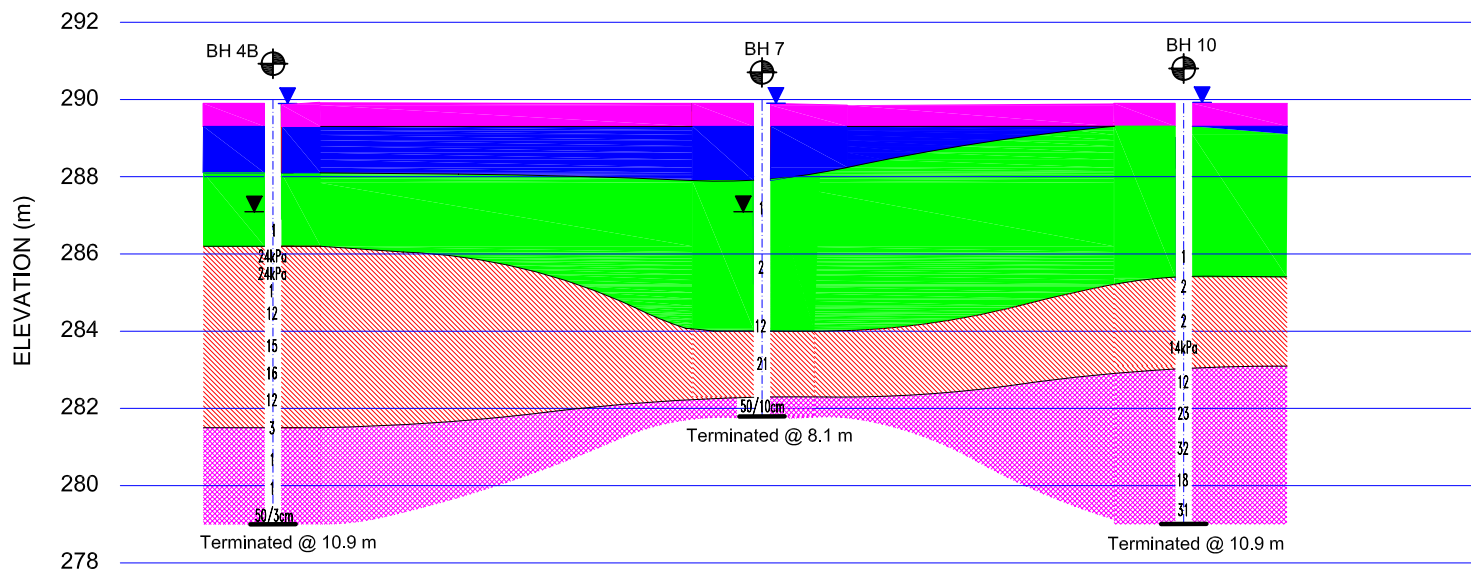
008+71

006+900



PLAN



Scale: 1 : 800

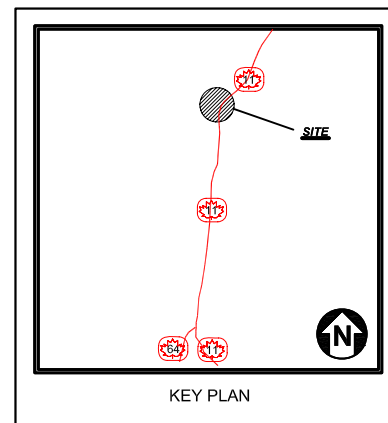




PROFILE

Scale: Horizontal 1 : 800
Vertical 1 : 200

METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

AGREEMENT No.	5006-E-0070	
FOUNDATION INVESTIGATION HWY 11 AT PAN LAKE, 10.8KM NORTH OF HWY 64 OLIVE TWP, ONTARIO ASSIGNMENT #7		
Dwg. Title	Stratigraphic Cross Section BH4B, BH7, BH10	TB7206007 Figure No. 6
 AMEC Earth & Environmental, a Division of AMEC Americas Limited		













LEGEND			
	BOREHOLE LOCATION		
	WATER LEVEL		
BOREHOLE	UTM COORDINATES		ELEVATION (m)
	NORTHING	EASTING	
-	-	-	-
-	-	-	-
-	-	-	-

NOTES:

1. The boundaries between soil strata have been established only at borehole locations. Between boreholes, the boundaries are assumed from geological evidence and may be subject to considerable error.

SOIL STRATIGRAPHY

	Ice		Asphalt
	Water		Silt, Sand & Gravel
	Peat / Organics		Cobbles and Boulders
	Silty Clay		No Data Available
	Silt / Silty Sand		Borehole Terminated


APPENDIX A

RECORD OF BOREHOLES

RECORD OF BOREHOLE No 1

1 OF 1

PROJECT Foundation Investigation and Design LOCATION As shown on Borehole Location Plan. ORIGINATED BY JF
 CLIENT MTO NE Region - Cont. #5006-E-0070 Sta(14+750), 4.0m left of center line. COMPILED BY LC
 JOB NO. TB7206007 DATE 28 March 2008 CHECKED BY HS

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	DEPTH (m)	STANDARD PENETRATION TEST <input type="checkbox"/> DYNAMIC PENETRATION TEST <input checked="" type="checkbox"/>					WATER CONTENT (%)			OBSERVATIONS & REMARKS
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH (kPa)							
						10 20 30 40 50 ○ UNCONFINED ▲ FIELD VANE ● QUICK TRIAXIAL ✱ LAB VANE					20 40 60				
299.5															
0.0	185 mm ASPHALT over														
299.1	15 mm SAND & GRAVEL		1	SS	20										
0.4	over														
	220 mm ASPHALT														
298.2	GRAVELY SAND TO SAND , some silt, trace clay.		2	SS	50/3cm										
1.3	BOREHOLE TERMINATED DUE TO AUGER REFUSAL ON ASSUMED ROCKFILL/BEDROCK														

Borehole open and dry upon completion.
SS1
 75 µm to 4.75 mm - 62.0%
 2 µm to 75 µm - 9.9%
 <2µm - 3.4%
SS2
 75 µm to 4.75 mm - 69.8%
 2 µm to 75 µm - 13.4%
 <2µm - 4.0%

RECORD OF BOREHOLE No 3

1 OF 1



PROJECT Foundation Investigation and Design LOCATION As shown on Borehole Location Plan. ORIGINATED BY JF
 CLIENT MTO NE Region - Cont. #5006-E-0070 Sta(14+800), 4.0m left of center line. COMPILED BY LC
 JOB NO. TB7206007 DATE 28 March 2008 CHECKED BY HS

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	DEPTH (m)	STANDARD PENETRATION TEST <input type="checkbox"/> DYNAMIC PENETRATION TEST <input checked="" type="checkbox"/>					WATER CONTENT (%)			OBSERVATIONS & REMARKS
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH (kPa)							
						10	20	30	40	50					
296.9	330 mm ASPHALT														
0.0															
296.6	Dark Brown SAND & GRAVEL moist.		1	SS	17										
0.3															
296.0			2	SS	50/3cm										
0.9	BOREHOLE TERMINATED DUE TO SPLIT SPOON REFUSAL ON ASSUMED ROCKFILL/BEDROCK													Borehole open and dry upon completion.	

RECORD OF BOREHOLE No 5

1 OF 1

PROJECT Foundation Investigation and Design LOCATION As shown on Borehole Location Plan. ORIGINATED BY JF
 CLIENT MTO NE Region - Cont. #5006-E-0070 Sta(14+850), 4.2m left of center line. COMPILED BY LC
 JOB NO. TB7206007 DATE 28 March 2008 CHECKED BY HS

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	DEPTH (m)	STANDARD PENETRATION TEST <input type="checkbox"/> DYNAMIC PENETRATION TEST <input checked="" type="checkbox"/>					WATER CONTENT (%)			OBSERVATIONS & REMARKS
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH (kPa)							
						10	20	30	40	50					
295.7															
295.0	Frozen SAND , some silt and gravel, trace clay.		1	AUGER											
0.3	Yellowish Brown GRAVELY SAND , trace silt and clay, compact.		2	SS	19										
294.6	BOREHOLE TERMINATED DUE TO SPLIT SPOON REFUSAL ON ASSUMED ROCKFILL/BEDROCK														
1.1															

Borehole open and
dry upon
completion.
AS1
 75 µm
 to 4.75 mm -
 65.0%
 2 µm
 to 75 µm - 16.8%
 <2µm - 4.0%
SS2
 75 µm
 to 4.75 mm -
 62.2%
 2 µm
 to 75 µm - 8.0%
 <2µm - 2.6%

RECORD OF BOREHOLE No 7

1 OF 1

PROJECT Foundation Investigation and Design LOCATION As shown on Borehole Location Plan. ORIGINATED BY JF
 CLIENT MTO NE Region - Cont. #5006-E-0070 Sta(14+850), 20.0m left of center line. COMPILED BY LC
 JOB NO. TB7206007 DATE 31 March 2008 CHECKED BY HS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH (m)	STANDARD PENETRATION TEST <input type="checkbox"/> DYNAMIC PENETRATION TEST <input checked="" type="checkbox"/>					WATER CONTENT (%)			OBSERVATIONS & REMARKS	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)									
								10		20		30		40			50
289.9 0.0	ICE																
289.3 0.6	WATER																
287.9 2.0	Dark Brown PEAT , trace rootlets and wood chips.		1	AUGER													
			2	AUGER													
			3	AUGER													
285.3 4.6	Brown SILT AND SAND to SILT , some sand and silt, trace clay and gravel, some organics.		4	SS	1												
284.0 5.9	Grey SILTY CLAY TO SILT , trace sand, apl, stiff to very stiff.		5	SS	2												
			6	VANE													
			7	SS	12												
			8	SS	21												
282.3 7.6	Grey SILT , some sand, trace clay and gravel, occasional cobbles, moist to wet, very dense.		9	SS	50/10cm												
281.8 8.1	BOREHOLE TERMINATED DUE TO SPLIT SPOON REFUSAL ON ASSUMED BEDROCK Borehole was backfilled with Bentonite upon completion.																

SS4
 75 µm to 4.75 mm - 37.8%
 2 µm to 75 µm - 56.2%
 <2µm - 6.0%

SS5
 75 µm to 4.75 mm - 10.2%
 2 µm to 75 µm - 80.6%
 <2µm - 6.5%

SS5
 LL-29%, PL-28%, PI-1%
 Field Vane 33.5kPa, 14.4kPa
 Borehole caved to 0.9 m and water at surface upon completion.

SS7
 75 µm to 4.75 mm - 2.5%
 2 µm to 75 µm - 87.5%
 <2µm - 10.0%

SS8
 75 µm to 4.75 mm - 4.5%
 2 µm to 75 µm - 83.5%
 <2µm - 11.0%

SS8
 Non-plastic

SS9
 75 µm to 4.75 mm - 10.8%
 2 µm to 75 µm - 78.1%
 <2µm - 9.5%

SS9
 Non-plastic

RECORD OF BOREHOLE No 10

1 OF 1

PROJECT Foundation Investigation and Design LOCATION As shown on Borehole Location Plan. ORIGINATED BY JF
 CLIENT MTO NE Region - Cont. #5006-E-0070 Sta(14+900), 20.0m left of center line. COMPILED BY LC
 JOB NO. TB7206007 DATE 31 March 2008 CHECKED BY HS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH (m)	STANDARD PENETRATION TEST <input type="checkbox"/> DYNAMIC PENETRATION TEST <input checked="" type="checkbox"/>					WATER CONTENT				OBSERVATIONS & REMARKS
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)					(%)				
								10	20	30	40	50	20	40	60		
							○ UNCONFINED ▲ FIELD VANE ● QUICK TRIAXIAL ✱ LAB VANE										
							100 200 300					20 40 60					
289.9 0.0	ICE																
289.3 0.6	Dark Brown PEAT , some wood chips.						1										
							2										
							3										
							4										
285.4 4.5	Grey CLAYEY SILT, apl, very soft.		1	SS	1		4										
			2	SS	2		5										
			3	SS	2		6										
			4	VANE													
283.1 6.8	Grey CLAYEY SILT to SILT , with clay, trace sand and gravel, apl and wet, compact to dense.		5	SS	12		7										
			6	SS	23		8										
			7	SS	32		9										
			8	SS	18												
			9	SS	31		10										
279.0 10.9	BOREHOLE TERMINATED DUE TO SPLIT SPOON REFUSAL ON ASSUMED ROCKFILL/BEDROCK Borehole was backfilled with Bentonite upon completion.																

SS2
 75 µm to 4.75 mm - 1.0%
 2 µm to 75 µm - 73.0%
 <2µm - 26.0%
 Field Vane = 14.4kPa, 9.6kPa

SS5
 75 µm to 4.75 mm - 3.0%
 2 µm to 75 µm - 71.5%
 <2µm - 25.5%

SS6
 75 µm to 4.75 mm - 2.6%
 2 µm to 75 µm - 79.9%
 <2µm - 17.5%

SS6
 LL-19%, PL-18%, PI-1%

SS7
 75 µm to 4.75 mm - 3.1%
 2 µm to 75 µm - 90.4%
 <2µm - 6.5%

SS7
 LL-17%, PL-16%, PI-1%

Borehole caved to 4.5 m and water at surface upon completion.

SS8
 75 µm to 4.75 mm - 11.8%
 2 µm to 75 µm - 78.2%
 <2µm - 10.0%



SS8
 Non-plastic

SS9
 75 µm to 4.75 mm - 16.8%
 2 µm to 75 µm - 67.0%
 <2µm - 8.5%

RECORD OF BOREHOLE No 11

1 OF 1

PROJECT Foundation Investigation and Design LOCATION As shown on Borehole Location Plan. ORIGINATED BY JF
 CLIENT MTO NE Region - Cont. #5006-E-0070 Sta(14+950), 4.2m left of center line. COMPILED BY LC
 JOB NO. TB7206007 DATE 28 March 2008 CHECKED BY HS

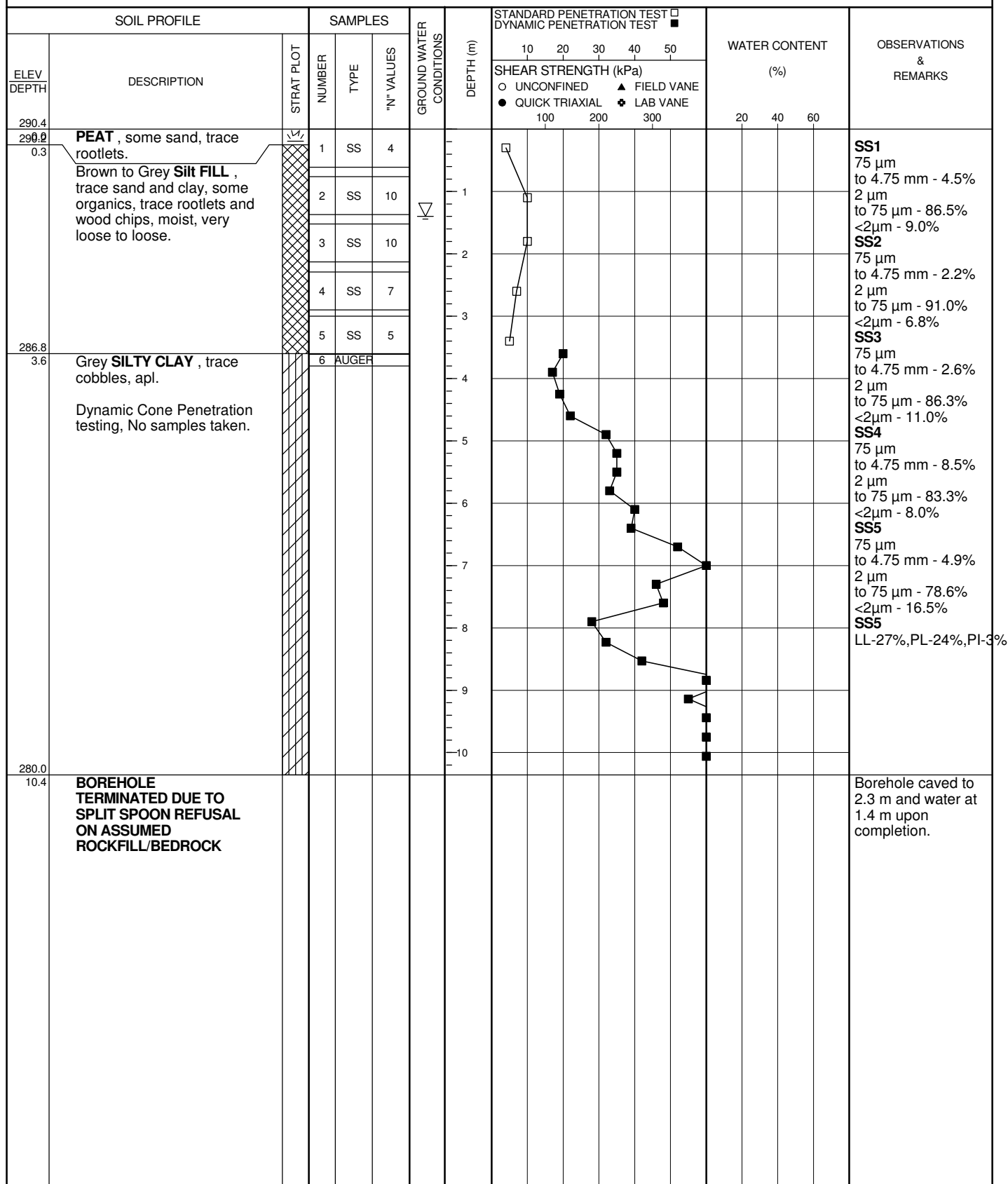
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	DEPTH (m)	STANDARD PENETRATION TEST <input type="checkbox"/> DYNAMIC PENETRATION TEST <input checked="" type="checkbox"/>					WATER CONTENT (%)			OBSERVATIONS & REMARKS
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH (kPa)							
						10	20	30	40	50					
291.1															
0.0	Frozen SAND & GRAVEL		1	SS	40										
290.6	, some silt, trace clay.														
0.5	SILTY SAND , trace clay		2	SS	50/10cm										
290.0	and gravel, moist.														
1.1	BOREHOLE TERMINATED DUE TO AUGER REFUSAL ON ASSUMED ROCKFILL/BEDROCK														

Borehole open and dry upon completion.
SS1
 75 µm to 4.75 mm - 50.9%
 2 µm to 75 µm - 8.0%
 <2µm - 5.5%
SS2
 75 µm to 4.75 mm - 67.1%
 2 µm to 75 µm - 23.2%
 <2µm - 5.0%

RECORD OF BOREHOLE No 12

1 OF 1

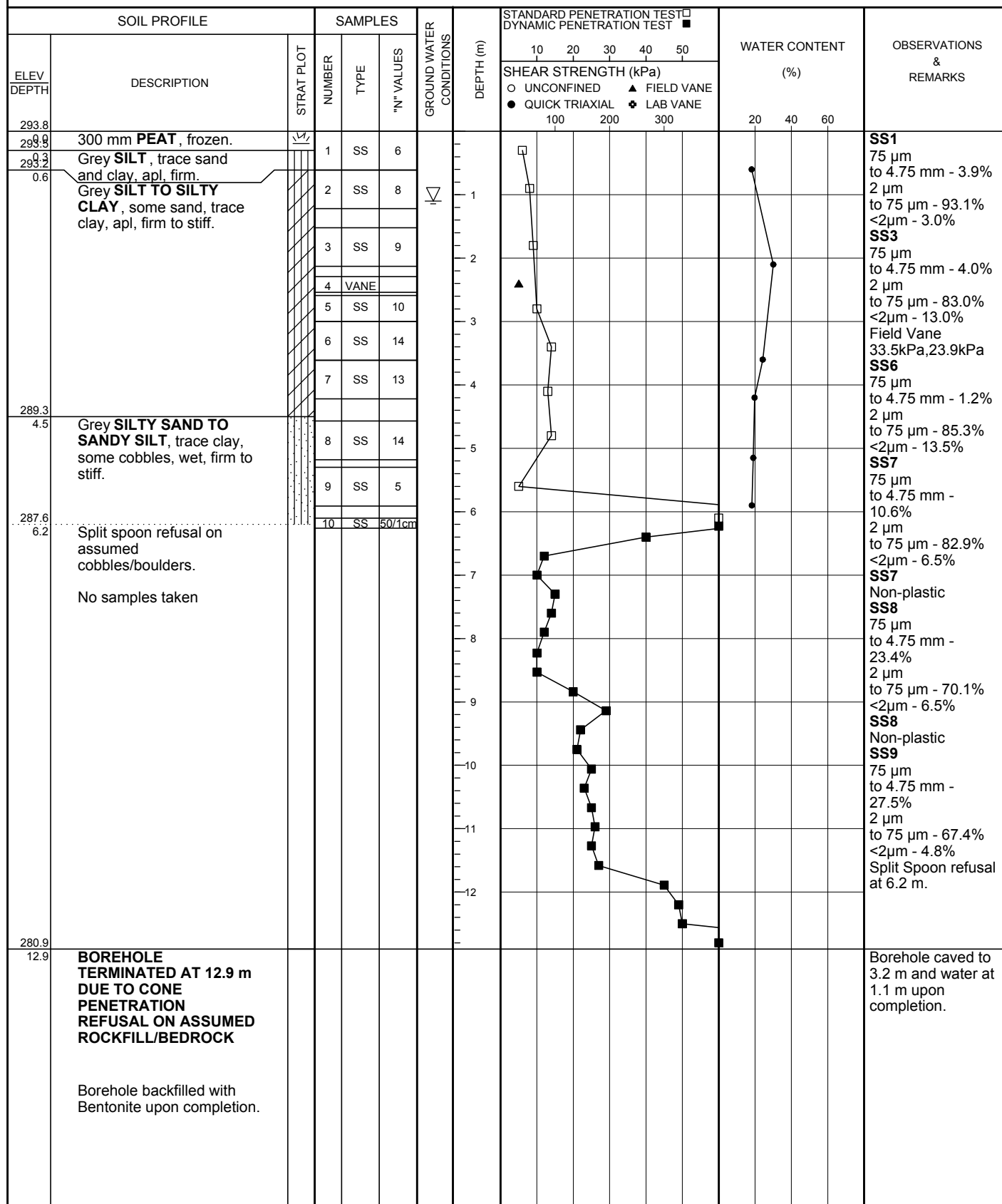
PROJECT Foundation Investigation and Design LOCATION As shown on Borehole Location Plan. ORIGINATED BY JF
 CLIENT MTO NE Region - Cont. #5006-E-0070 Sta(14+950), 12.0m left of center line. COMPILED BY LC
 JOB NO. TB7206007 DATE 2 April 2008 CHECKED BY HS



RECORD OF BOREHOLE No 2A

1 OF 1

PROJECT Foundation Investigation and Design LOCATION As shown on Borehole Location Plan. ORIGINATED BY JF
 CLIENT MTO NE Region - Cont. #5006-E-0070 Sta(14+750), 17.0m left of center line. COMPILED BY LC
 JOB NO. TB7206007 DATE 28 March 2008 CHECKED BY HS



RECORD OF BOREHOLE No 4B

1 OF 1

PROJECT Foundation Investigation and Design LOCATION As shown on Borehole Location Plan. ORIGINATED BY JF
 CLIENT MTO NE Region - Cont. #5006-E-0070 Sta(14+800), 18.0m left of center line. COMPILED BY LC
 JOB NO. TB7206007 DATE 2 April 2008 CHECKED BY HS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH (m)	STANDARD PENETRATION TEST <input type="checkbox"/> DYNAMIC PENETRATION TEST <input checked="" type="checkbox"/>					WATER CONTENT (%)			OBSERVATIONS & REMARKS
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)								
								10	20	30	40	50	○ UNCONFINED	▲ FIELD VANE	● QUICK TRIAXIAL	
289.9 0.0	ICE															
289.3 0.6	WATER						1									
288.1 1.8	Brown PEAT , some silt.		1	AUGER			2									
286.2 3.7	Grey SILTY CLAY TO SILT , trace sand, apl, very soft to very stiff.		2	SS	1		3									
			3	VANE			4									
			4	VANE			5									
			5	SS	1		6									
			6	SS	12		7									
			7	SS	15		8									
			8	SS	16		9									
			9	SS	12		10									
281.5 8.4	SANDY SILT/SILTY SAND to SAND, trace clay, wet, very loose.		10	SS	3		11									
			11	SS	1		12									
			12	SS	1		13									
279.1 10.9	BOREHOLE TERMINATED DUE TO SPLIT SPOON REFUSAL ON ASSUMED ROCKFILL/BEDROCK Borehole backfilled with Bentonite upon completion.															

RECORD OF BOREHOLE No 6B

1 OF 1

PROJECT Foundation Investigation and Design LOCATION As shown on Borehole Location Plan. ORIGINATED BY JF
 CLIENT MTO NE Region - Cont. #5006-E-0070 Sta(14+850), 15.0m left of center line. COMPILED BY LC
 JOB NO. TB7206007 DATE 31 March 2008 CHECKED BY HS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH (m)	STANDARD PENETRATION TEST <input type="checkbox"/> DYNAMIC PENETRATION TEST <input checked="" type="checkbox"/>					WATER CONTENT			OBSERVATIONS & REMARKS
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)					WATER CONTENT (%)			
								10	20	30	40	50	20	40	60	
								UNCONFINED FIELD VANE QUICK TRIAXIAL LAB VANE								
289.8 0.0	ICE															
289.2 0.6	WATER															
288.7 1.1	PEAT															
286.4 3.4	No sample taken. Dynamic Cone Penetration test.															
281.4 8.4	BOREHOLE TERMINATED DUE TO CONE PENETRATION REFUSAL ON ASSUMED ROCKFILL/BEDROCK Borehole backfilled with Bentonite upon completion.														Borehole caved and water at surface upon completion.	

RECORD OF BOREHOLE No 9A

1 OF 1

PROJECT Foundation Investigation and Design LOCATION As shown on Borehole Location Plan. ORIGINATED BY JF
 CLIENT MTO NE Region - Cont. #5006-E-0070 Sta(14+900), 13.0m left of center line. COMPILED BY LC
 JOB NO. TB7206007 DATE 2 April 2008 CHECKED BY HS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH (m)	STANDARD PENETRATION TEST <input type="checkbox"/> DYNAMIC PENETRATION TEST <input checked="" type="checkbox"/>		WATER CONTENT (%)	OBSERVATIONS & REMARKS	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)				
289.9 0.0	ICE							10 20 30 40 50		20 40 60		
289.3 0.6	WATER								100 200 300			
288.7 1.2	No Samples taken. Dynamic Cone Penetration testing to 10 mbgs.											
279.9 10.0	BOREHOLE TERMINATED DUE TO CONE PENETRATION REFUSAL ON ASSUMED ROCKFILL/BEDROCK Borehole backfilled with Bentonite upon completion.										Borehole caved and water at surface upon completion.	

BOREHOLE LOG DATA

Note: All units of measurement are in millimeters unless otherwise noted.

BH# 1A: Sta(14+725), o/s 4.7 m Lt of Hwy 11 CL
Shoulder

0	-	600	Sa & Gr	
600	-	1.36 m	Gr(y) Sa	moist
			NFP (Blds)	

BH# 3A: Sta(14+790), o/s 4.0 m Lt of Hwy 11 CL
Edge of Pavement

0	-	345	Asph	
345	-	600	Sa & Gr	moist
600	-	920	F Sa Tr Gr	moist
			NFP (Blds)	

BH# 3B: Sta(14+780), o/s 4.0 m Lt of Hwy 11 CL
Edge of Pavement

0	-	410	Asph	
410	-	610	Sa & Gr	moist
610	-	1.2 m	F Sa Tr Gr	moist
			NFP (Blds)	

BH# 3C: Sta(14+776), o/s 4.0 m Lt of Hwy 11 CL
Edge of Pavement

0	-	170	Asph	
170	-	220	Sa & Gr	moist
220	-	450	Asph	moist
450	-	700	Sa & Gr	moist
700	-	1.25 m	Si(y) Sa Tr Gr & Cl	
			w @900 mm = 13.3%	
		4.75 mm	92.4	
		2.00 mm	86.7	
		425 mm	78.4	
		75 µm	30.8	
		5 µm	6.5	
		2 µm	4.5	
			NFP (Blds)	

Soil Description:
And > 40%.
Adjective (Si(y), Sa(y) 30-40%
With 20-30%
Some 10-20%
Trace 1-10%

BOREHOLE LOG DATA

BH# 3D:

Edge of Pavement

Sta(14+760), o/s 4.0 m Lt of Hwy 11 CL

0	-	180		
180	-	210	Asph	moist
210	-	410	Sa & Gr	
410	-	620	Asph	moist
			Sa, some Gr & Si, Tr Cl	
620	-	1.2 m	w @500 mm = 7.5%	moist
			4.75 mm	80.6
			2.00 mm	69.4
			425 mm	47.6
			75 µm	16.9
			5 µm	4.8
			2 µm	3.5

Gr(y) Sa
NFP (Blds)

BH# 4A:

Sta(14+800), o/s 14.0 m Lt of Hwy 11 CL

0	-	600	
600	-	1.2 m	Ice
1.2 m	-	1.5 m	Cobs & Si(y) Sa & Gr
			Cobs & Blds
			NFP (Blds)

BH# 6:

Sta(14+850), o/s 12.0 m Lt of Hwy 11 CL

0	-	760	
760	-	1.5 m	Snow & Ice
			Org
			NFP (Blds)

BH# 6A:

Sta(14+850), o/s 13.0 m Lt of Hwy 11 CL

0	-	600	
600	-	2.3 m	Ice
			Org
			NFP (Blds)

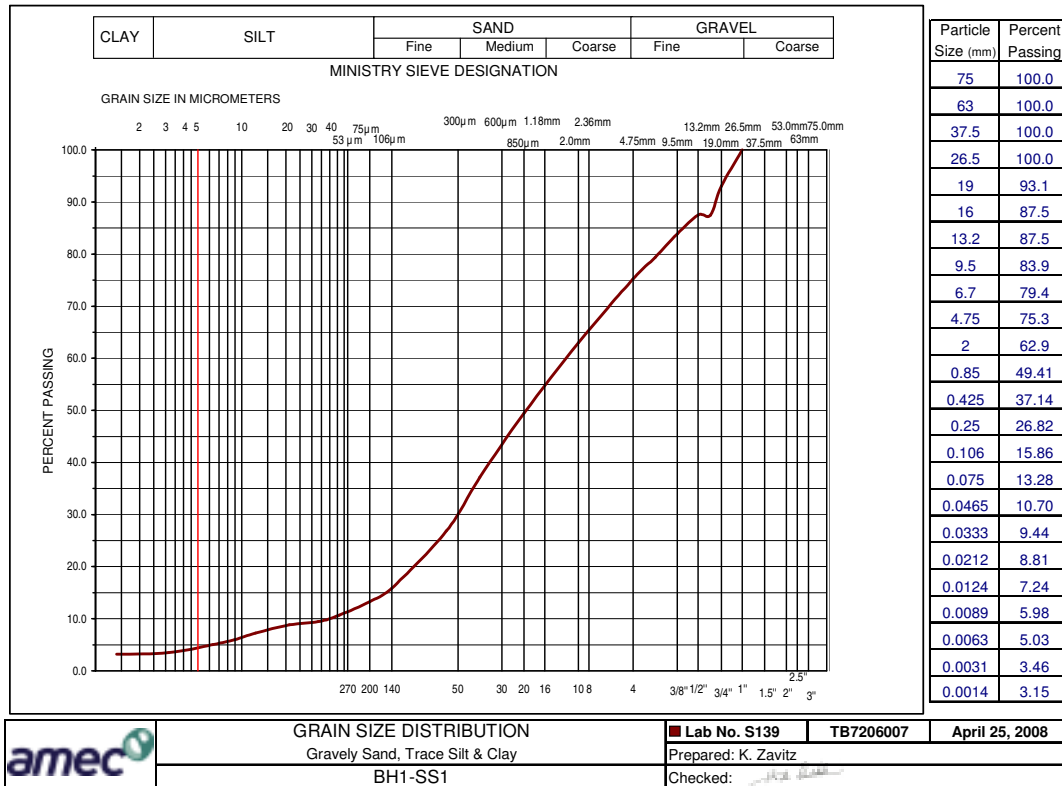
Soil Description:
And > 40%.
Adjective (Si(y), Sa(y) 30-40%
With 20-30%
Some 10-20%
Trace 1-10%

APPENDIX B

LABORATORY TEST RESULTS

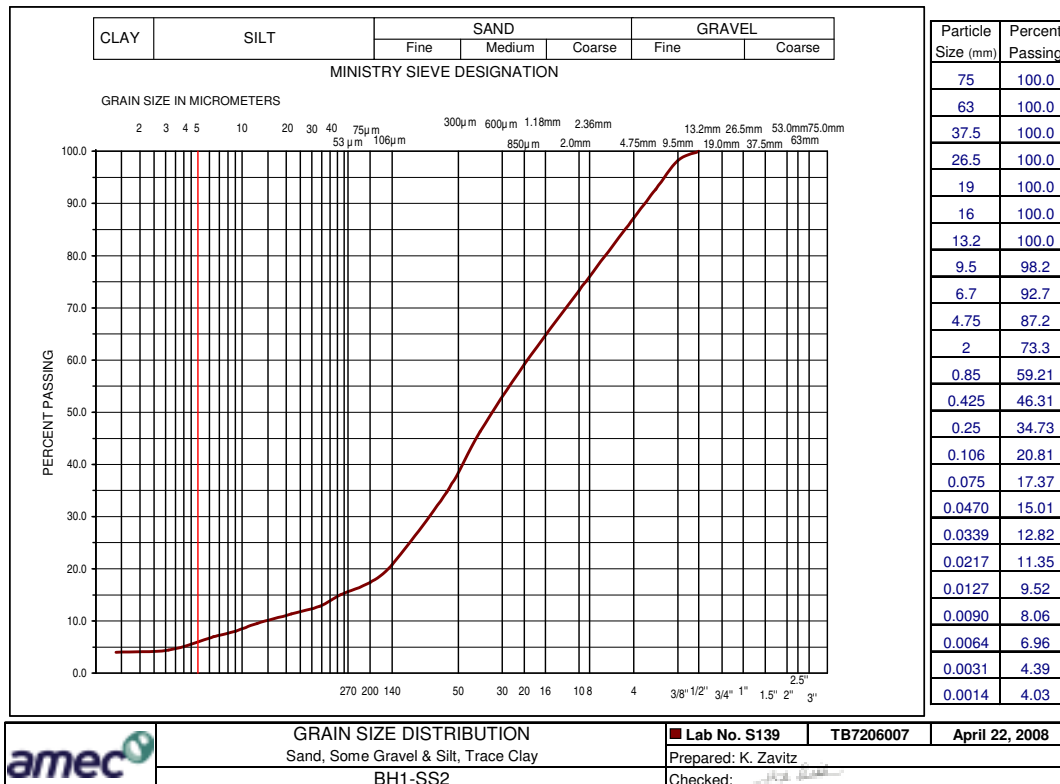
UNIFIED SOIL CLASSIFICATION SYSTEM

Enclosure: 1B



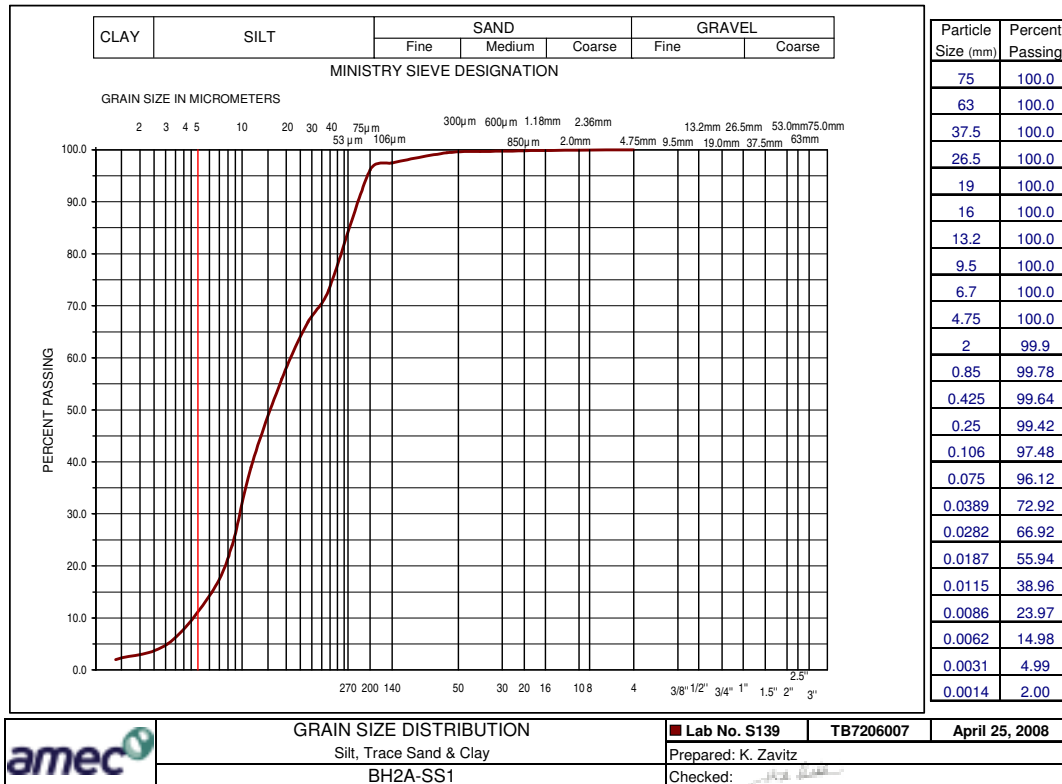
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Enclosure: 2B



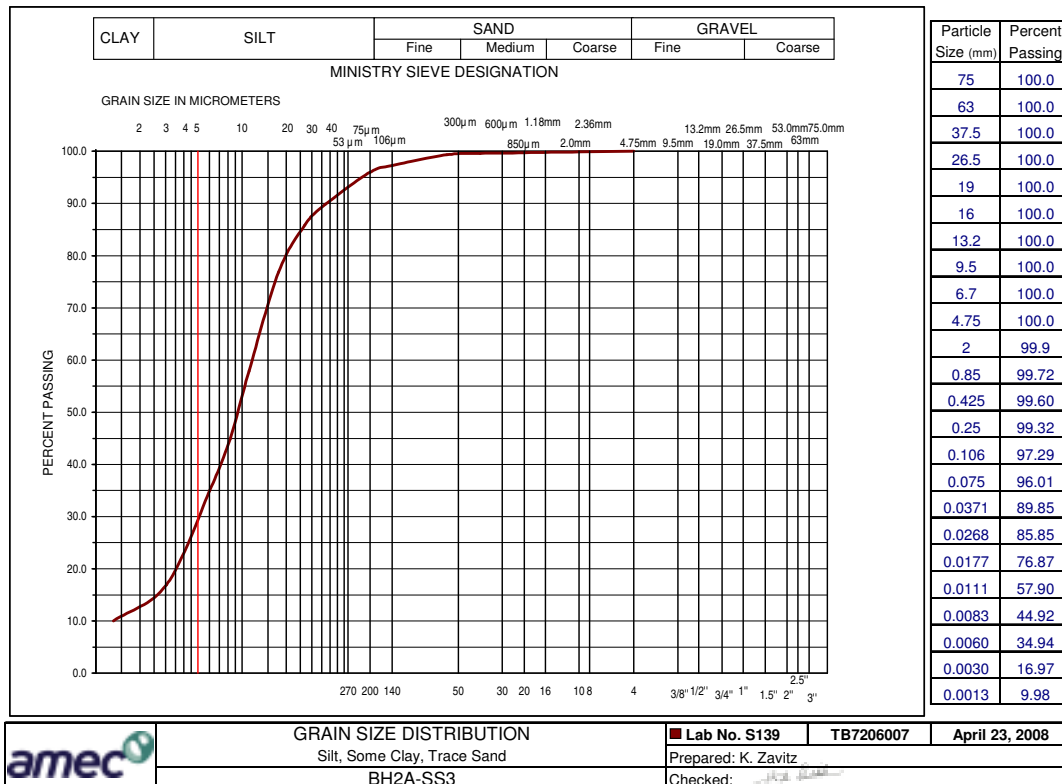
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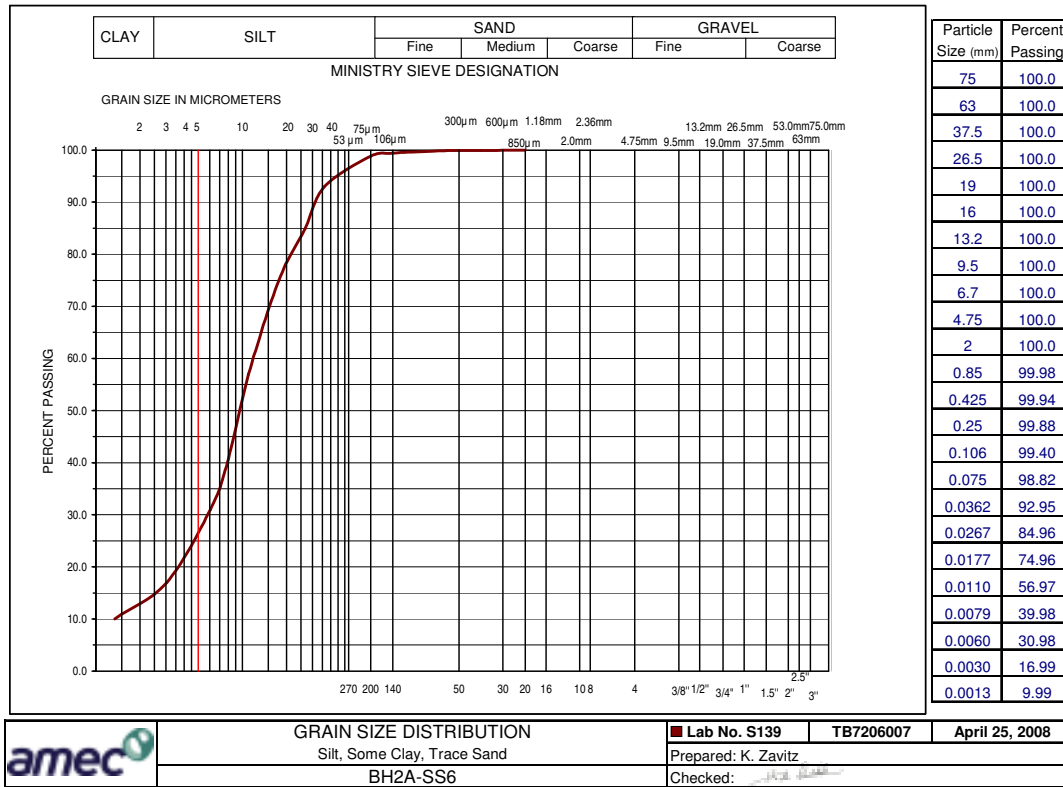
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Enclosure: 4B



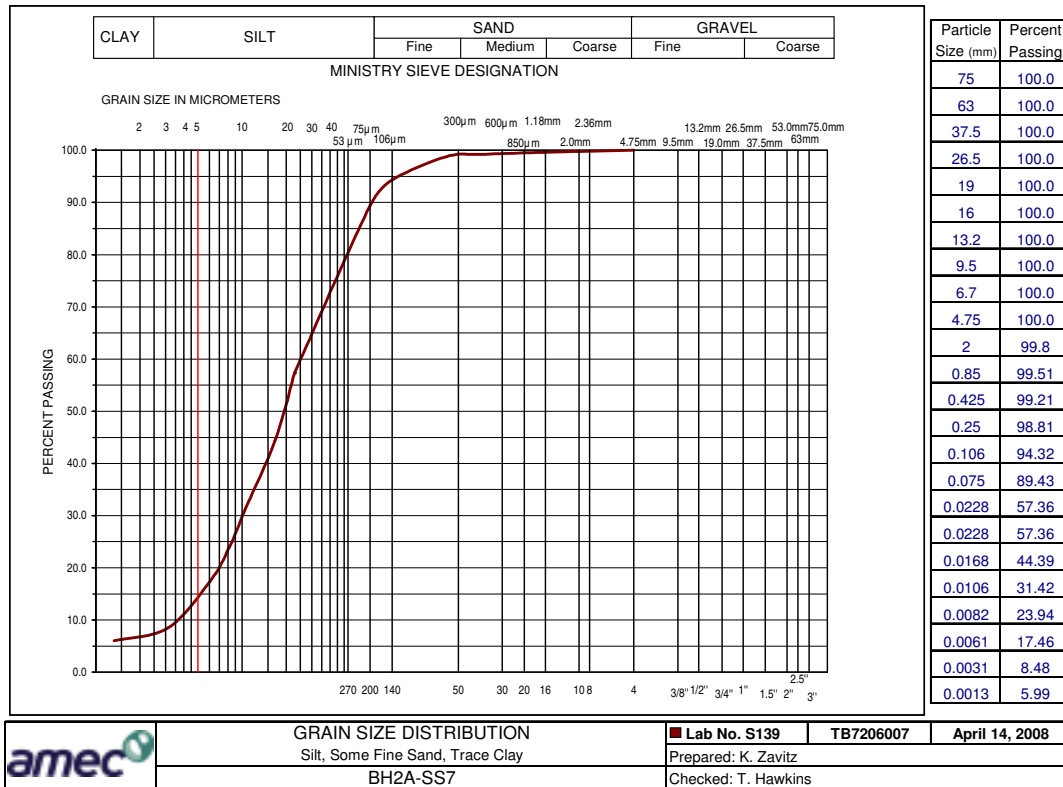
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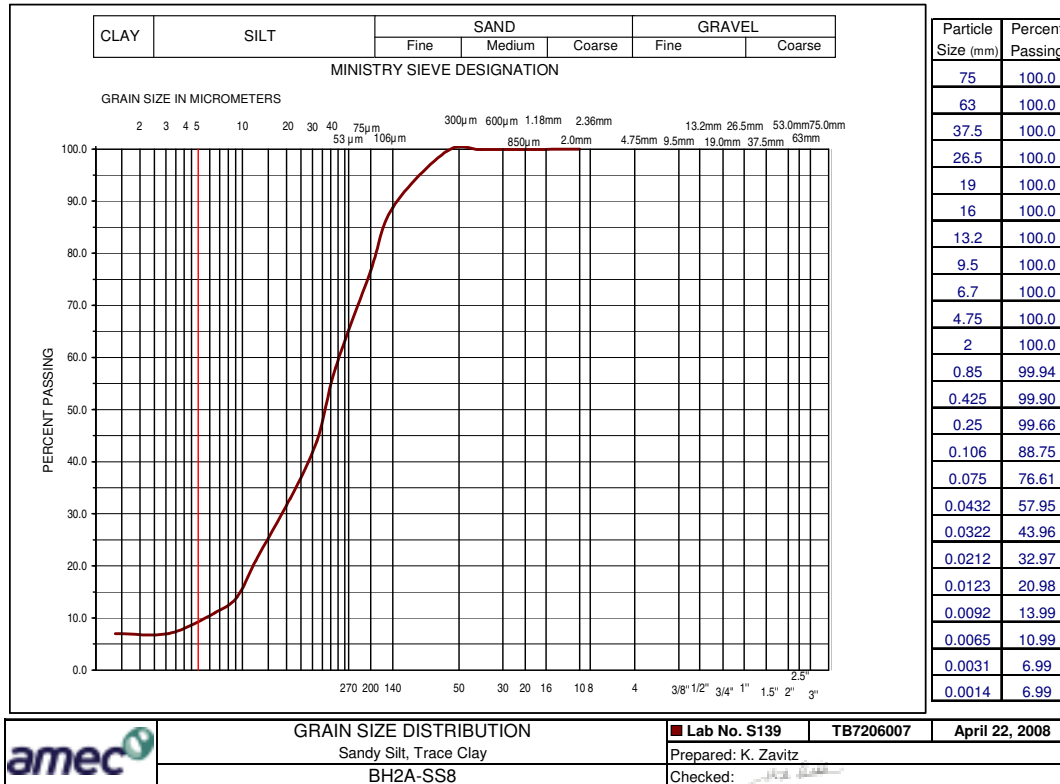
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Enclosure: 6B



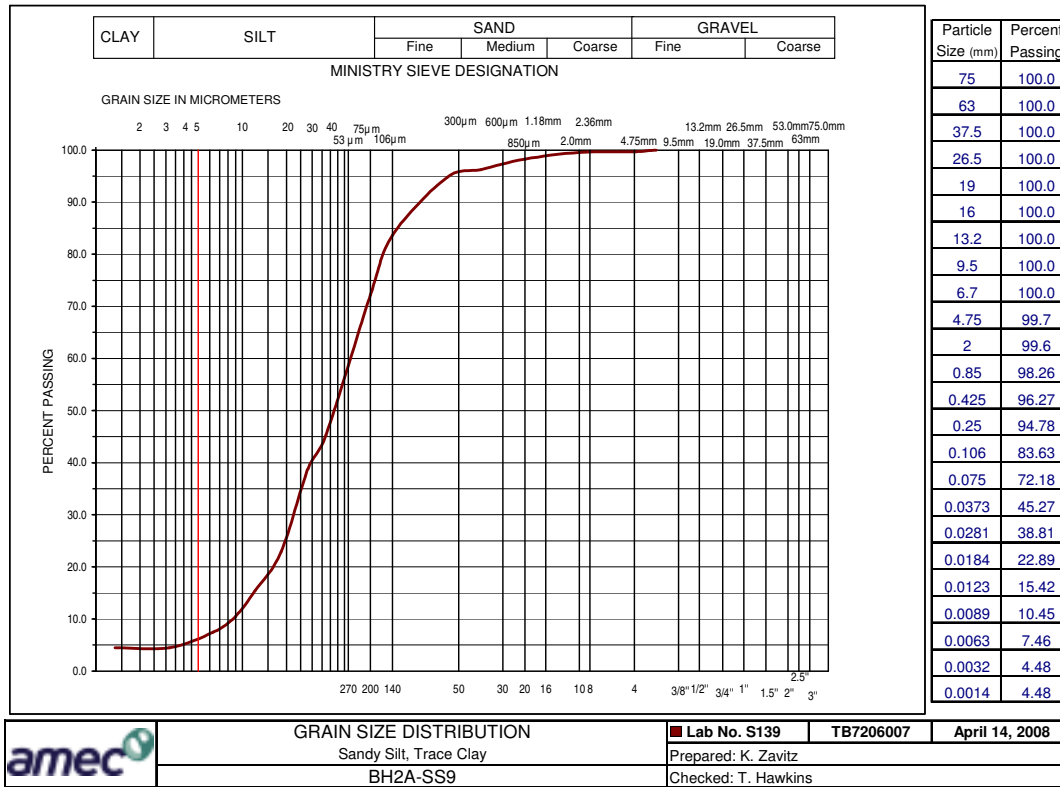
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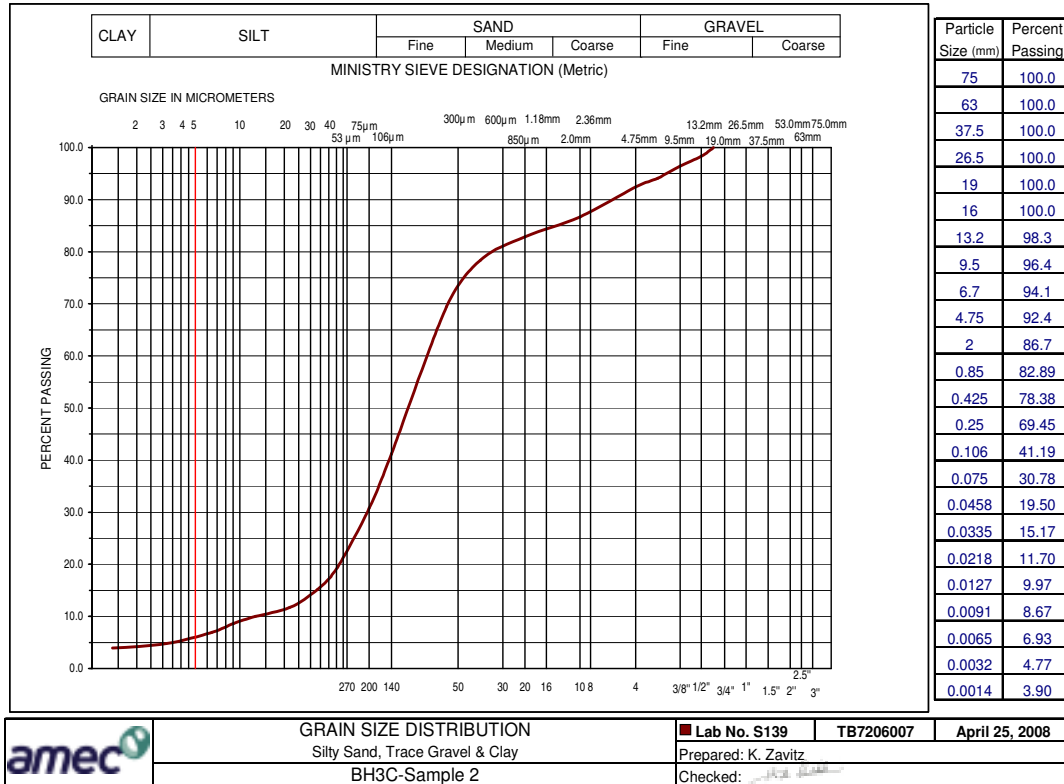
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Enclosure: 8B



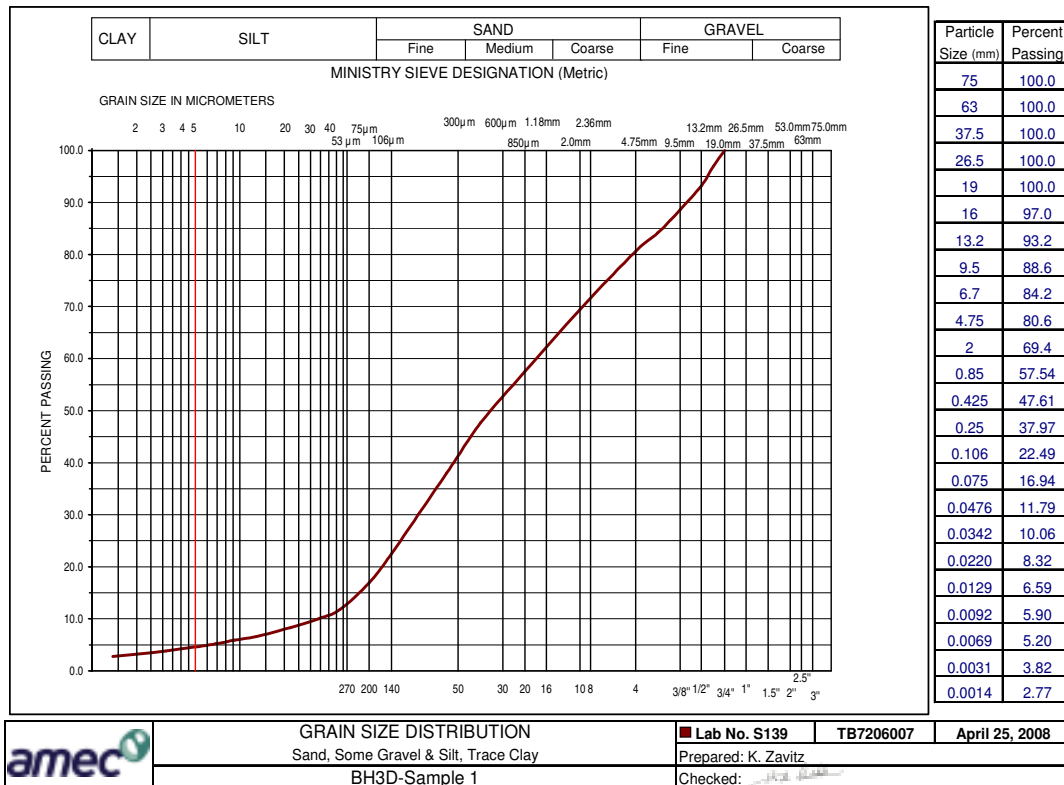
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Enclosure: 9B



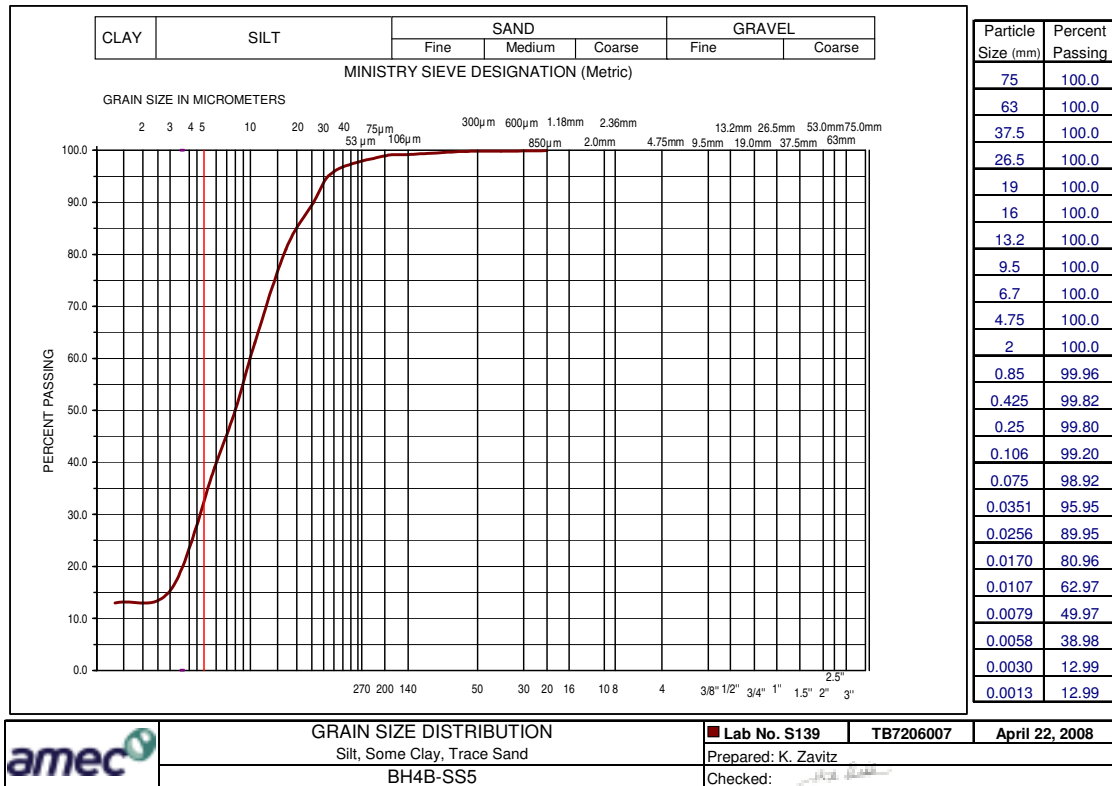
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Enclosure: 10B



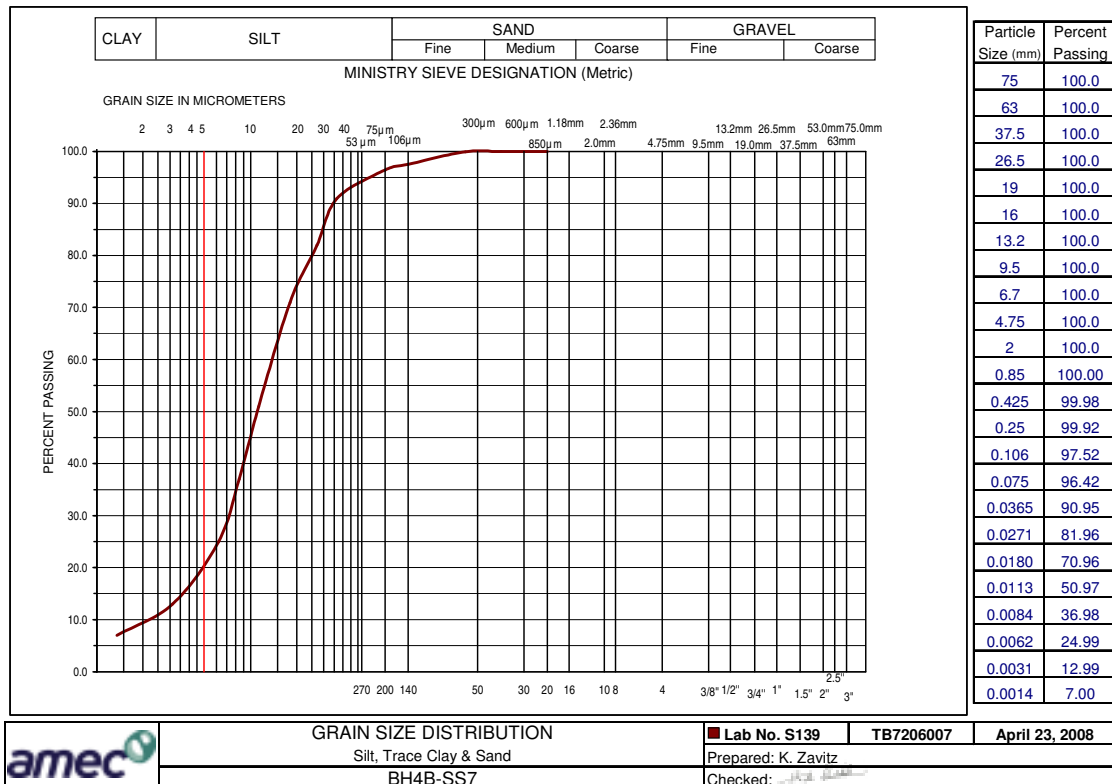
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Enclosure: 11B



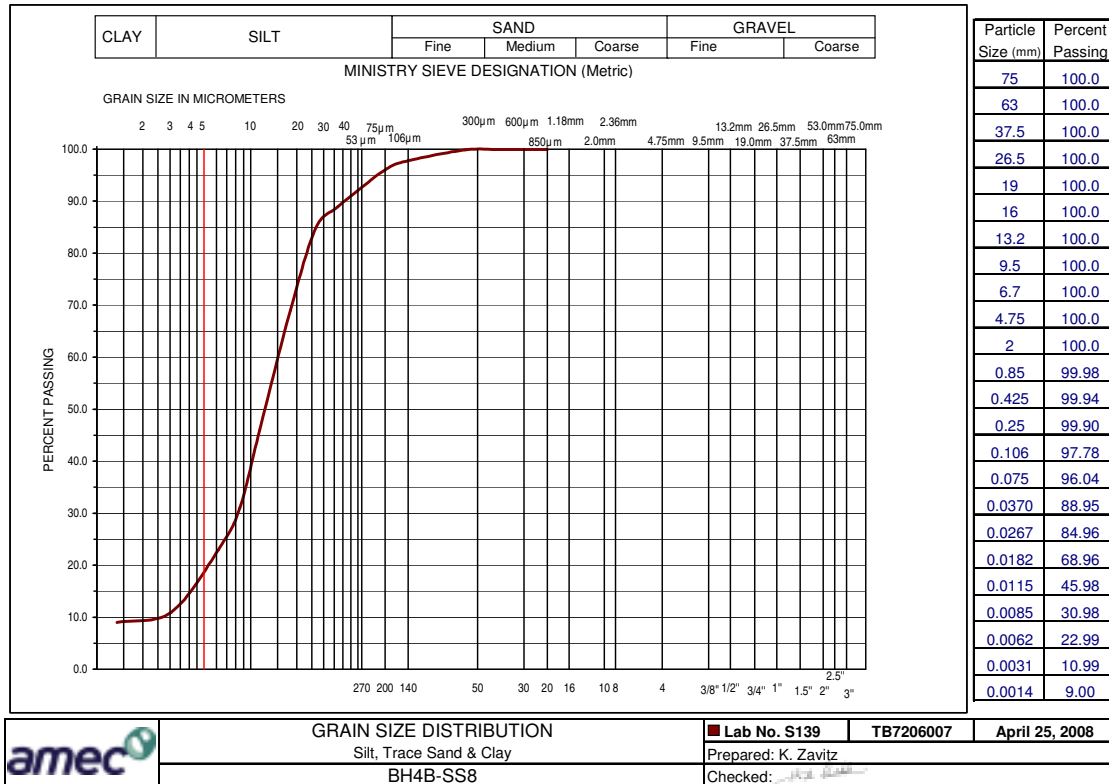
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Enclosure: 12B



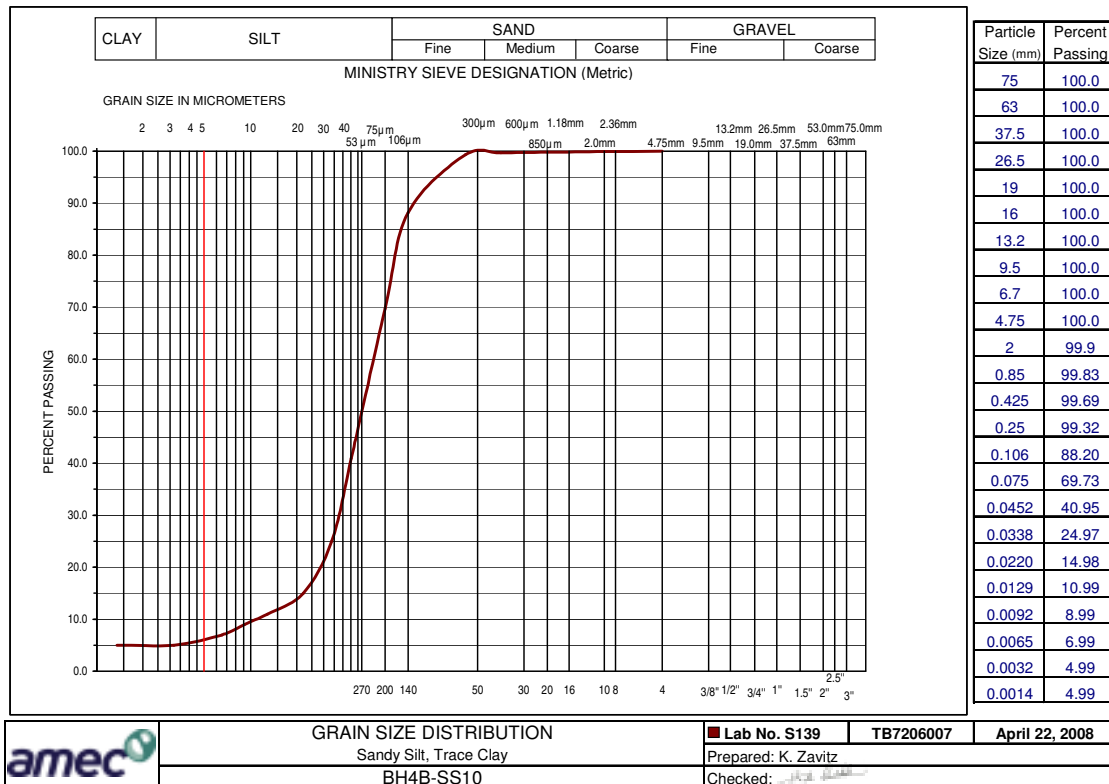
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Enclosure: 13B



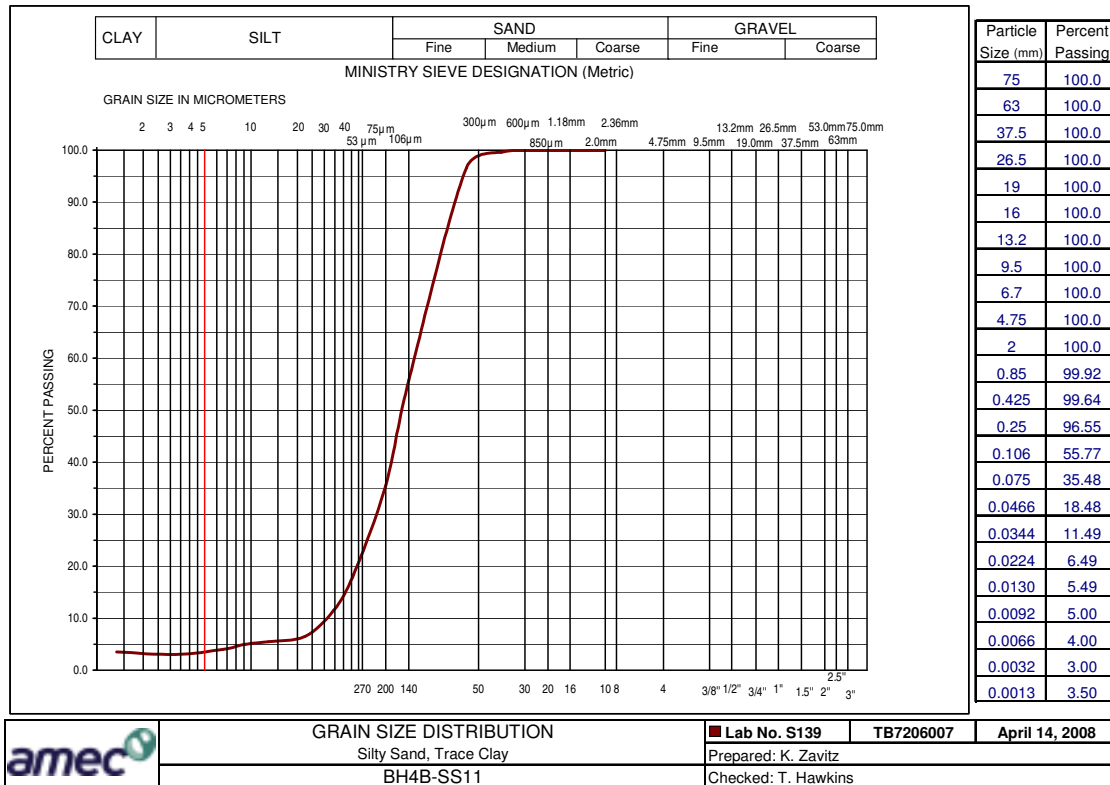
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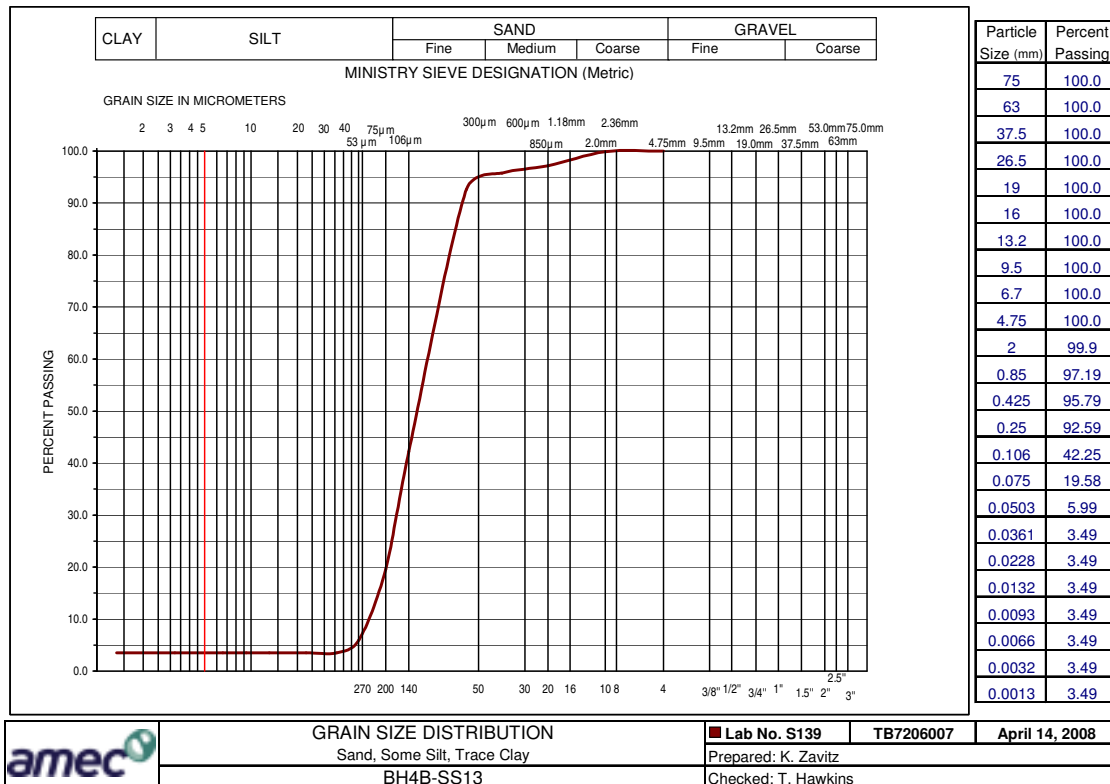
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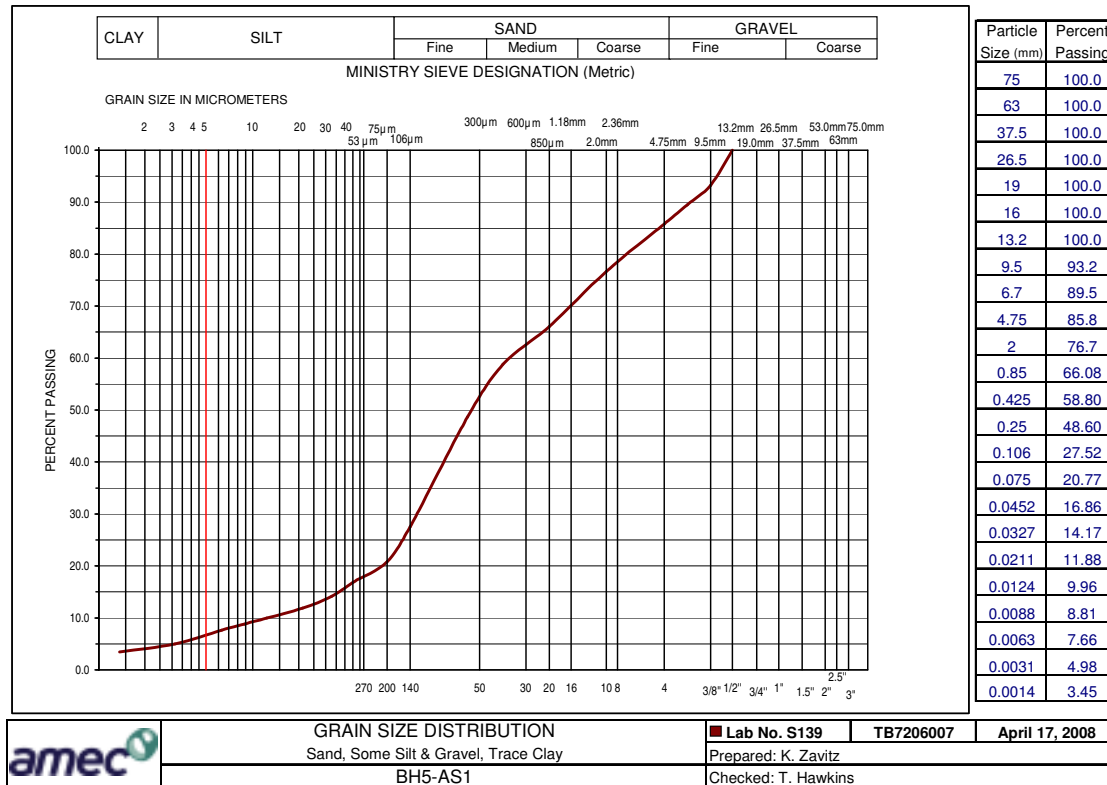
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Enclosure: 16B



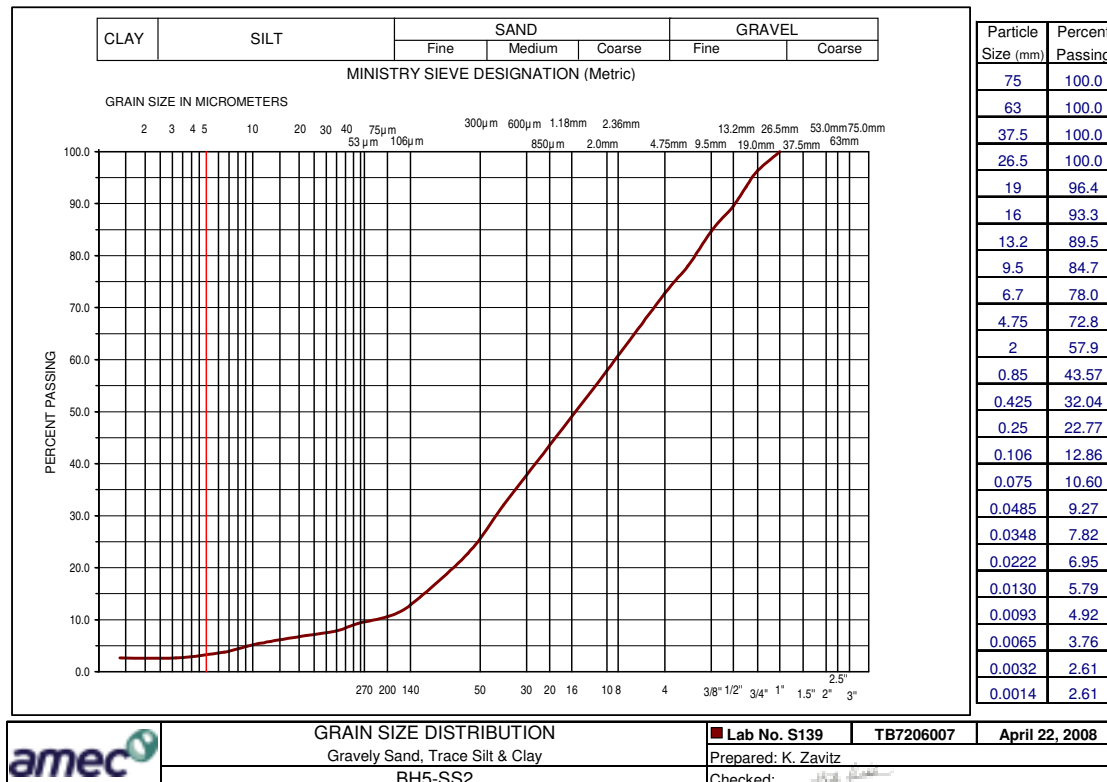
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Enclosure: 17B



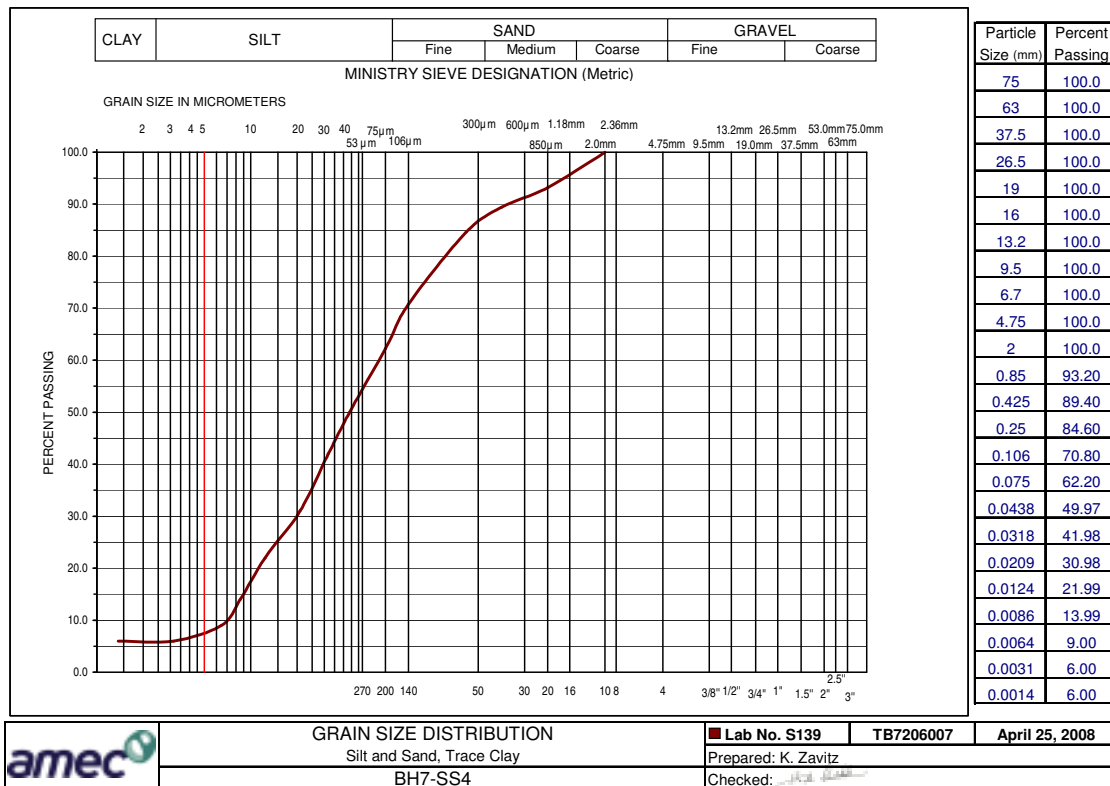
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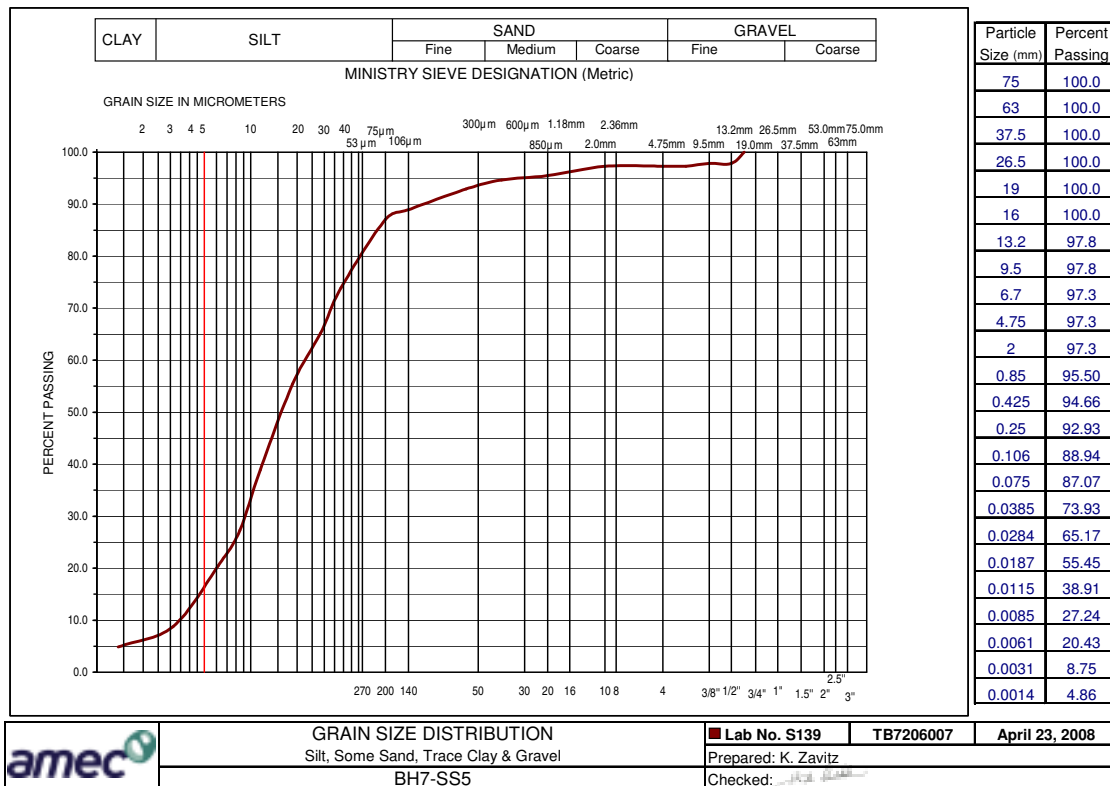
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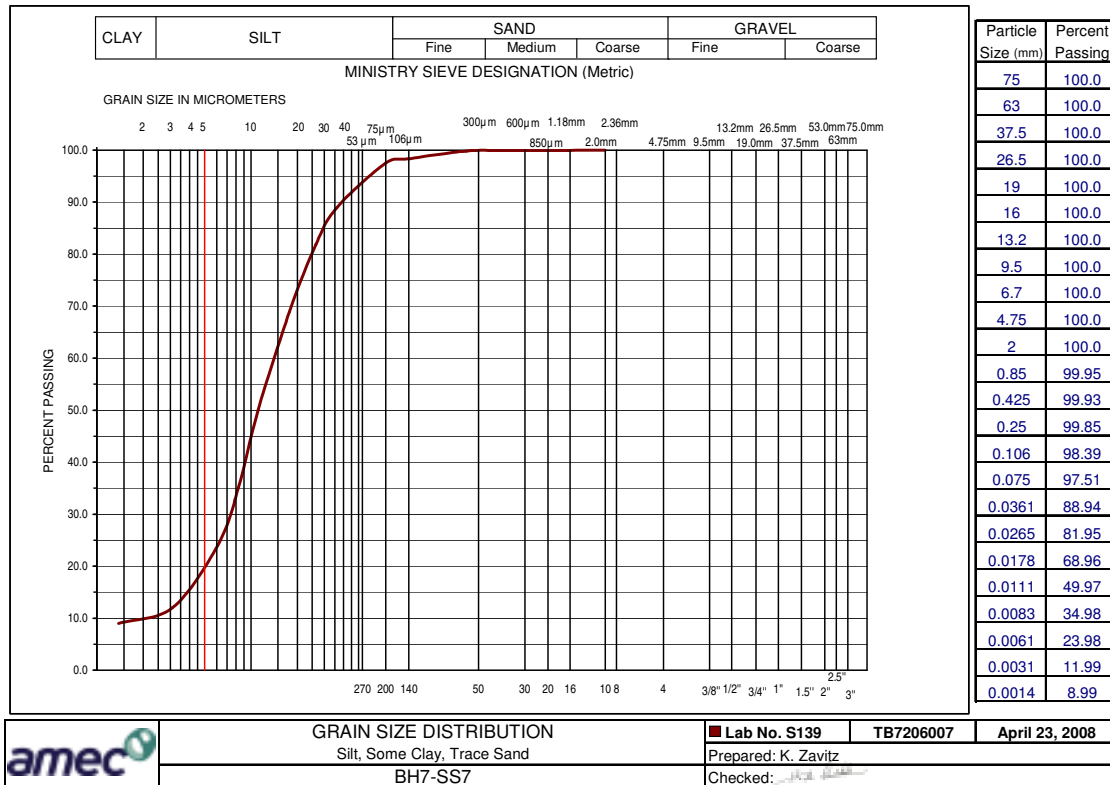
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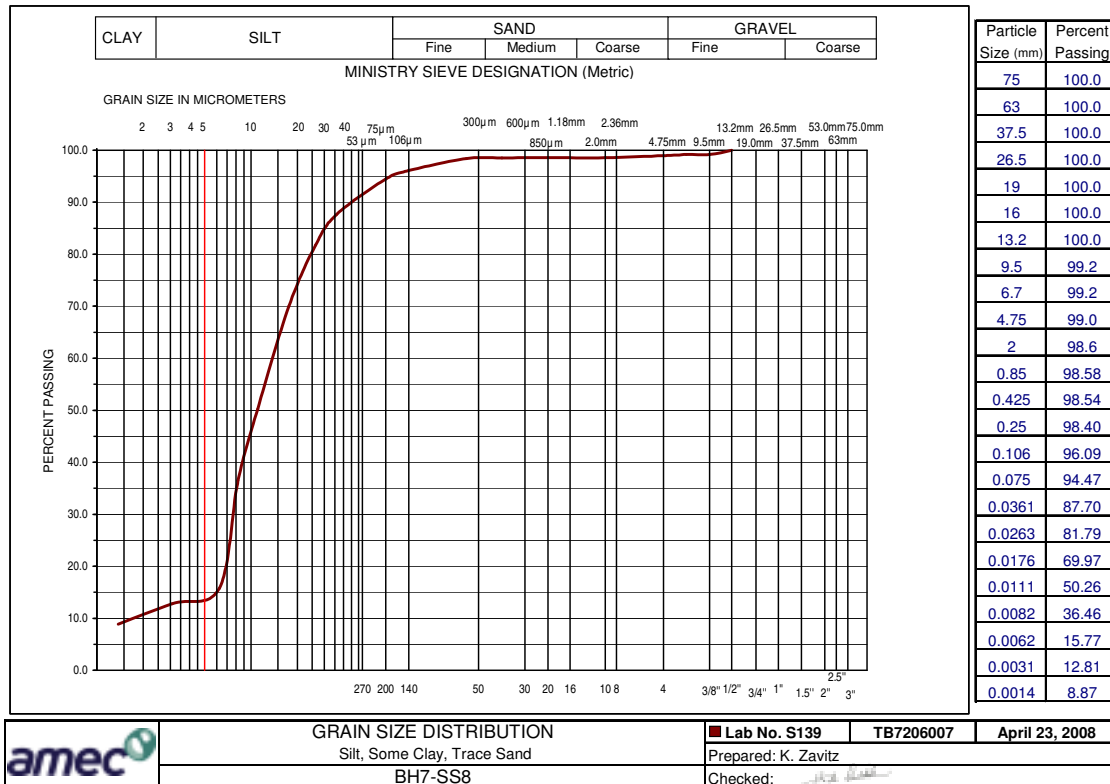
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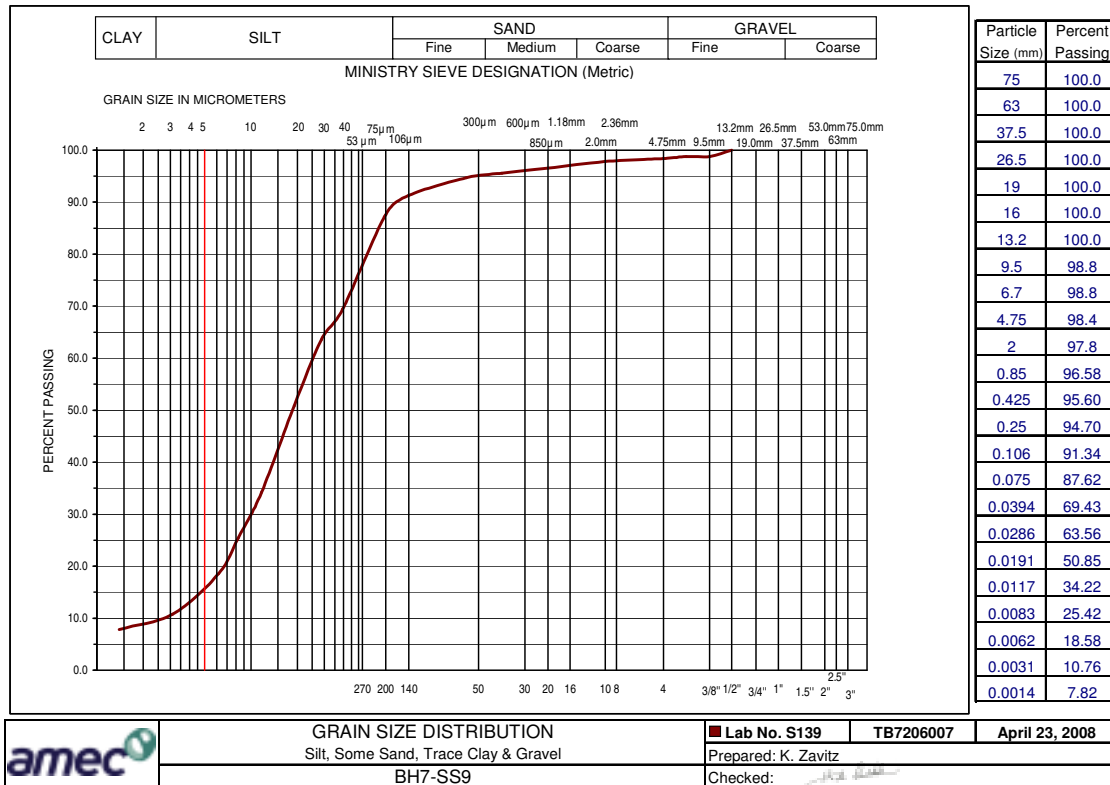
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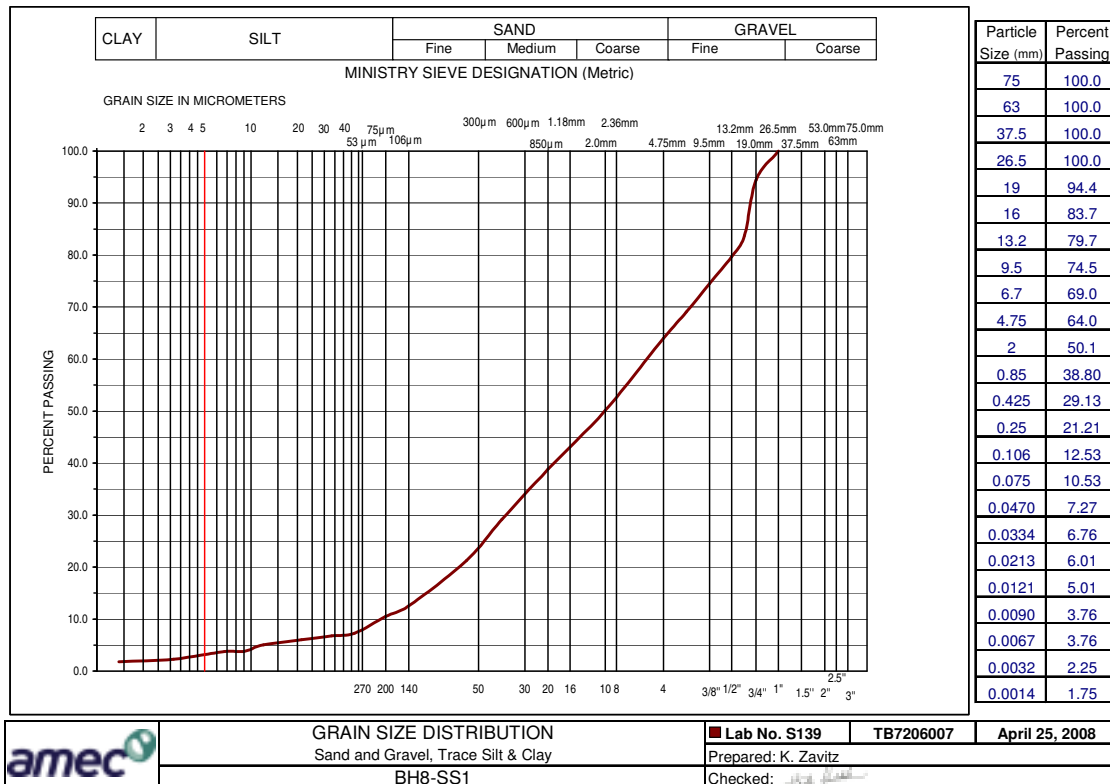
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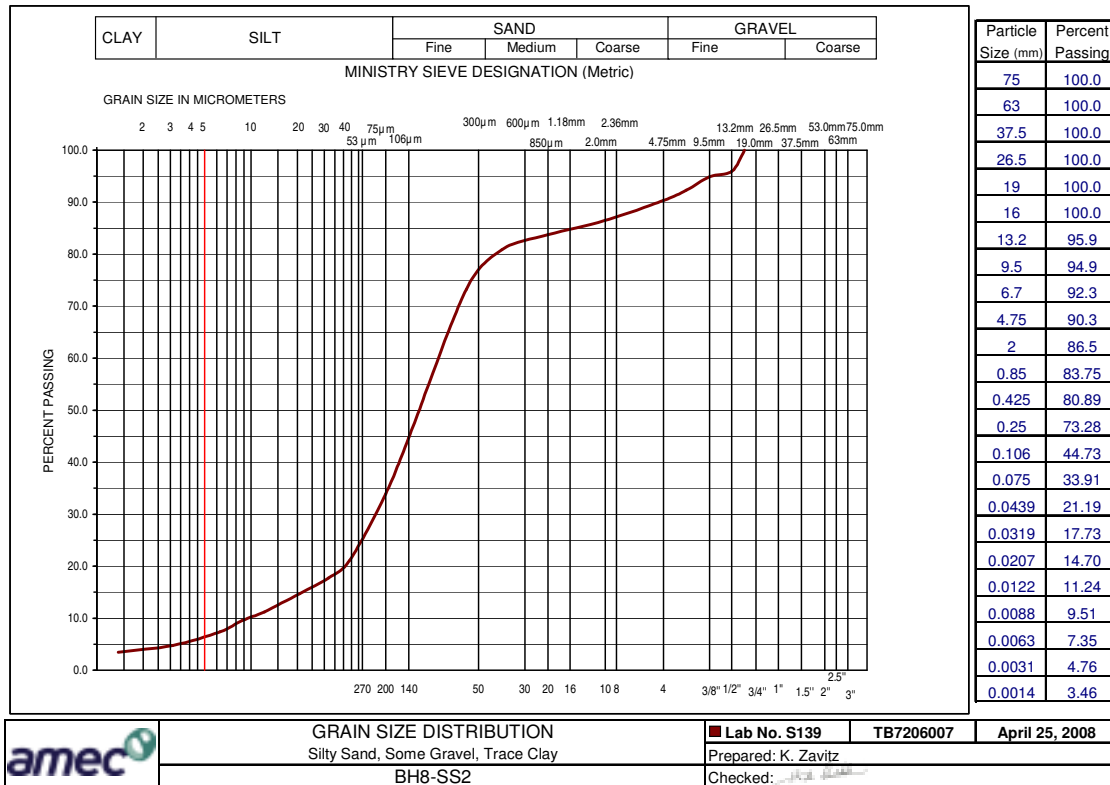
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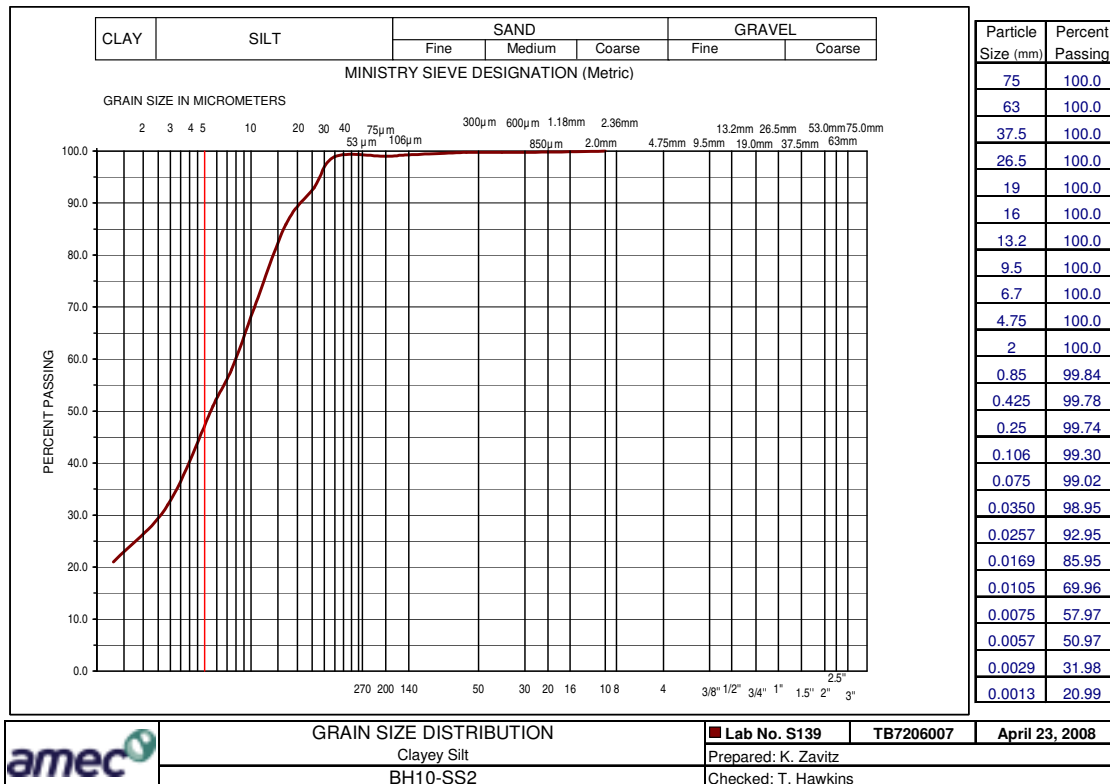
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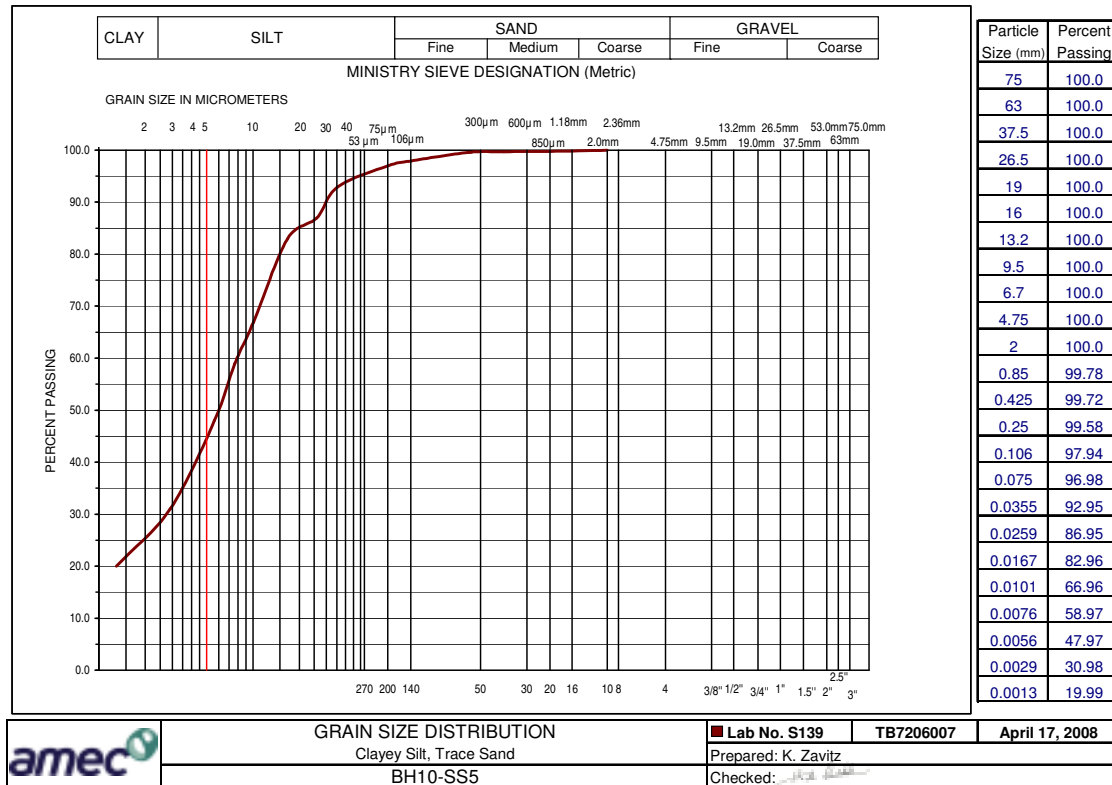
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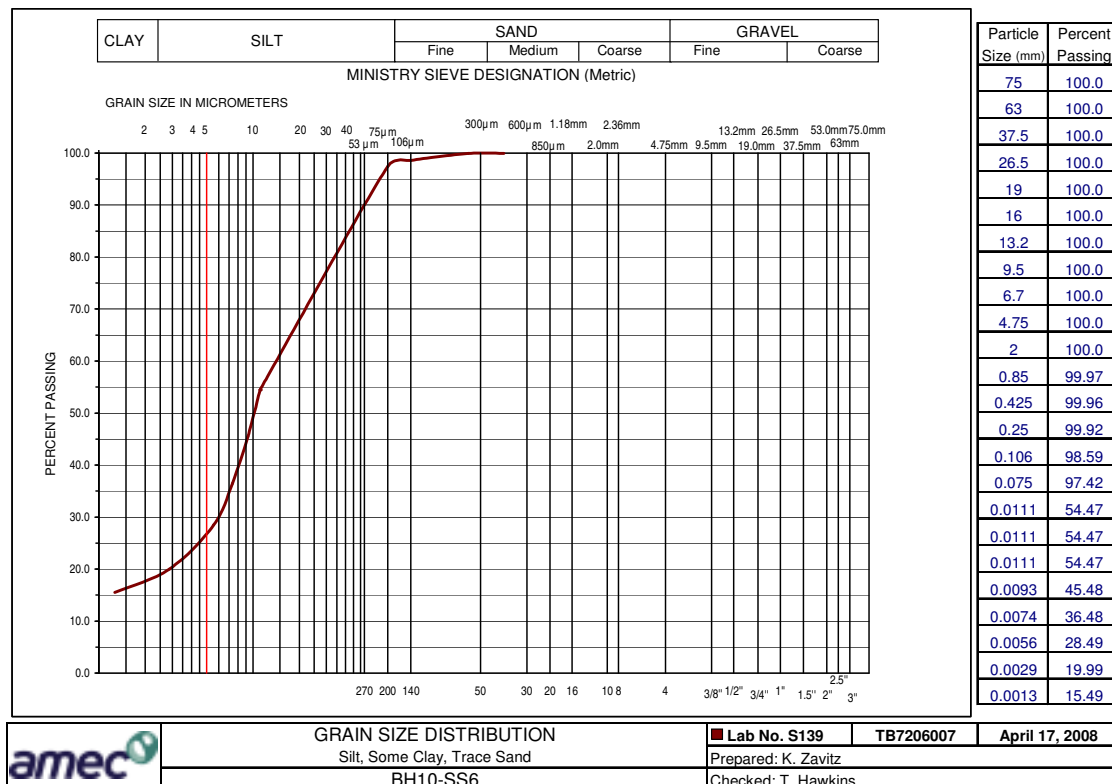
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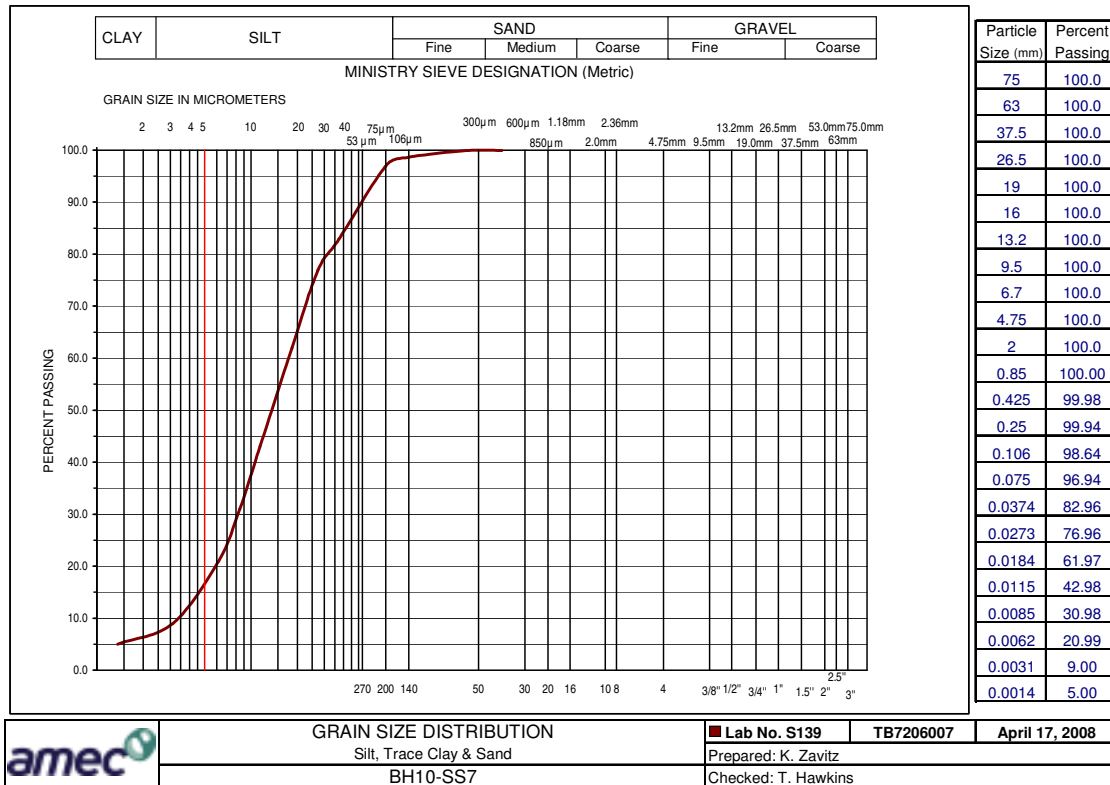
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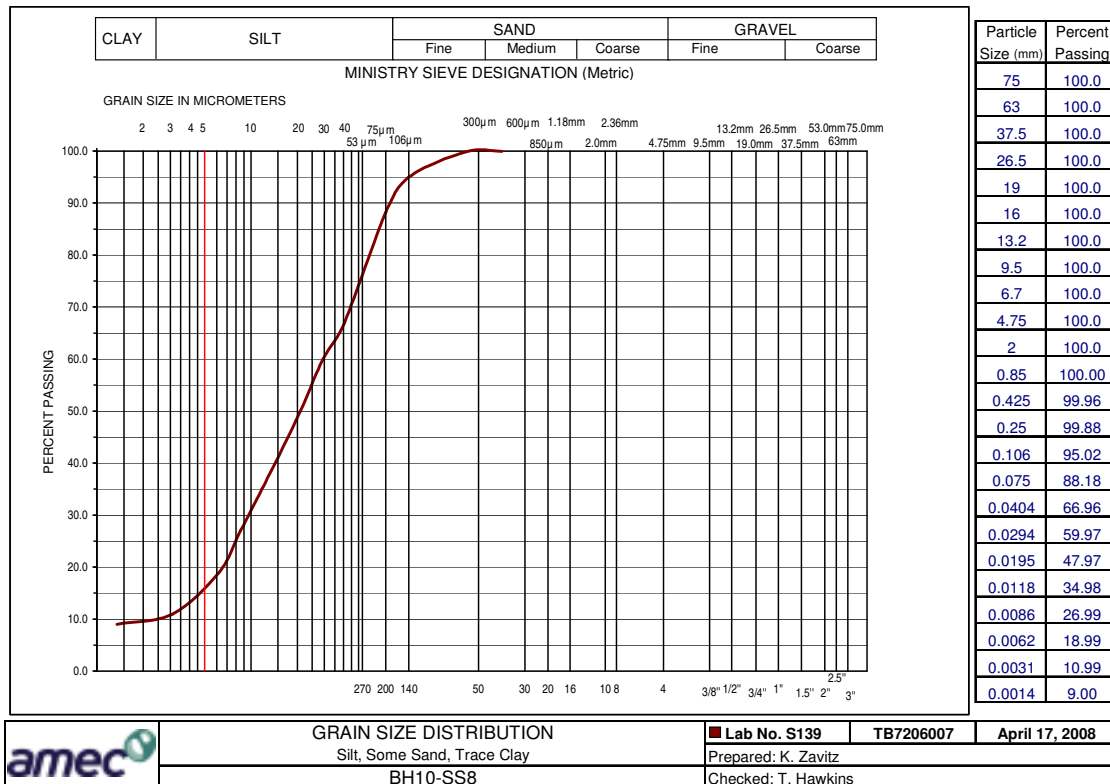
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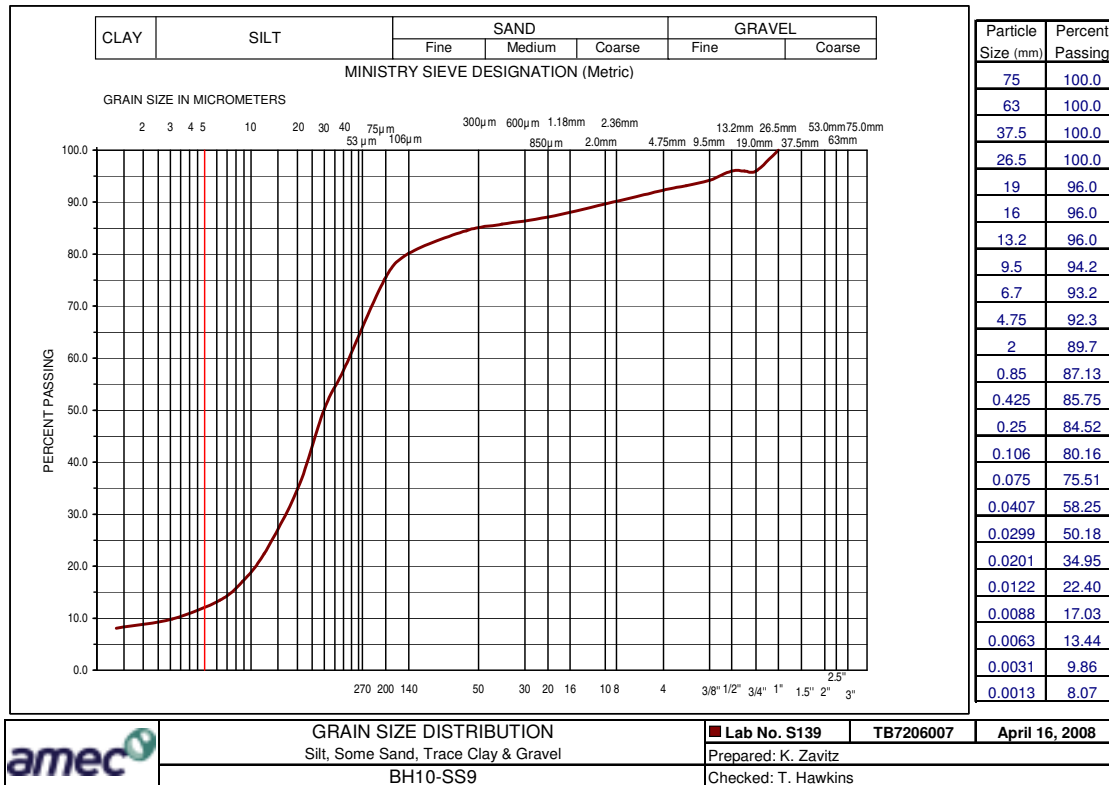
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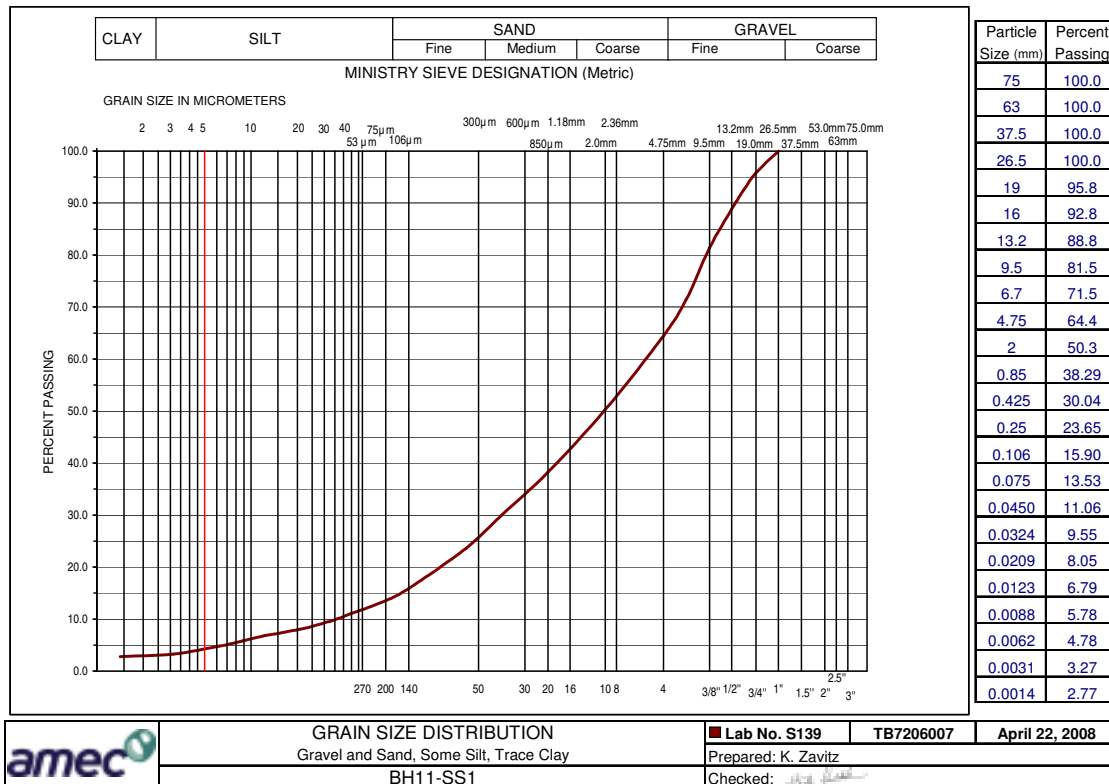
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Enclosure: 31B



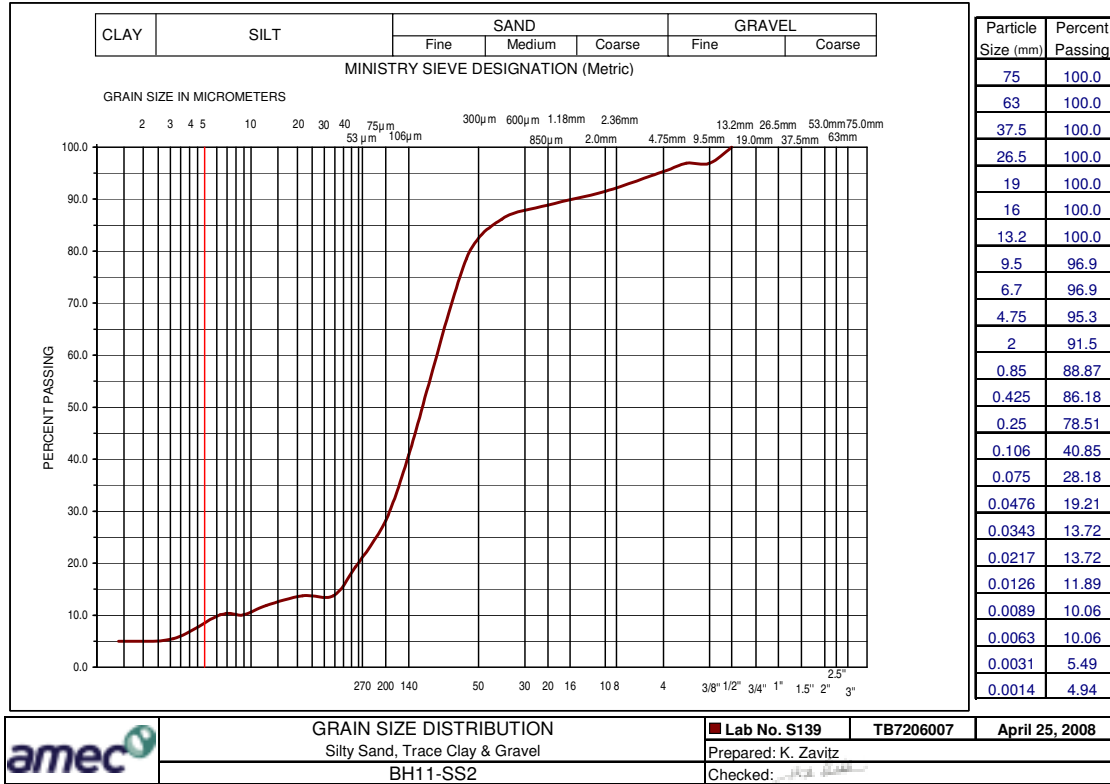
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Enclosure: 32B



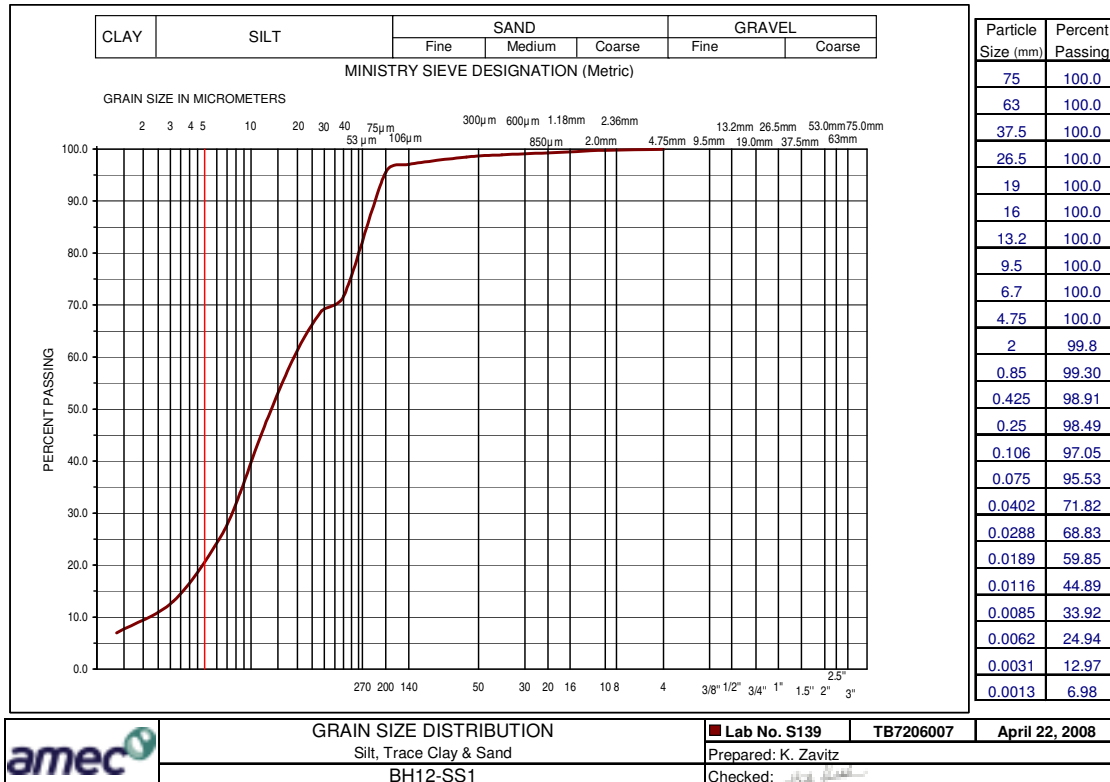
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Enclosure: 33B



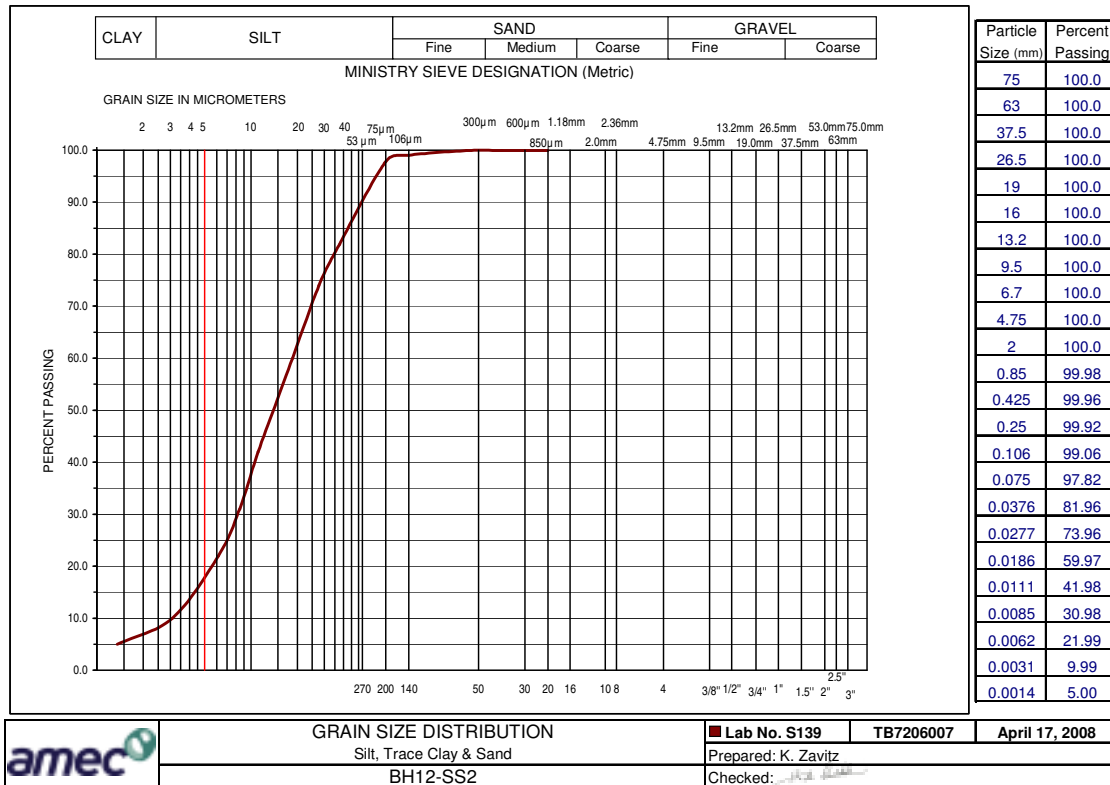
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Enclosure: 34B



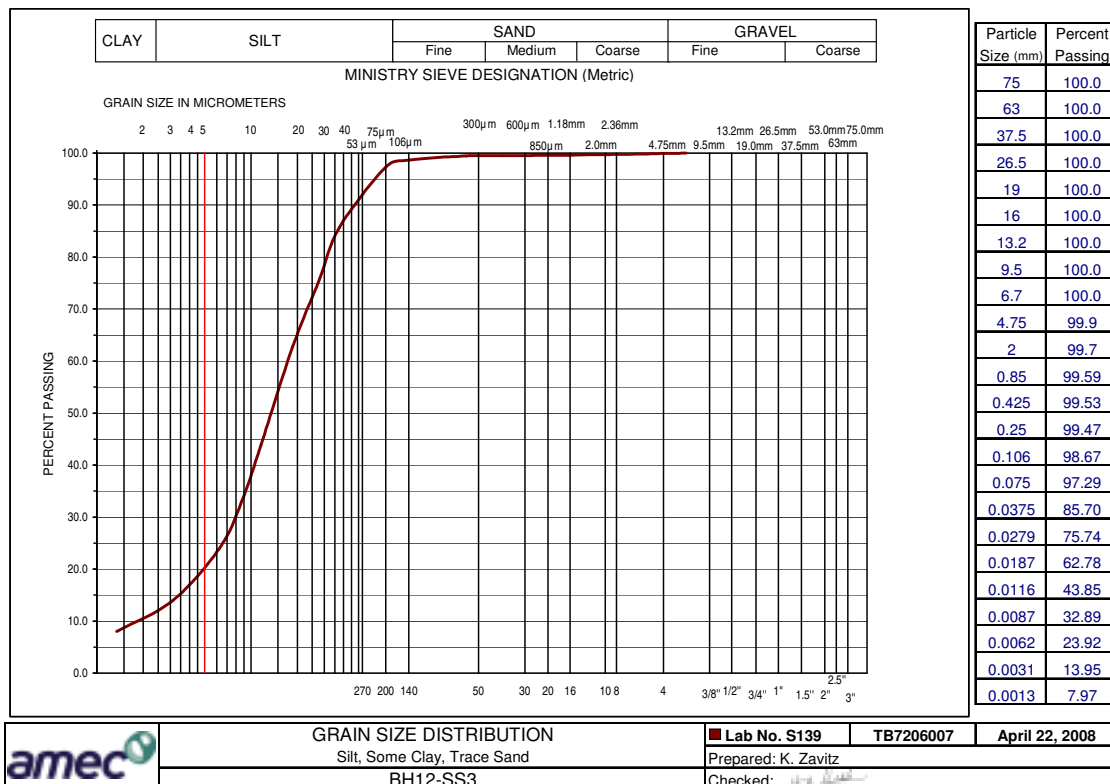
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Enclosure: 35B



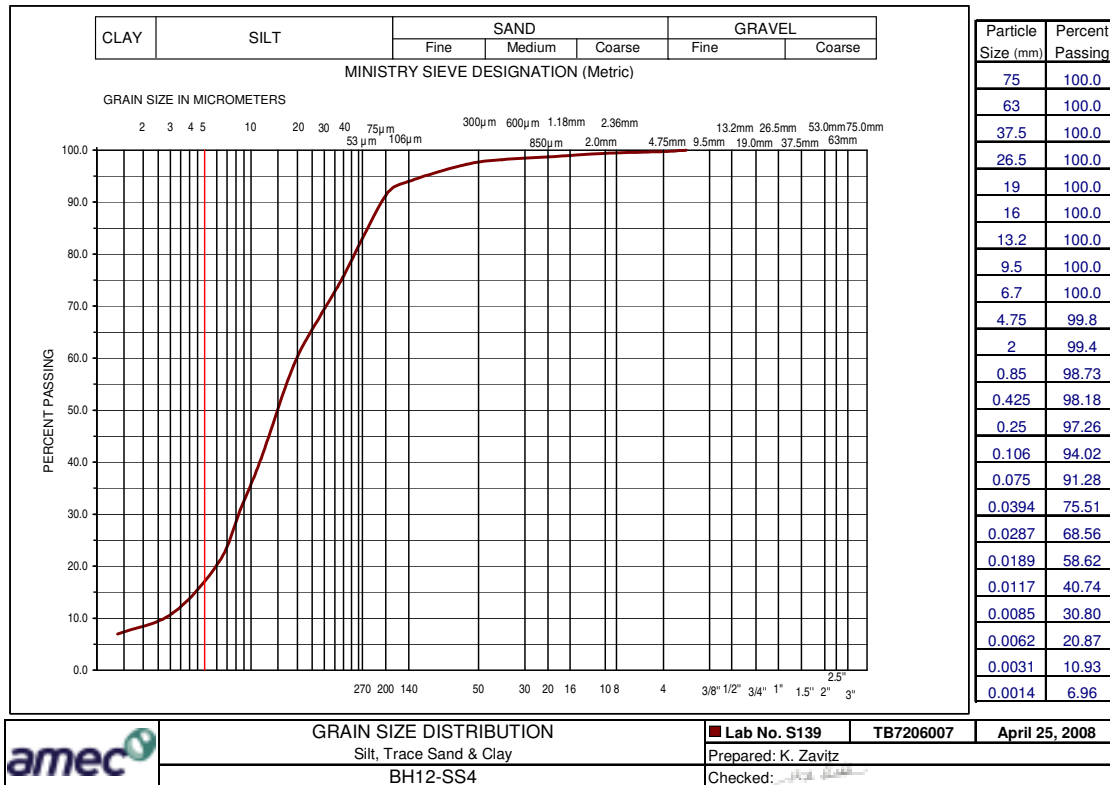
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Enclosure: 36B



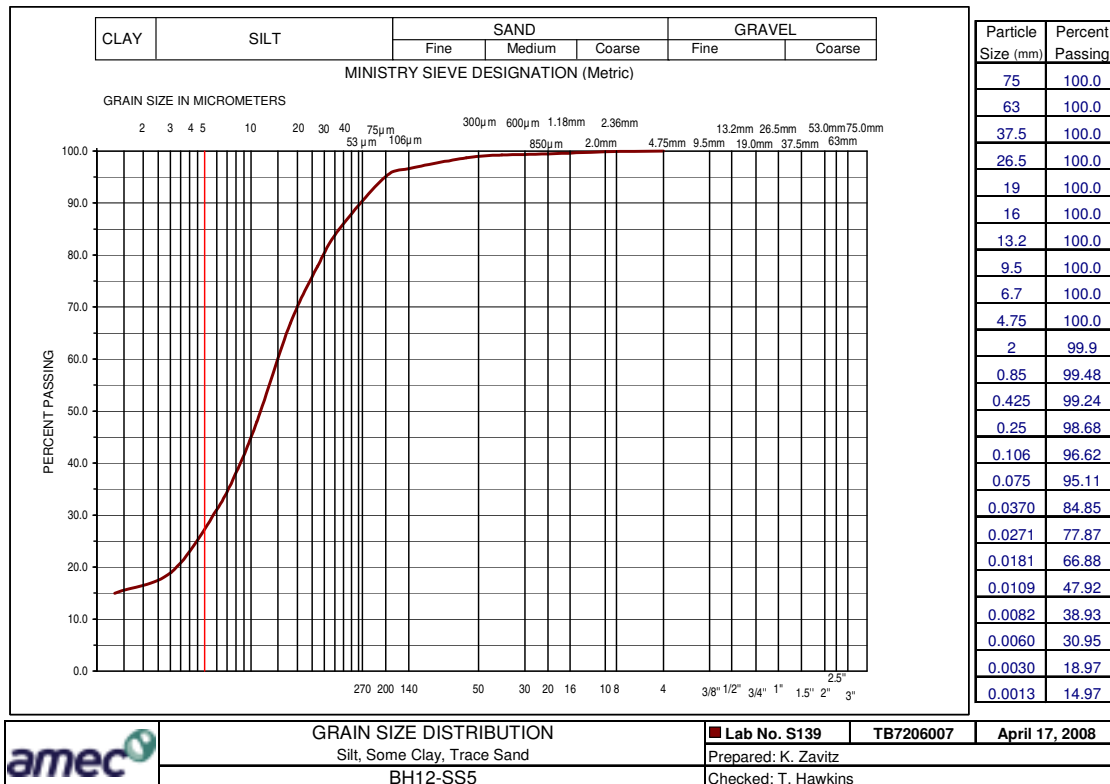
UNIFIED SOIL CLASSIFICATION SYSTEM

Enclosure: 37B



UNIFIED SOIL CLASSIFICATION SYSTEM

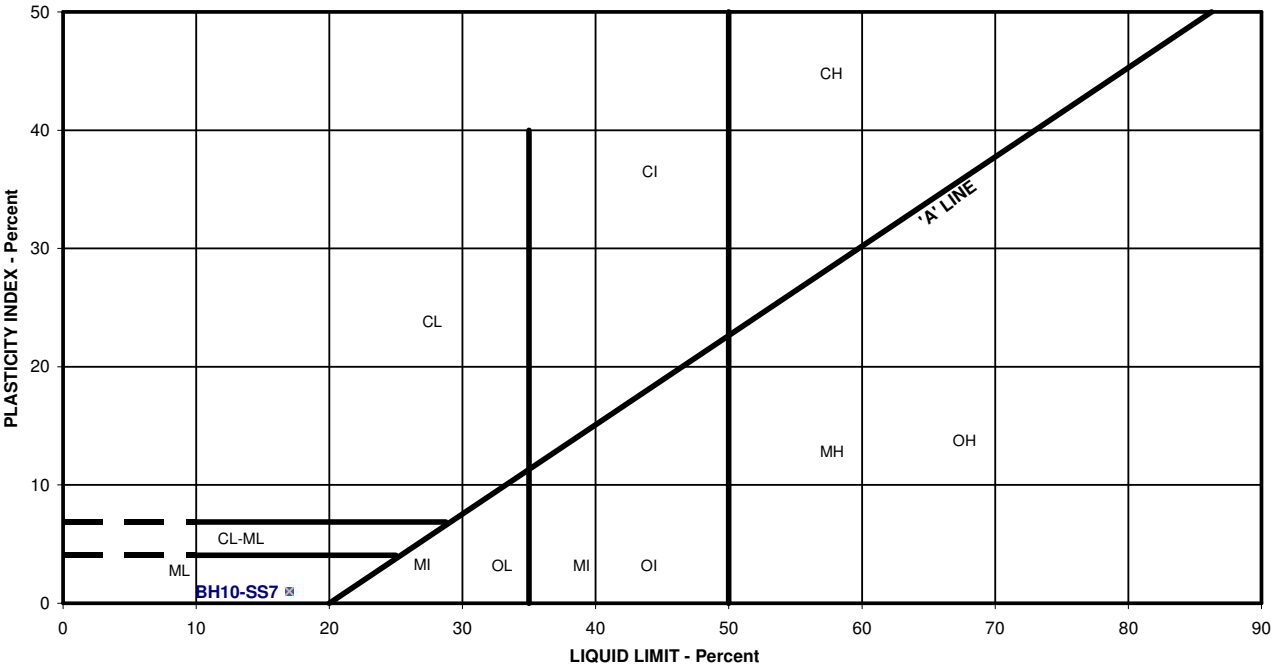
Enclosure: 38B



PLASTICITY CHART

(BH10-SS7): LL = 17, PL = 16, PI = 1

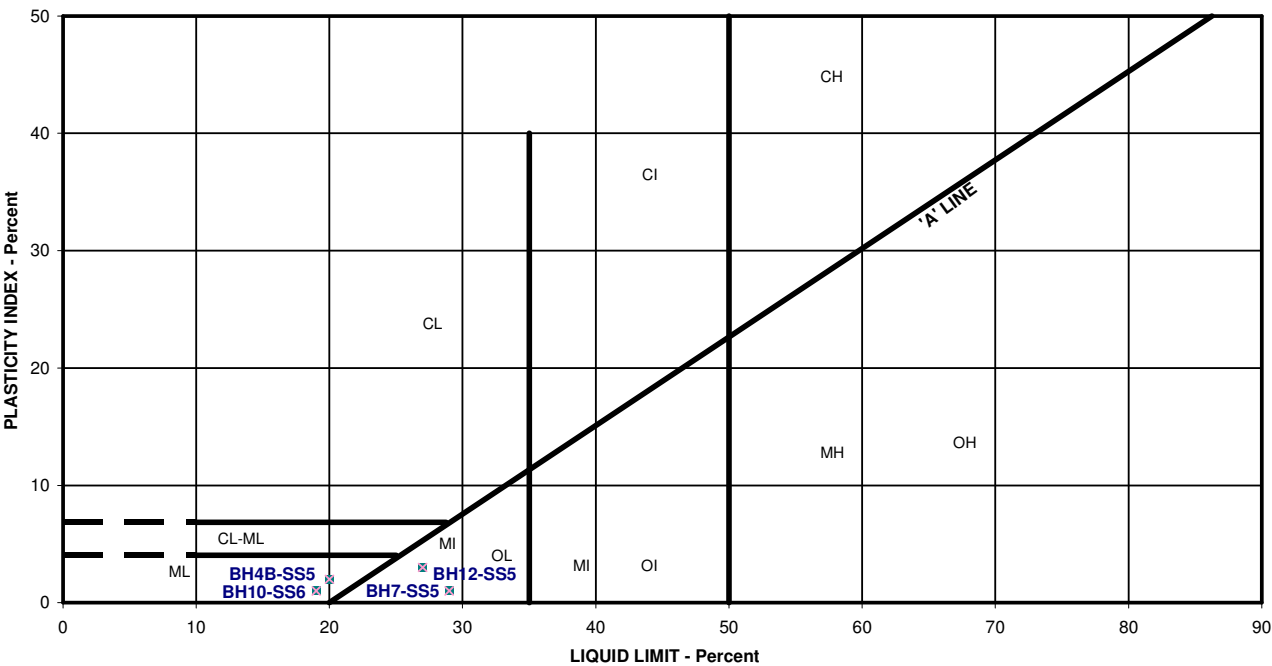
BH7-SS9, BH2A-SS8, BH4B-SS7, BH10-SS8, BH7-SS8, BH2A-SS7 were found to be non-plastic



PLASTICITY CHART

D1 (BH4B-SS5): LL = 20, PL = 18, PI = 2 ~ D2 (BH10-SS6): LL = 19, PL = 18, PI = 1

M1 (BH7-SS5): LL = 29, PL = 28, PI = 1 ~ M2 (BH12-SS5): LL = 27, PL = 24, PI = 3



<p>APPENDIX C</p> <p>SITE PHOTOGRAPHS</p>

APPENDIX C - PHOTOGRAPHIC RECORD

PROJECT NO. MTO NE Region Agreement #5006-E-0070

PROJECT Hwy 11 at Pan Lake, 10.6km North Of Highway 64

LOCATION Olive Twp, Ontario

ENCLOSURE 1



PHOTOGRAPH

1

General View

Hwy 11 Pan Lake Looking South



PHOTOGRAPH

2

General View

Hwy 11 Pan Lake Looking North

APPENDIX C - PHOTOGRAPHIC RECORD

PROJECT NO. MTO NE Region Agreement #5006-E-0070

PROJECT Hwy 11 at Pan Lake, 10.6km North Of Highway 64

LOCATION Olive Twp, Ontario

ENCLOSURE 2



PHOTOGRAPH

3

Guiderail

Hwy 11 Pan Lake Looking North. Existing guiderail and embankment on Highway 11 at Pan Lake



PHOTOGRAPH

4

Guiderail

Hwy 11 Pan Lake Looking North

APPENDIX C - PHOTOGRAPHIC RECORD

PROJECT NO. MTO NE Region Agreement #5006-E-0070

PROJECT Hwy 11 at Pan Lake, 10.6km North Of Highway 64

LOCATION Olive Twp, Ontario

ENCLOSURE 3

	<table border="1"> <tr> <td>PHOTOGRAPH</td><td>5</td></tr> </table>	PHOTOGRAPH	5
PHOTOGRAPH	5		
<table border="1"> <tr> <td>General View</td></tr> </table>	General View		
General View			
<p>Hwy 11 Pan Lake Looking North</p>			

		<table border="1"> <tr> <td>PHOTOGRAPH</td><td>6</td></tr> </table>	PHOTOGRAPH	6
PHOTOGRAPH	6			
<table border="1"> <tr> <td>BH #7 @ Station 14+850</td></tr> </table>	BH #7 @ Station 14+850			
BH #7 @ Station 14+850				
<p>Hwy 11 Pan Lake Looking North. Tripod Drill rig and hand tools</p>				

APPENDIX C - PHOTOGRAPHIC RECORD

PROJECT NO. MTO NE Region Agreement #5006-E-0070

PROJECT Hwy 11 at Pan Lake, 10.6km North Of Highway 64

LOCATION Olive Twp, Ontario

ENCLOSURE 4



PHOTOGRAPH

7

Pavement Condition

Hwy 11 Pan Lake Looking North



PHOTOGRAPH

8

Site Condition

Existing guiderail and embankment on Highway 11 at Pan Lake

APPENDIX D

SLOPE STABILITY ANALYSES

Ref.: TB7206007
 STATION 14+800
 Total Stress Analysis
 (Based on Boreholes BH3, BH4, BH4A & BH4B)

Soil Properties Used

Soil Layer No	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (deg.)
1 Water			
2 Rock Fill	21	0	35
3 Very Soft Clay	16	10	0
4 Soft Clay	17	20	0
5 Very stiff Clay	18	60	0
6 Loose Sand	18	0	29
7 Bedrock			

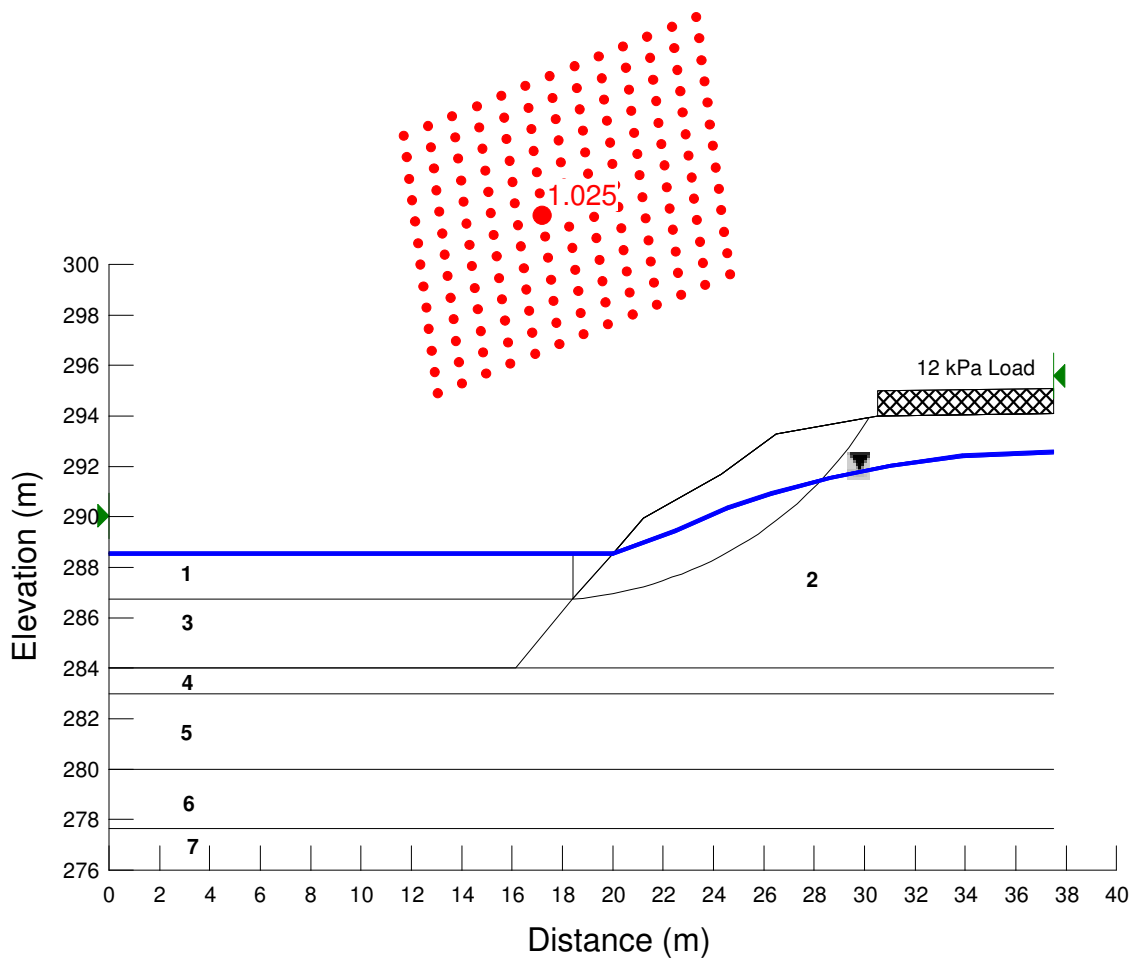


Figure D1.1 Stability of HWY11 Road Section at Sta. 14+800
 (Slip Surface within Rockfill)

Ref.: TB7206007
 STATION 14+800
 Total Stress Analysis
 (Based on Boreholes BH3, BH4, BH4A & BH4B)

Soil Properties Used			
Soil Layer No	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (deg.)
1 Water			
2 Rock Fill	21	0	35
3 Very Soft Clay	16	10	0
4 Soft Clay	17	20	0
5 Very stiff Clay	18	60	0
6 Loose Sand	18	0	29
7 Bedrock			

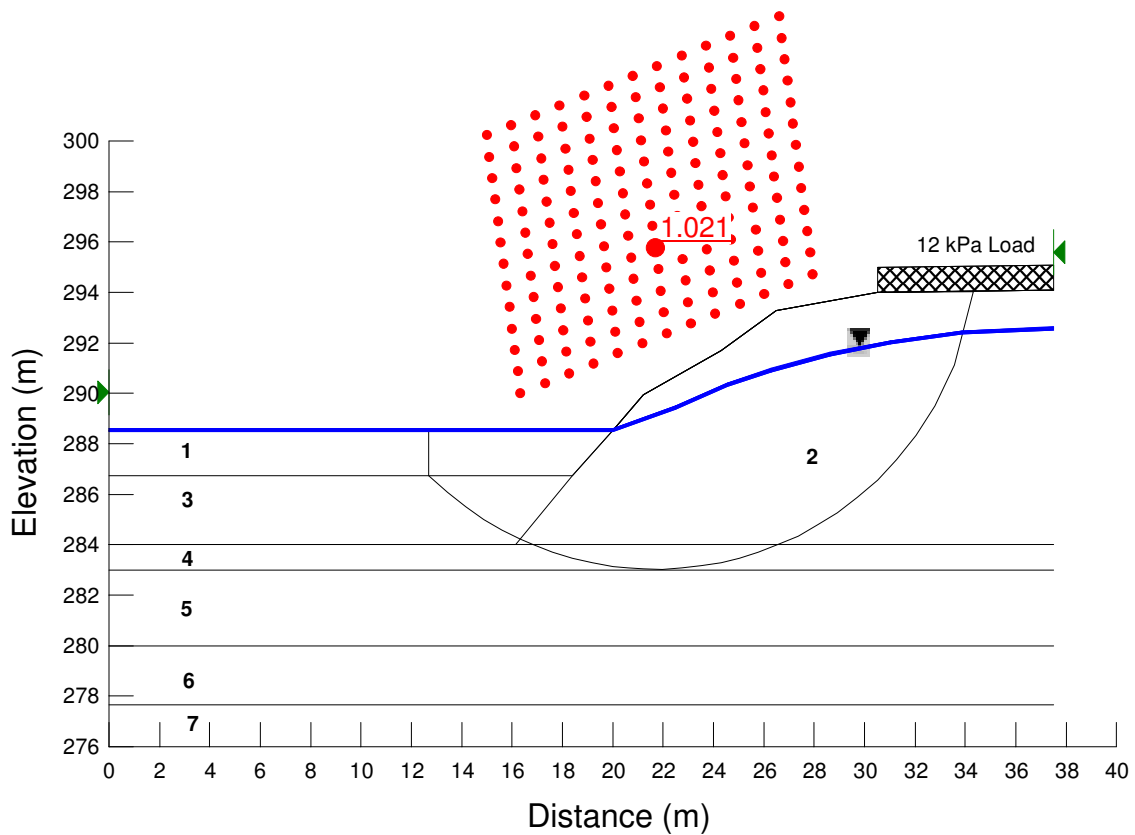


Figure D1.2 Stability of HWY11 Road Section at Sta. 14+800
 (Deep Seated Slip Surface with Weak Layer below Rockfill)

Ref.: TB7206007
 STATION 14+800
 Total Stress Analysis
 (Based on Boreholes BH3, BH4, BH4A & BH4B)

Soil Properties Used

Soil Layer No	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (deg.)
1 Water			
2 Rock Fill	21	0	35
3 Very Soft Clay	16	10	0
4 Very stiff Clay	18	60	0
5 Very stiff Clay	18	60	0
6 Loose Sand	18	0	29
7 Bedrock			

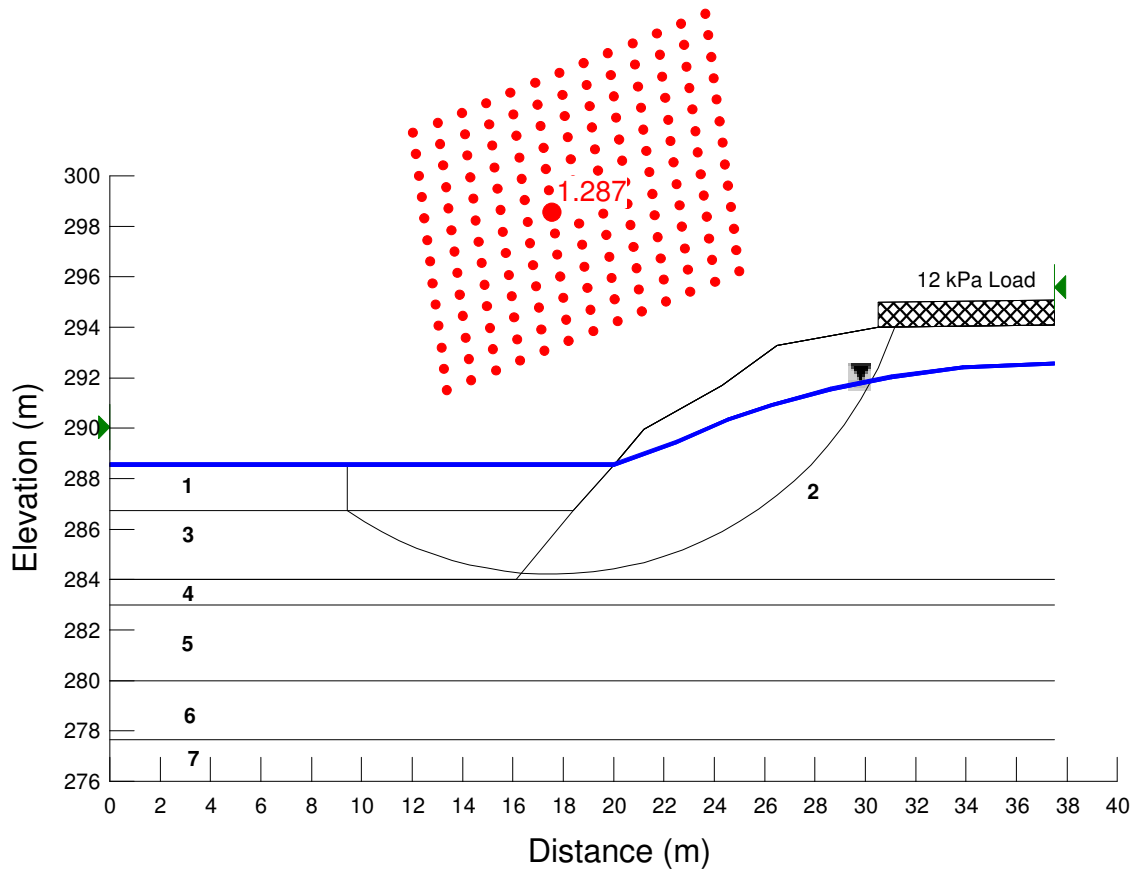


Figure D1.3 Stability of HWY11 Road Section at Sta. 14+800
 (Deep Seated Slip Surface without Weak Layer below Rockfill)

Ref.: TB7206007
 STATION 14+800
 Total Stress Analysis
 (Based on Boreholes BH3, BH4, BH4A & BH4B)

Soil Properties Used

Soil Layer No	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (deg.)
1 Water			
2 Rock Fill	21	0	35
3 Very Soft Clay	16	10	0
4 Soft Clay	17	20	0
5 Very stiff Clay	18	60	0
6 Loose Sand	18	0	29
7 Bedrock			

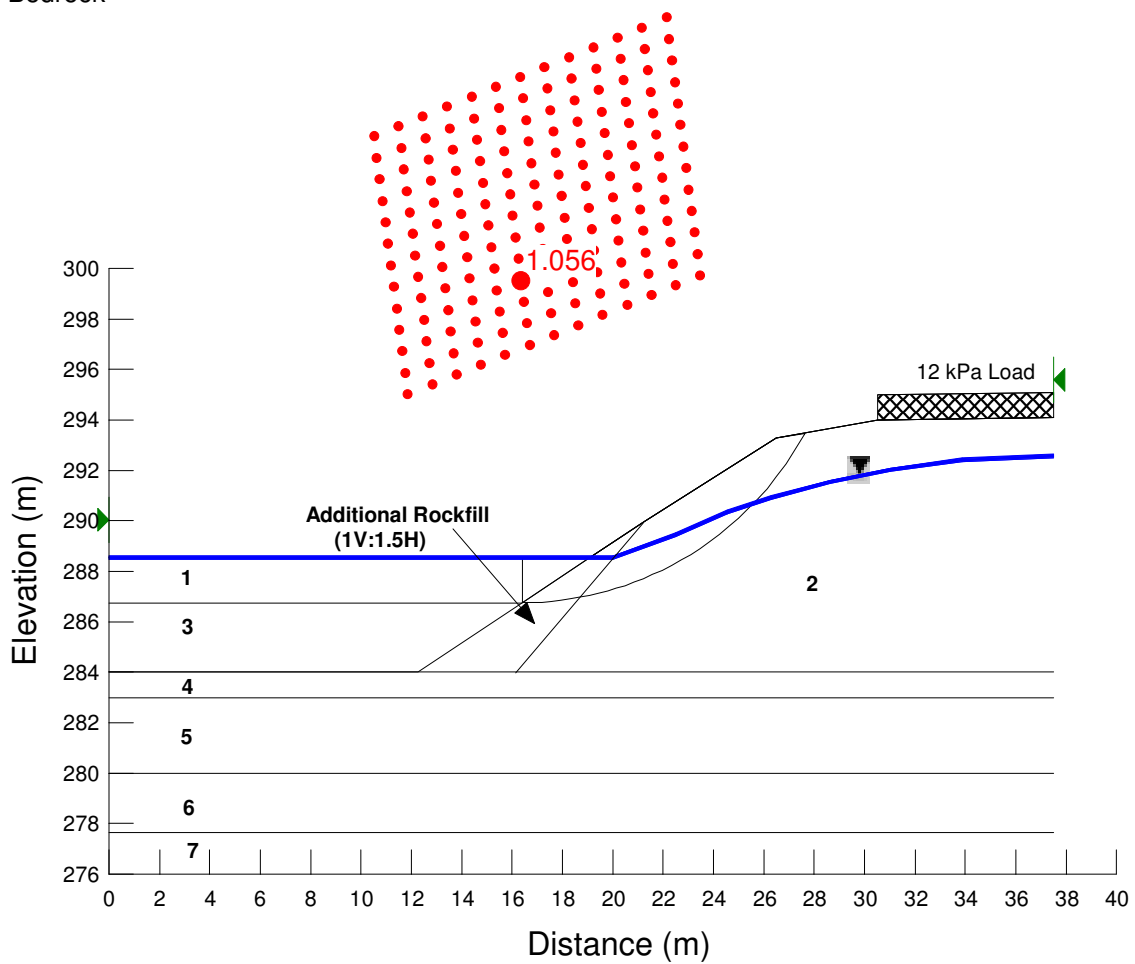


Figure D2.1 Stability of HWY11 Road Section at Sta. 14+800
 (Slip Surface within Rockfill with additional Rockfill in Lake)

Ref.: TB7206007
 STATION 14+800
 Total Stress Analysis
 (Based on Boreholes BH3, BH4, BH4A & BH4B)

Soil Properties Used

Soil Layer No	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (deg.)
1 Water			
2 Rock Fill	21	0	35
3 Very Soft Clay	16	10	0
4 Soft Clay	17	20	0
5 Very stiff Clay	18	60	0
6 Loose Sand	18	0	29
7 Bedrock			

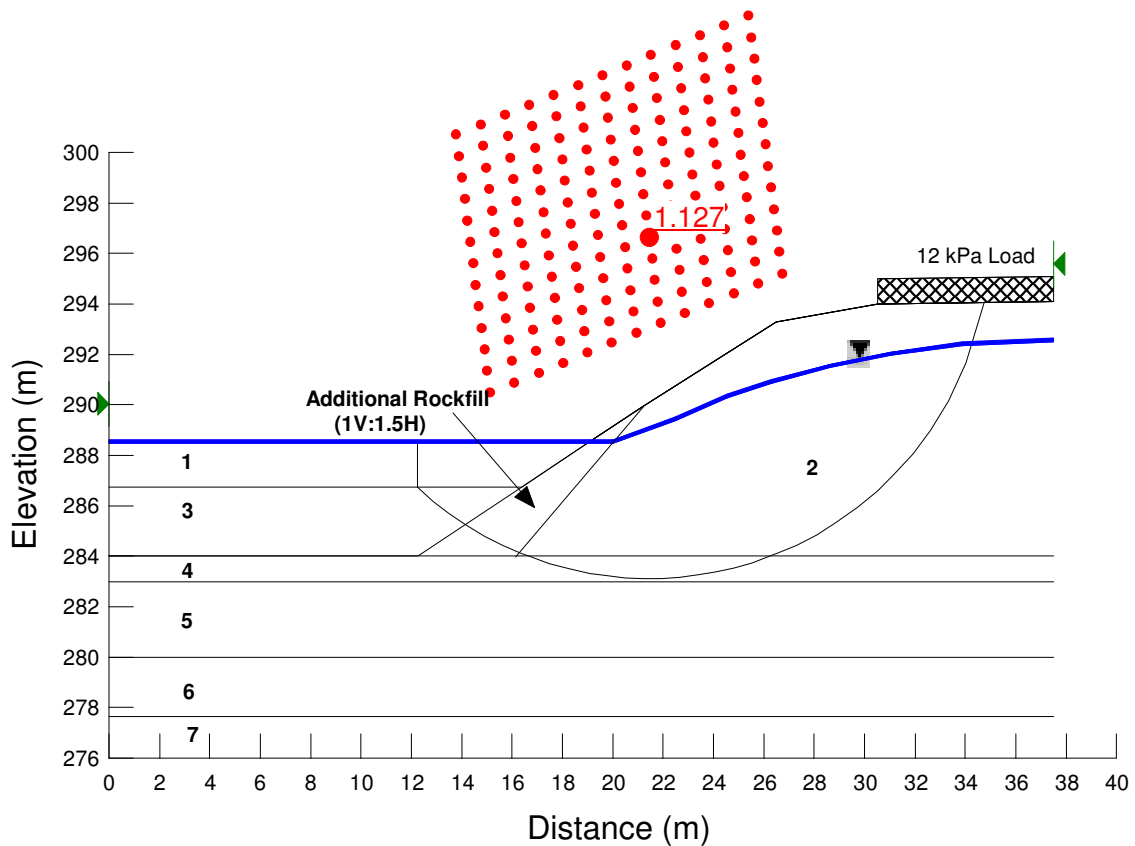


Figure D2.2 Stability of HWY11 Road Section at Sta. 14+800
 (Deep Seated Slip Surface with additional Rockfill in Lake)

Ref.: TB7206007
 STATION 14+800
 Total Stress Analysis
 (Based on Boreholes BH3, BH4, BH4A & BH4B)

Soil Properties Used

Soil Layer No	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (deg.)
1 Water			
2 Rock Fill	21	0	35
3 Very Soft Clay	16	10	0
4 Soft Clay	17	20	0
5 Very stiff Clay	18	60	0
6 Loose Sand	18	0	29
7 Bedrock			

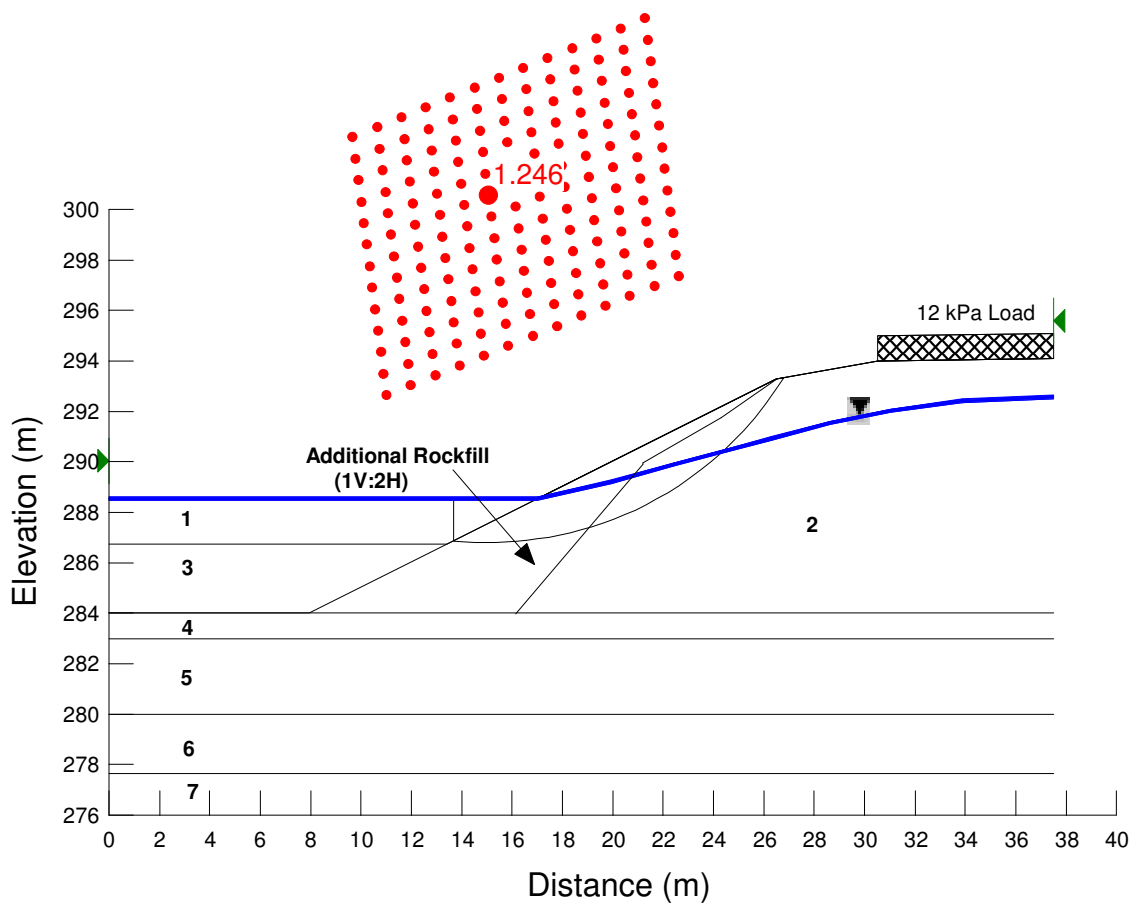


Figure D2.3 Stability of HWY11 Road Section at Sta. 14+800
 (Slip Surface within Rockfill with additional Rockfill in Lake)

Ref.: TB7206007
 STATION 14+800
 Total Stress Analysis
 (Based on Boreholes BH3, BH4, BH4A & BH4B)

Soil Properties Used

Soil Layer No	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (deg.)
1 Water			
2 Rock Fill	21	0	35
3 Very Soft Clay	16	10	0
4 Soft Clay	17	20	0
5 Very stiff Clay	18	60	0
6 Loose Sand	18	0	29
7 Bedrock			

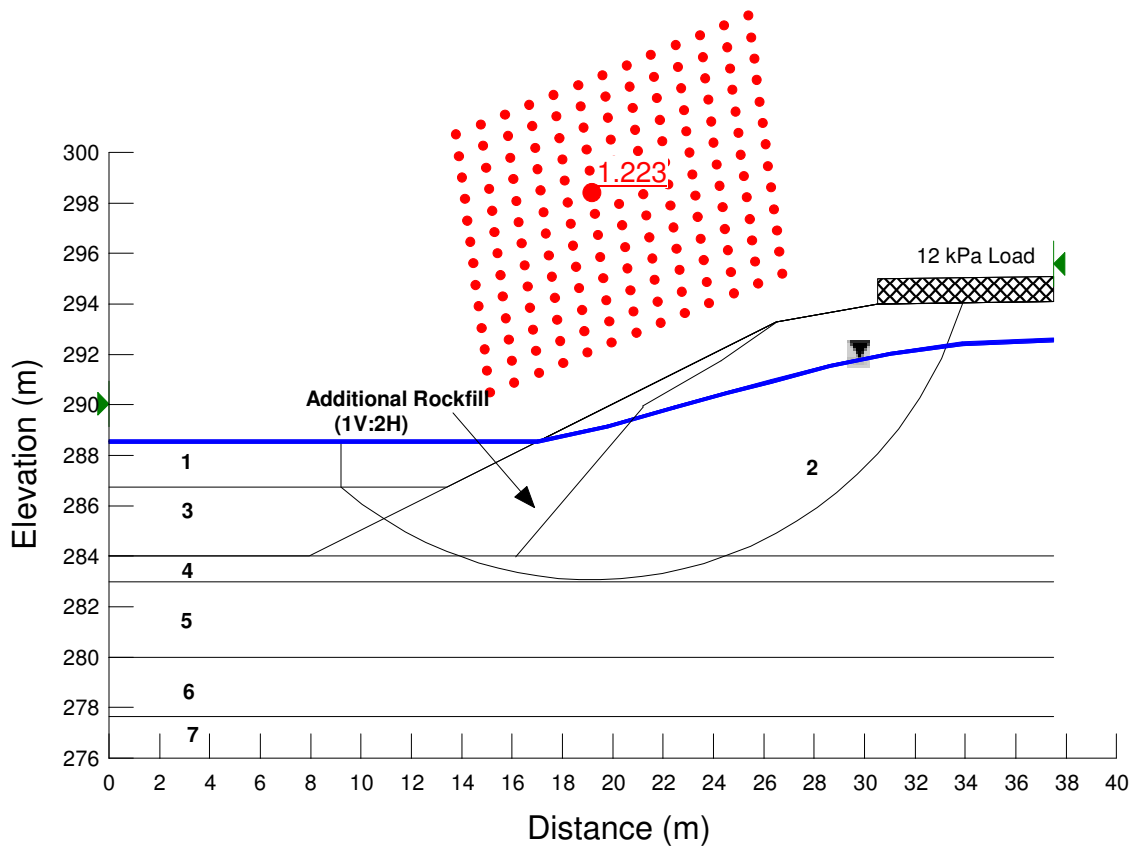
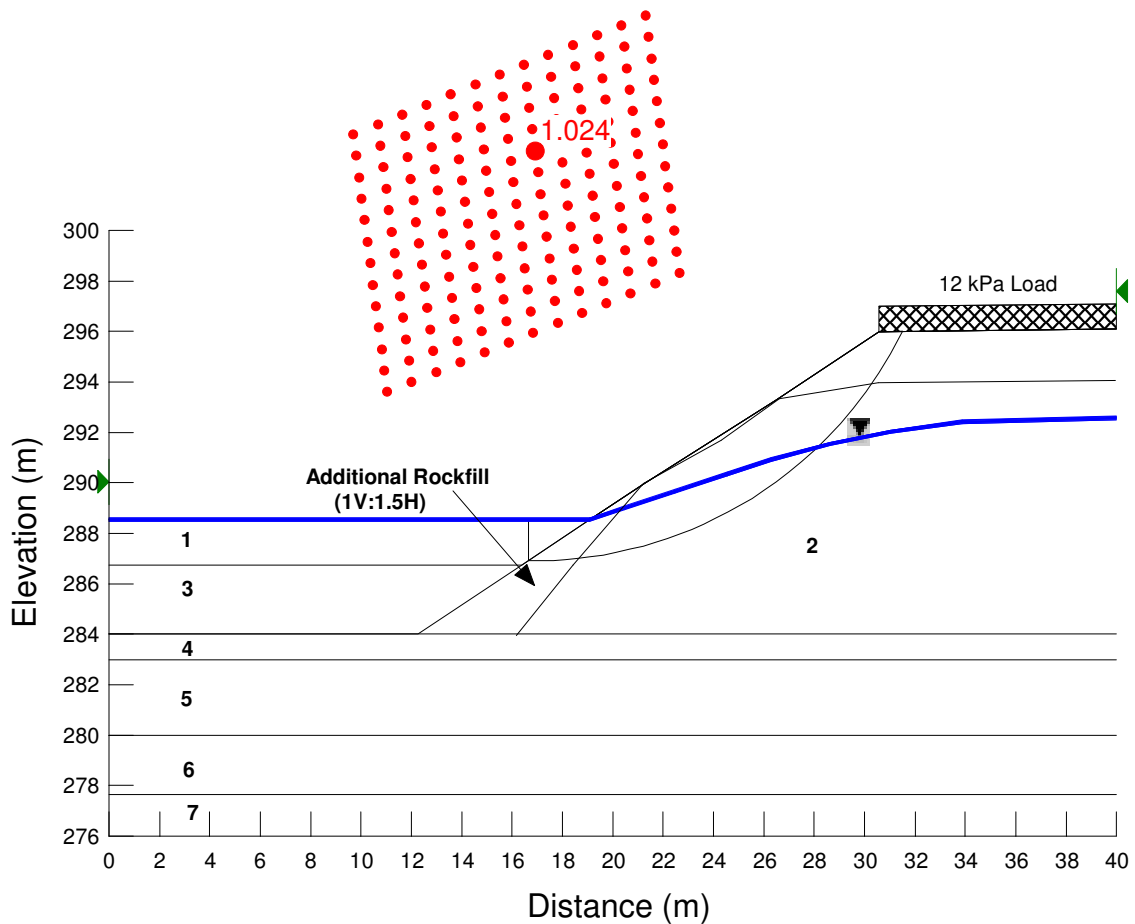


Figure D2.4 Stability of HWY11 Road Section at Sta. 14+800
 (Deep Seated Slip Surface with additional Rockfill in Lake)

Ref.: TB7206007
 STATION 14+800
 Total Stress Analysis
 (Based on Boreholes BH3, BH4, BH4A & BH4B)

Soil Properties Used

Soil Layer No	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (deg.)
1 Water			
2 Rock Fill	21	0	35
3 Very Soft Clay	16	10	0
4 Soft Clay	17	20	0
5 Very stiff Clay	18	60	0
6 Loose Sand	18	0	29
7 Bedrock			



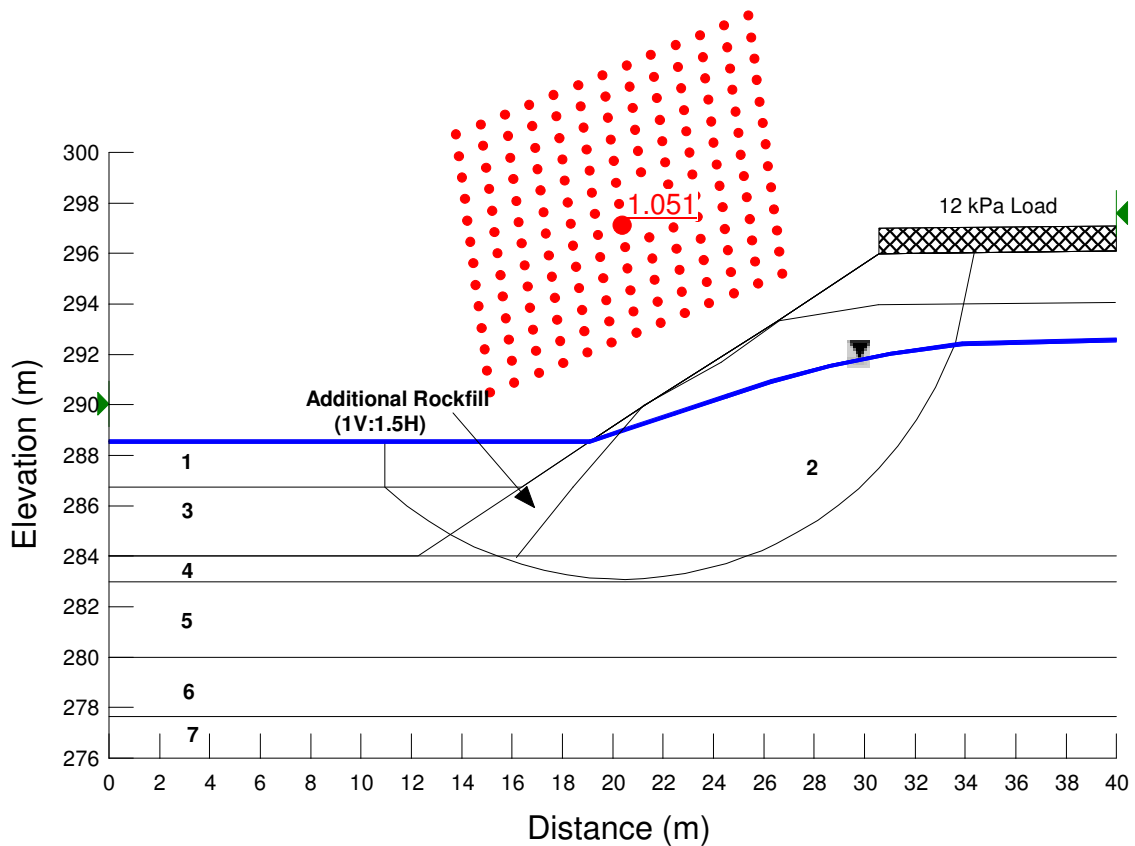
Embankment Widening - 2.5m horizontal alignment shift & a 2m grade raise

Figure D3.1 Stability of HWY11 Road Section at Sta. 14+800
 (Slip Surface within Rockfill with additional Rockfill in Lake)

Ref.: TB7206007
 STATION 14+800
 Total Stress Analysis
 (Based on Boreholes BH3, BH4, BH4A & BH4B)

Soil Properties Used

Soil Layer No	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (deg.)
1 Water			
2 Rock Fill	21	0	35
3 Very Soft Clay	16	10	0
4 Soft Clay	17	20	0
5 Very stiff Clay	18	60	0
6 Loose Sand	18	0	29
7 Bedrock			

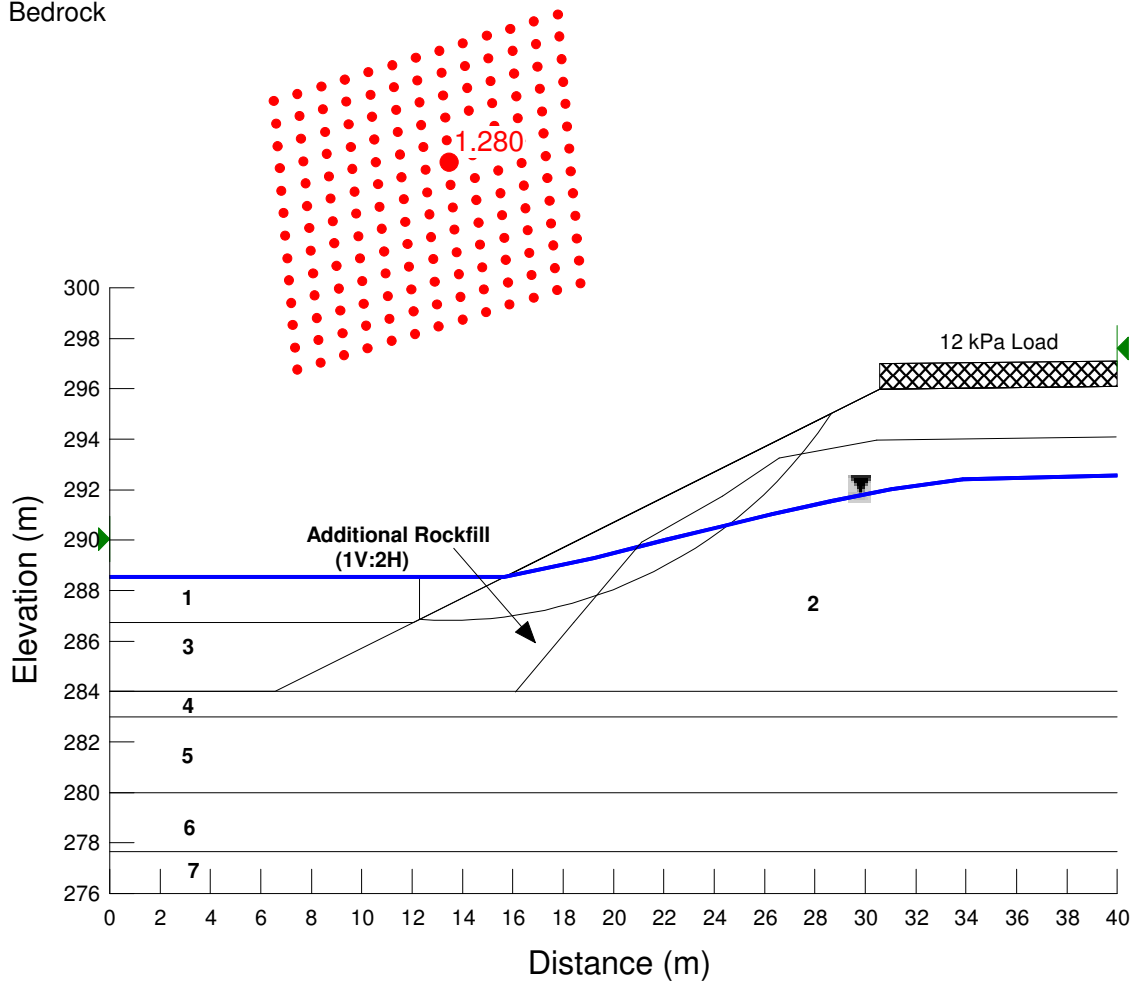


Embankment Widening - 2.5m horizontal alignment shift & a 2m grade raise

Figure D3.2 Stability of HWY11 Road Section at Sta. 14+800
 (Deep Seated Slip Surface with additional Rockfill in Lake)

Ref.: TB7206007
 STATION 14+800
 Total Stress Analysis
 (Based on Boreholes BH3, BH4, BH4A & BH4B)

Soil Properties Used			
Soil Layer No	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (deg.)
1 Water			
2 Rock Fill	21	0	35
3 Very Soft Clay	16	10	0
4 Soft Clay	17	20	0
5 Very stiff Clay	18	60	0
6 Loose Sand	18	0	29
7 Bedrock			



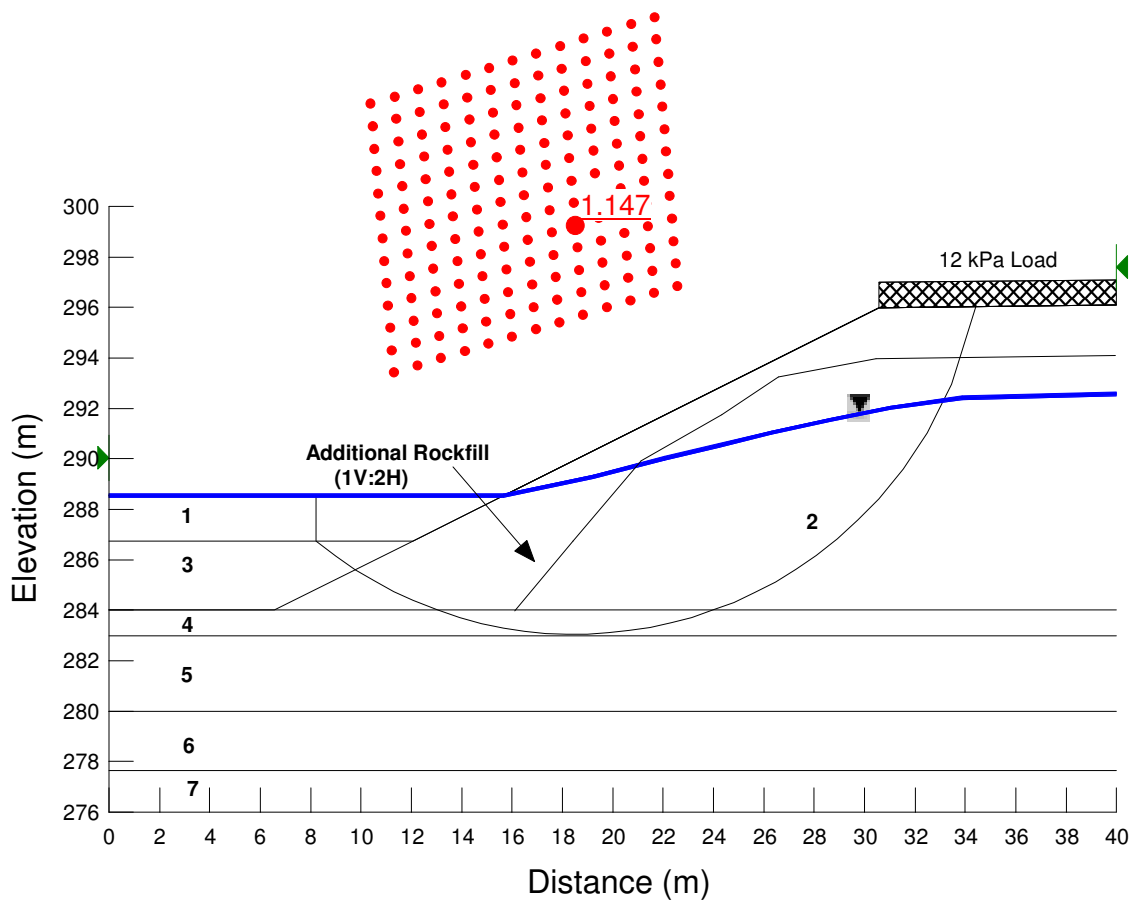
Embankment Widening - 2.5m horizontal alignment shift & a 2m grade raise

Figure D3.3 Stability of HWY11 Road Section at Sta. 14+800
 (Slip Surface within Rockfill with additional Rockfill in Lake)

Ref.: TB7206007
 STATION 14+800
 Total Stress Analysis
 (Based on Boreholes BH3, BH4, BH4A & BH4B)

Soil Properties Used

Soil Layer No	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (deg.)
1 Water			
2 Rock Fill	21	0	35
3 Very Soft Clay	16	10	0
4 Soft Clay	17	20	0
5 Very stiff Clay	18	60	0
6 Loose Sand	18	0	29
7 Bedrock			



Embankment Widening - 2.5m horizontal alignment shift & a 2m grade raise

Figure D3.4 Stability of HWY11 Road Section at Sta. 14+800
 (Deep Seated Slip Surface with additional Rockfill in Lake)

Ref.: TB7206007
 STATION 14+850
 Total Stress Analysis
 (Based on Boreholes BH5, BH6, BH6A, BH6B & BH7)

Soil Properties Used

Soil Layer No	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (deg.)
1 Water			
2 Rock Fill	21	0	35
3 Very Soft Clay	16	10	0
4 Soft Clay	17	20	0
5 Very stiff Clay	18	60	0
6 Bedrock			

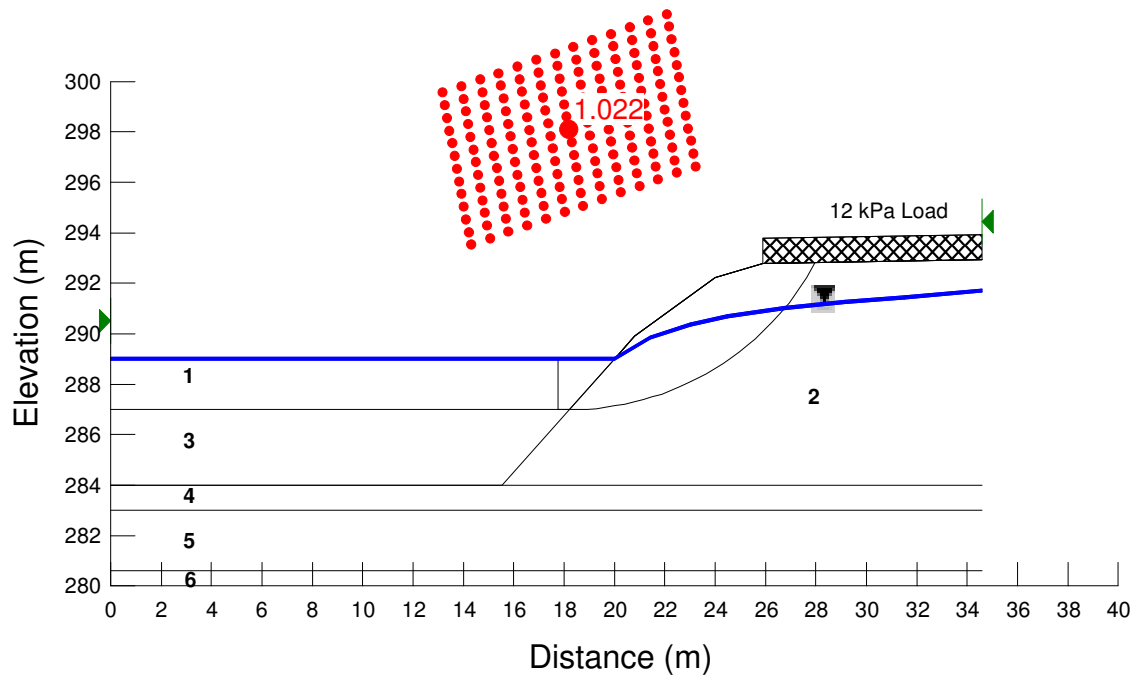


Figure D4.1 Stability of HWY11 Road Section at Sta. 14+850
 (Slip Surface within Rockfill)

Ref.: TB7206007
 STATION 14+850
 Total Stress Analysis
 (Based on Boreholes BH5, BH6, BH6A, BH6B & BH7)

Soil Properties Used

Soil Layer No	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (deg.)
1 Water			
2 Rock Fill	21	0	35
3 Very Soft Clay	16	10	0
4 Soft Clay	17	20	0
5 Very stiff Clay	18	60	0
6 Bedrock			

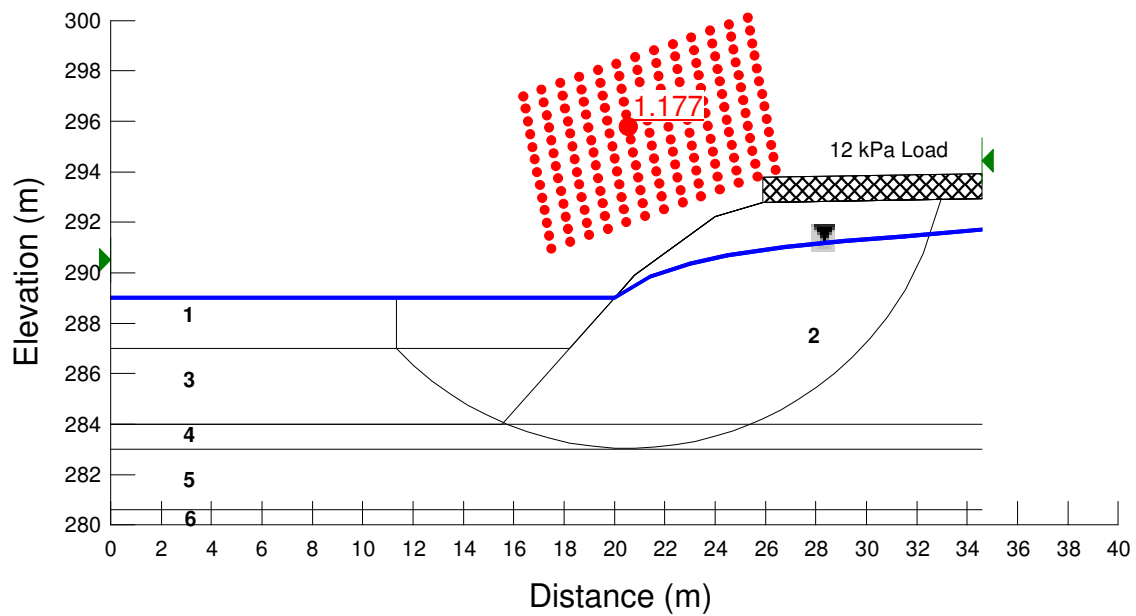


Figure D4.2 Stability of HWY11 Road Section at Sta. 14+850
 (Deep Seated Slip Surface with a Weak Layer below Rockfill)

Ref.: TB7206007
 STATION 14+850
 Total Stress Analysis
 (Based on Boreholes BH5, BH6, BH6A, BH6B & BH7)

Soil Properties Used

Soil Layer No	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (deg.)
1 Water			
2 Rock Fill	21	0	35
3 Very Soft Clay	16	10	0
4 Very stiff Clay	18	60	0
5 Very stiff Clay	18	60	0
6 Bedrock			

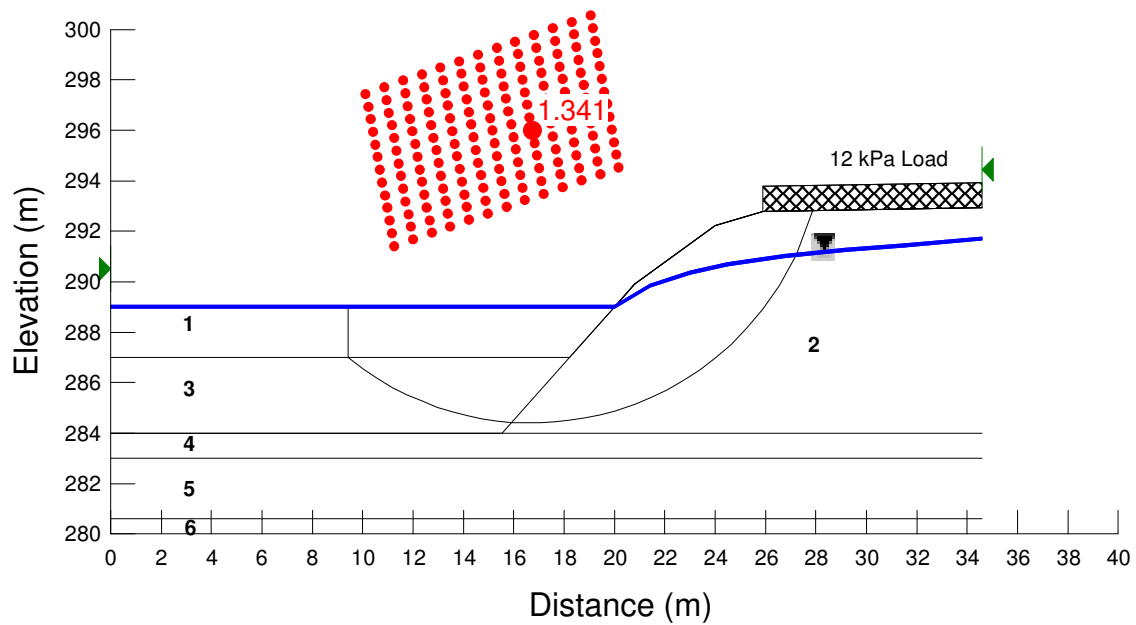


Figure D4.3 Stability of HWY11 Road Section at Sta. 14+850
 (Deep Seated Slip Surface without a Weak Layer below Rockfill)

Ref.: TB7206007
 STATION 14+850
 Total Stress Analysis
 (Based on Boreholes BH5, BH6, BH6A, BH6B & BH7)

Soil Properties Used

Soil Layer No	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (deg.)
1 Water			
2 Rock Fill	21	0	35
3 Very Soft Clay	16	10	0
4 Soft Clay	17	20	0
5 Very stiff Clay	18	60	0
6 Bedrock			

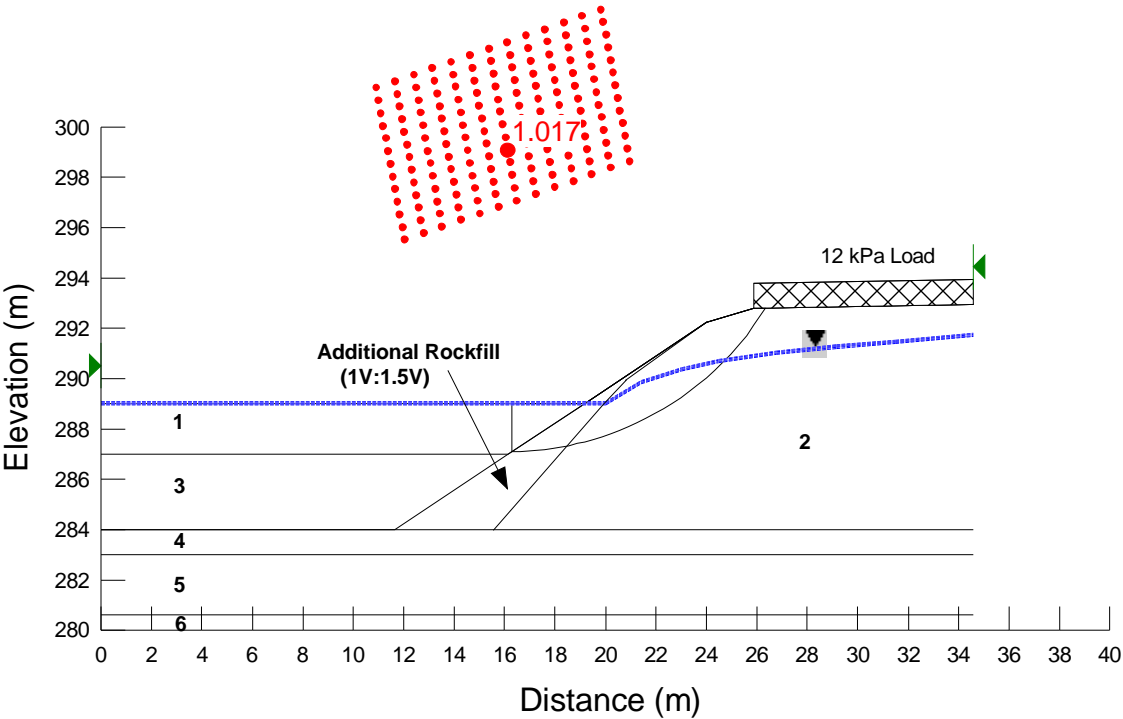


Figure D5.1 Stability of HWY11 Road Section at Sta. 14+850
 (Slip Surface within Rockfill with additional Rockfill in Lake)

Ref.: TB7206007
 STATION 14+850
 Total Stress Analysis
 (Based on Boreholes BH5, BH6, BH6A, BH6B & BH7)

Soil Properties Used

Soil Layer No	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (deg.)
1 Water			
2 Rock Fill	21	0	35
3 Very Soft Clay	16	10	0
4 Soft Clay	17	20	0
5 Very stiff Clay	18	60	0
6 Bedrock			

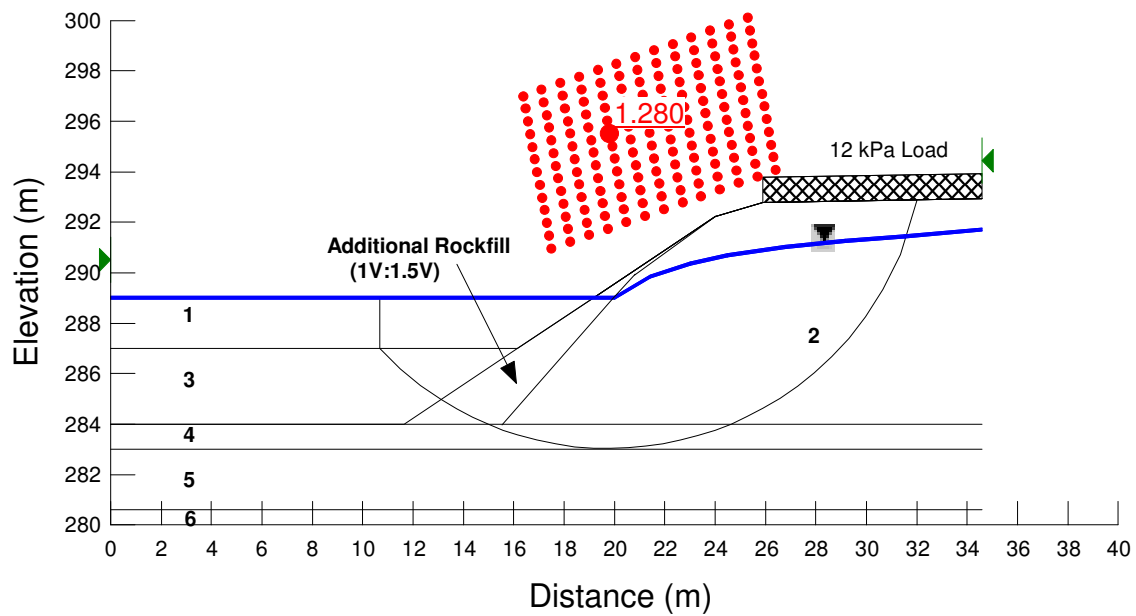


Figure D5.2 Stability of HWY11 Road Section at Sta. 14+850
 (Deep Seated Slip Surface with additional Rockfill in Lake)

Ref.: TB7206007
 STATION 14+850
 Total Stress Analysis
 (Based on Boreholes BH5, BH6, BH6A, BH6B & BH7)

Soil Properties Used

Soil Layer No	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (deg.)
1 Water			
2 Rock Fill	21	0	35
3 Very Soft Clay	16	10	0
4 Soft Clay	17	20	0
5 Very stiff Clay	18	60	0
6 Bedrock			

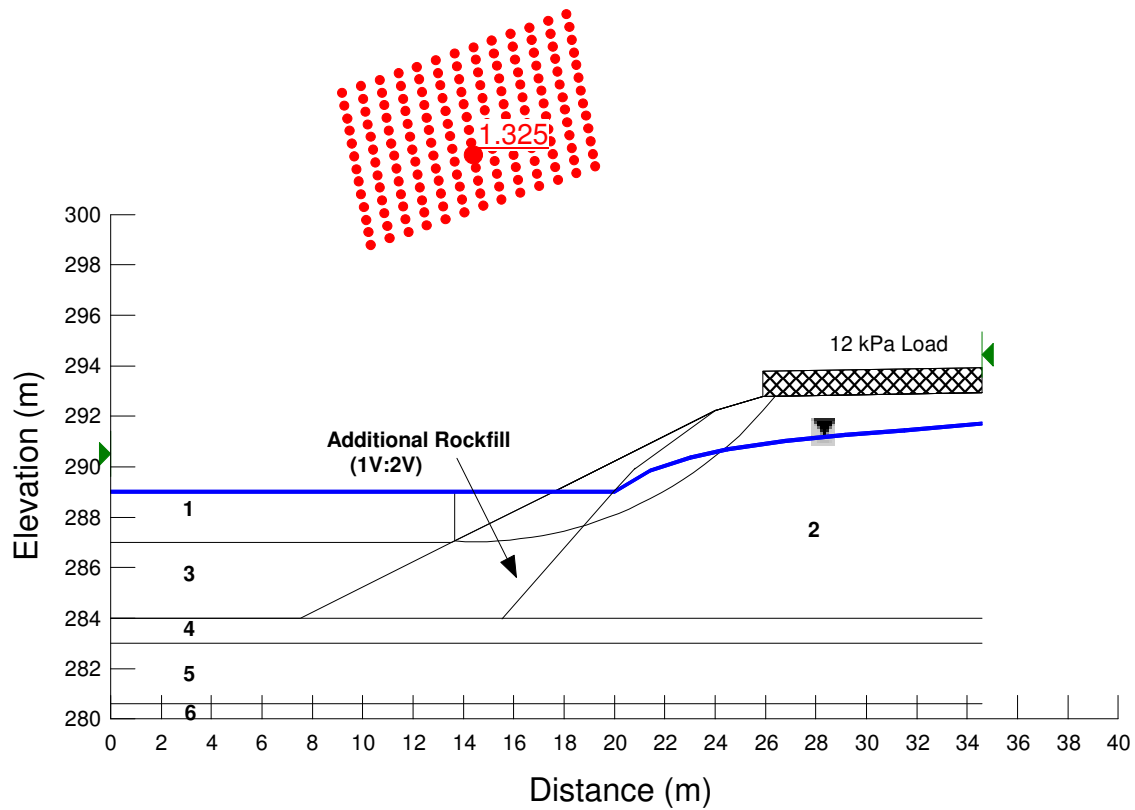


Figure D5.3 Stability of HWY11 Road Section at Sta. 14+850
 (Slip Surface within Rockfill with additional Rockfill in Lake)

Ref.: TB7206007
 STATION 14+850
 Total Stress Analysis
 (Based on Boreholes BH5, BH6, BH6A, BH6B & BH7)

Soil Properties Used

Soil Layer No	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (deg.)
1 Water			
2 Rock Fill	21	0	35
3 Very Soft Clay	16	10	0
4 Soft Clay	17	20	0
5 Very stiff Clay	18	60	0
6 Bedrock			

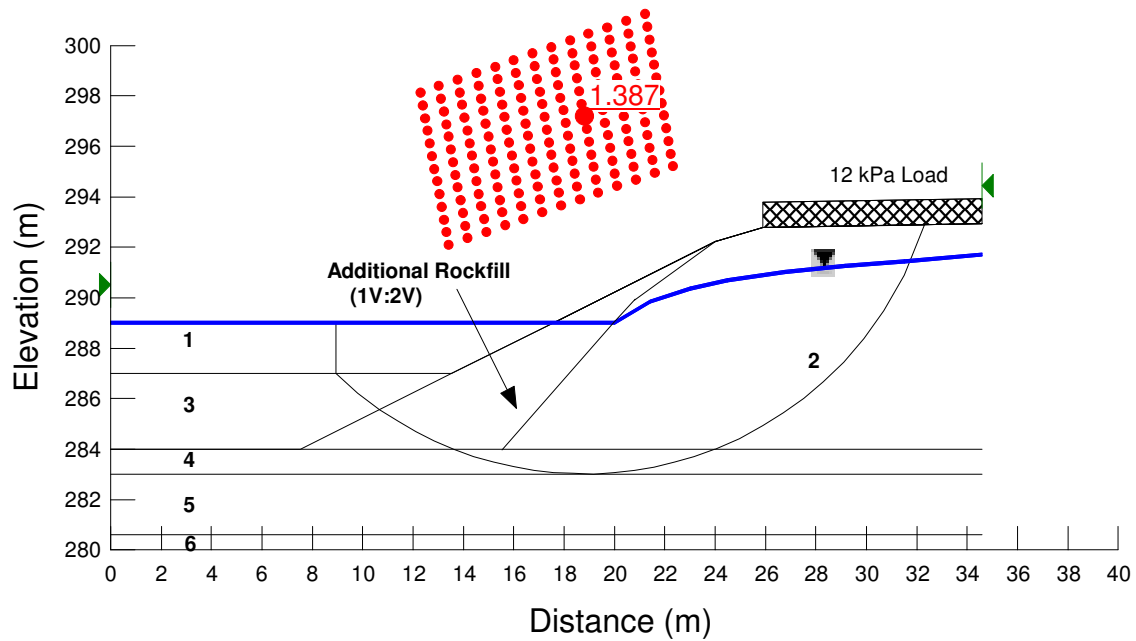
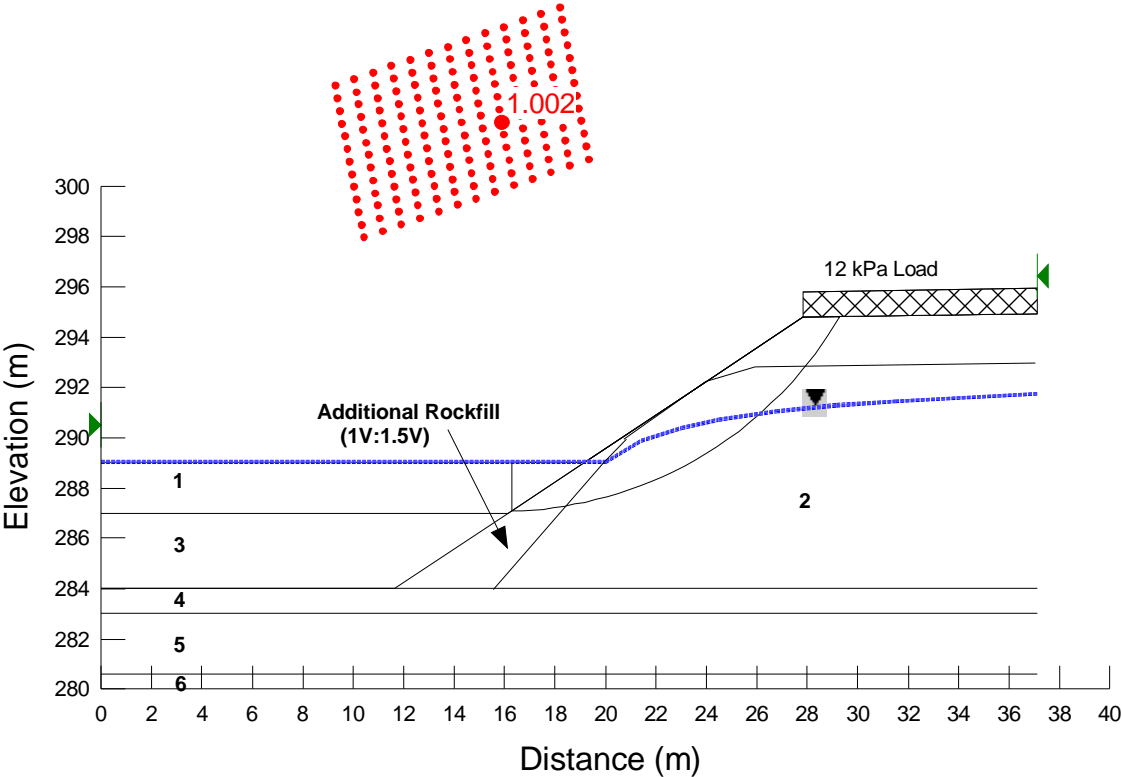


Figure D5.4 Stability of HWY11 Road Section at Sta. 14+850
 (Deep Seated Slip Surface with additional Rockfill in Lake)

Ref.: TB7206007
 STATION 14+850
 Total Stress Analysis
 (Based on Boreholes BH5, BH6, BH6A, BH6B & BH7)

Soil Properties Used

Soil Layer No	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (deg.)
1 Water			
2 Rock Fill	21	0	35
3 Very Soft Clay	16	10	0
4 Soft Clay	17	20	0
5 Very stiff Clay	18	60	0
6 Bedrock			



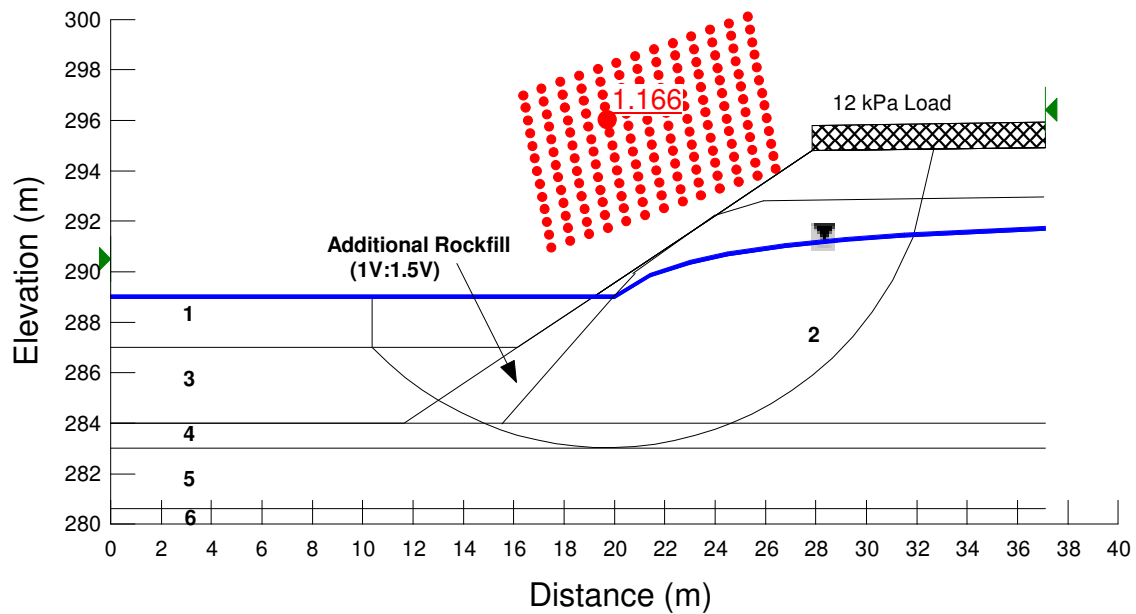
Embankment Widening - 2.5m horizontal alignment shift & a 2m grade raise

Figure D6.1 Stability of HWY11 Road Section at Sta. 14+850
 (Slip Surface within Rockfill with additional Rockfill in Lake)

Ref.: TB7206007
 STATION 14+850
 Total Stress Analysis
 (Based on Boreholes BH5, BH6, BH6A, BH6B & BH7)

Soil Properties Used

Soil Layer No	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (deg.)
1 Water			
2 Rock Fill	21	0	35
3 Very Soft Clay	16	10	0
4 Soft Clay	17	20	0
5 Very stiff Clay	18	60	0
6 Bedrock			



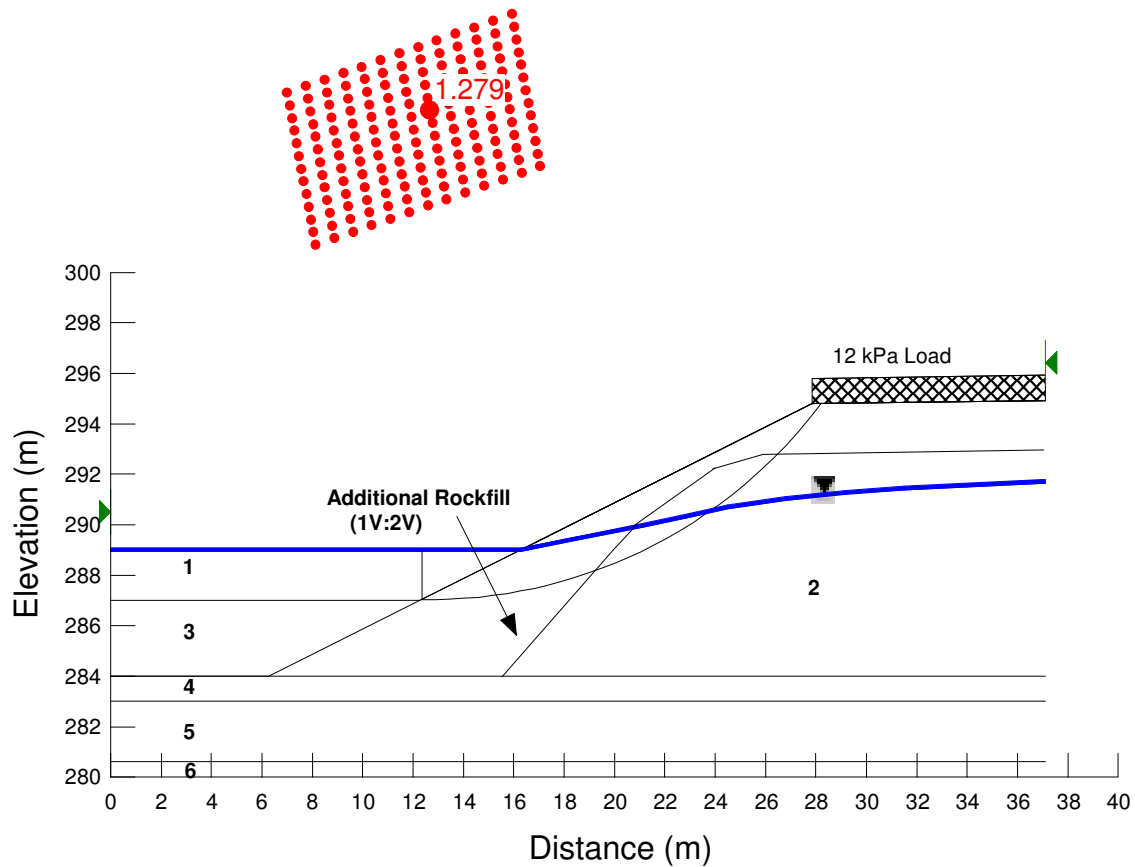
Embankment Widening - 2.5m horizontal alignment shift & a 2m grade raise

Figure D6.2 Stability of HWY11 Road Section at Sta. 14+850
 (Deep Seated Slip Surface with additional Rockfill in Lake)

Ref.: TB7206007
 STATION 14+850
 Total Stress Analysis
 (Based on Boreholes BH5, BH6, BH6A, BH6B & BH7)

Soil Properties Used

Soil Layer No	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (deg.)
1 Water			
2 Rock Fill	21	0	35
3 Very Soft Clay	16	10	0
4 Soft Clay	17	20	0
5 Very stiff Clay	18	60	0
6 Bedrock			



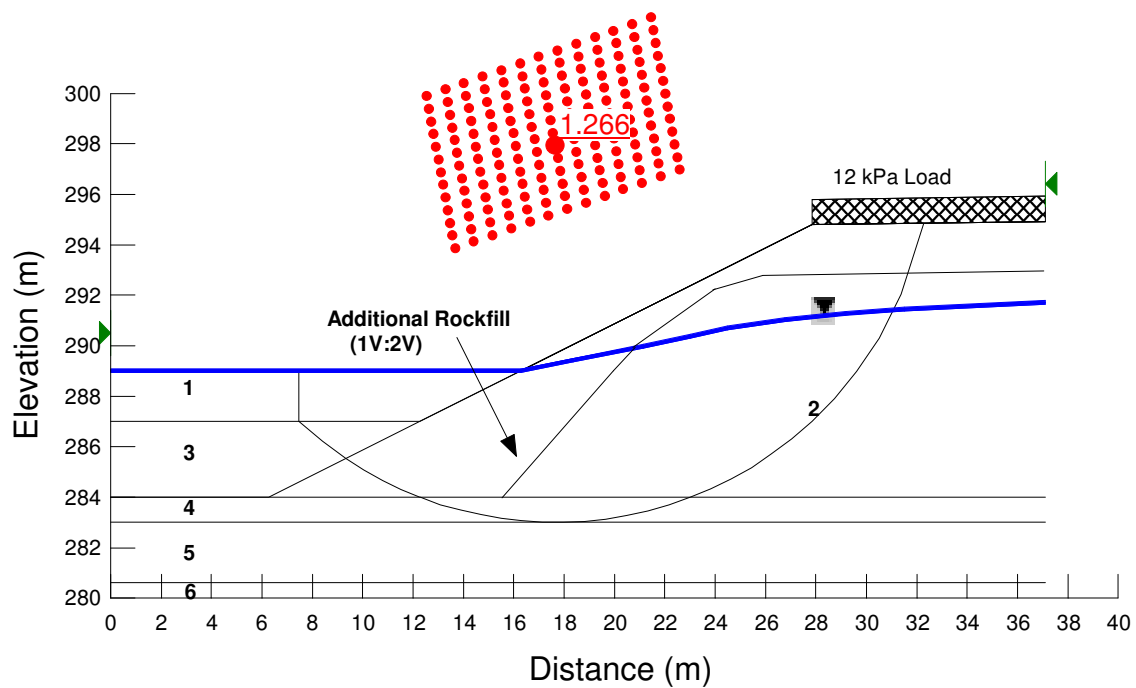
Embankment Widening - 2.5m horizontal alignment shift & a 2m grade raise

Figure D6.3 Stability of HWY11 Road Section at Sta. 14+850
 (Slip Surface within Rockfill with additional Rockfill in Lake)

Ref.: TB7206007
 STATION 14+850
 Total Stress Analysis
 (Based on Boreholes BH5, BH6, BH6A, BH6B & BH7)

Soil Properties Used

Soil Layer No	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (deg.)
1 Water			
2 Rock Fill	21	0	35
3 Very Soft Clay	16	10	0
4 Soft Clay	17	20	0
5 Very stiff Clay	18	60	0
6 Bedrock			



Embankment Widening - 2.5m horizontal alignment shift & a 2m grade raise

Figure D6.4 Stability of HWY11 Road Section at Sta. 14+850
 (Deep Seated Slip Surface with additional Rockfill in Lake)

Ref.: TB7206007
 STATION 14+900
 Total Stress Analysis
 (Based on Boreholes BH8, BH9, BH9A & BH10)

Soil Properties Used

Soil Layer No	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (deg.)
1 Water			
2 Rock Fill	21	0	35
3 Very Soft Clay	16	10	0
4 Soft Clay	17	20	0
5 Compact Sand	18	0	32
6 Bedrock			

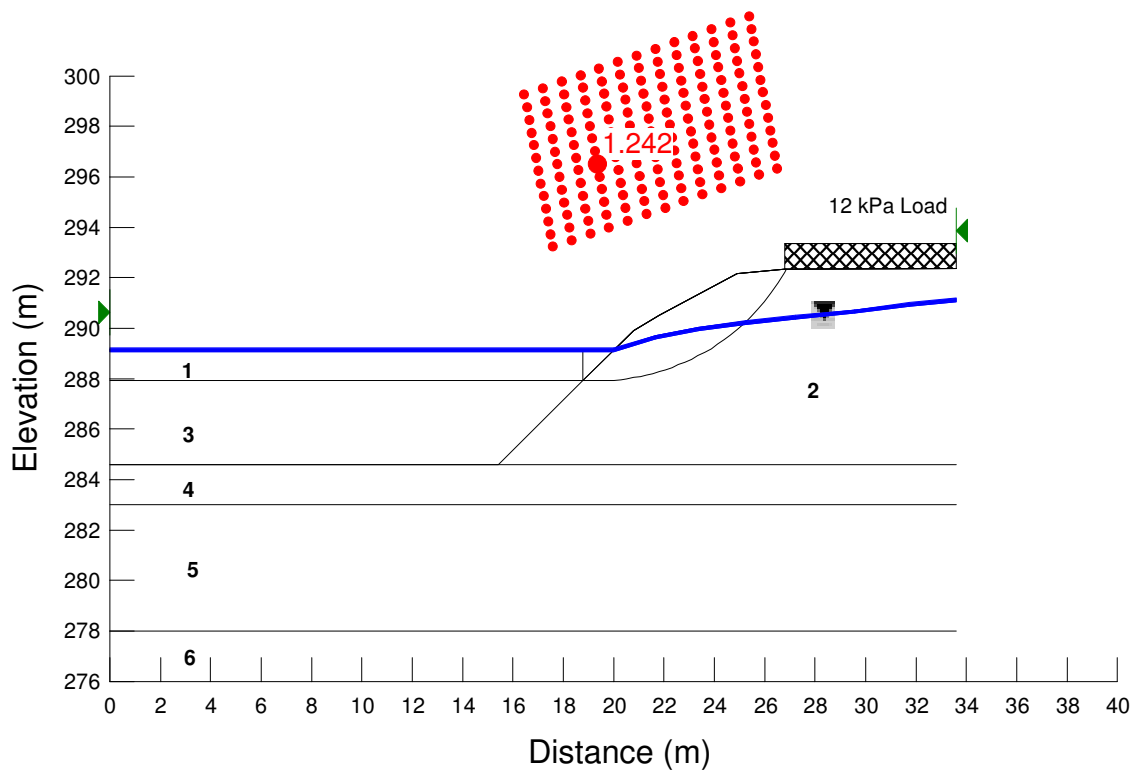


Figure D7.1 Stability of HWY11 Road Section at Sta. 14+900
 (Slip Surface within Rockfill)

Ref.: TB7206007
 STATION 14+900
 Total Stress Analysis
 (Based on Boreholes BH8, BH9, BH9A & BH10)

Soil Properties Used

Soil Layer No	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (deg.)
1 Water			
2 Rock Fill	21	0	35
3 Very Soft Clay	16	10	0
4 Soft Clay	17	20	0
5 Compact Sand	18	0	32
6 Bedrock			

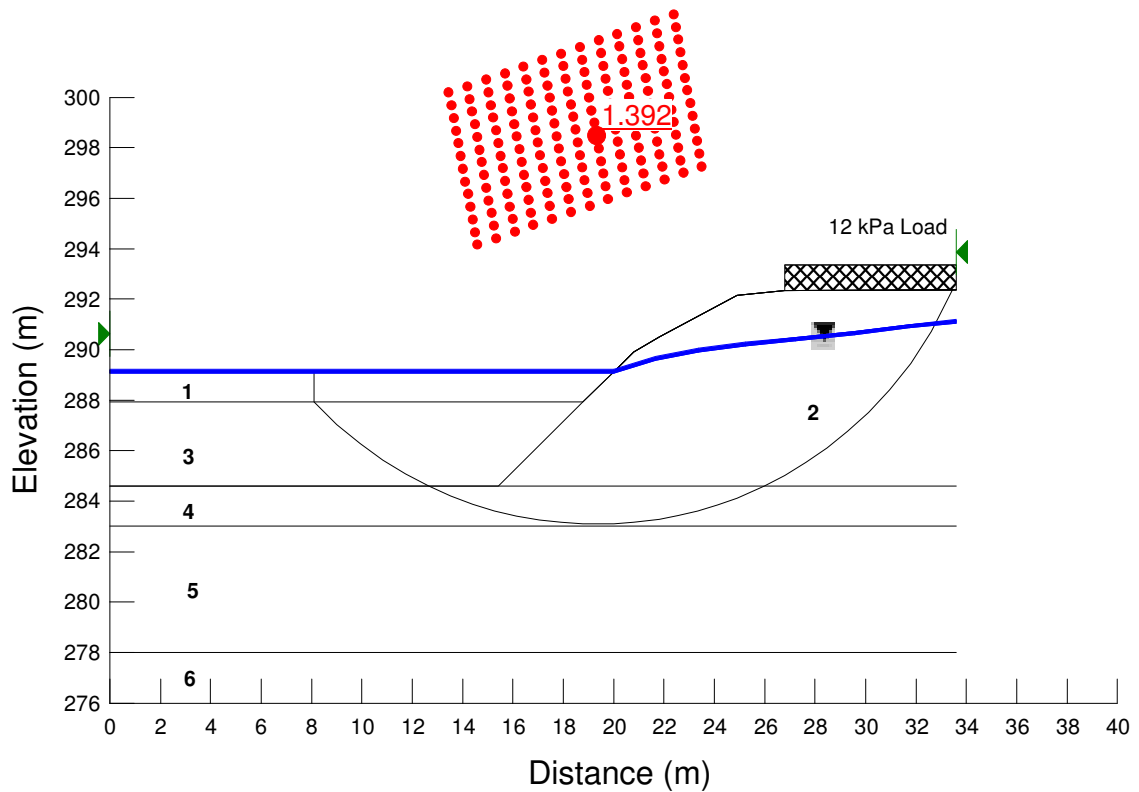


Figure D7.2 Stability of HWY11 Road Section at Sta. 14+900
 (Deep Seated Slip Surface with a weak Layer below Rockfill)

Ref.: TB7206007
 STATION 14+900
 Total Stress Analysis
 (Based on Boreholes BH8, BH9, BH9A & BH10)

Soil Properties Used

Soil Layer No	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (deg.)
1 Water			
2 Rock Fill	21	0	35
3 Very Soft Clay	16	10	0
4 Compact Sand	18	0	32
5 Compact Sand	18	0	32
6 Bedrock			

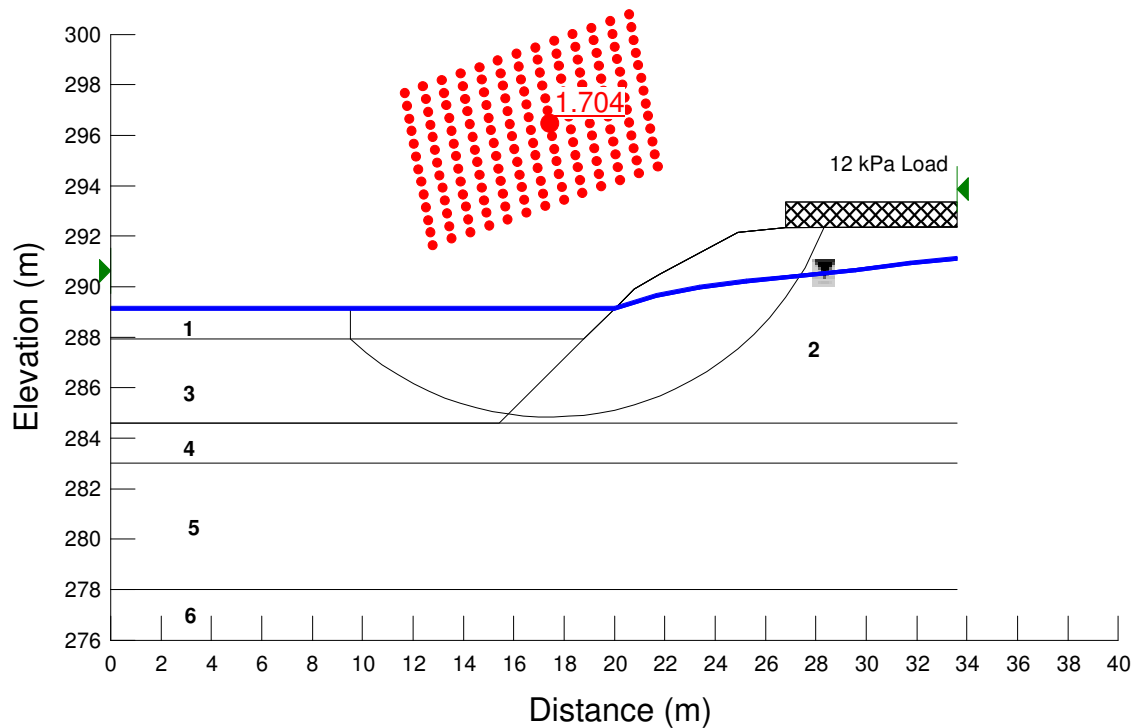


Figure D7.3 Stability of HWY11 Road Section at Sta. 14+900
 (Deep Seated Slip Surface without a weak Layer below Rockfill)

Ref.: TB7206007
 STATION 14+900
 Total Stress Analysis
 (Based on Boreholes BH8, BH9, BH9A & BH10)

Soil Properties Used

Soil Layer No	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (deg.)
1 Water			
2 Rock Fill	21	0	35
3 Very Soft Clay	16	10	0
4 Soft Clay	17	20	0
5 Compact Sand	18	0	32
6 Bedrock			

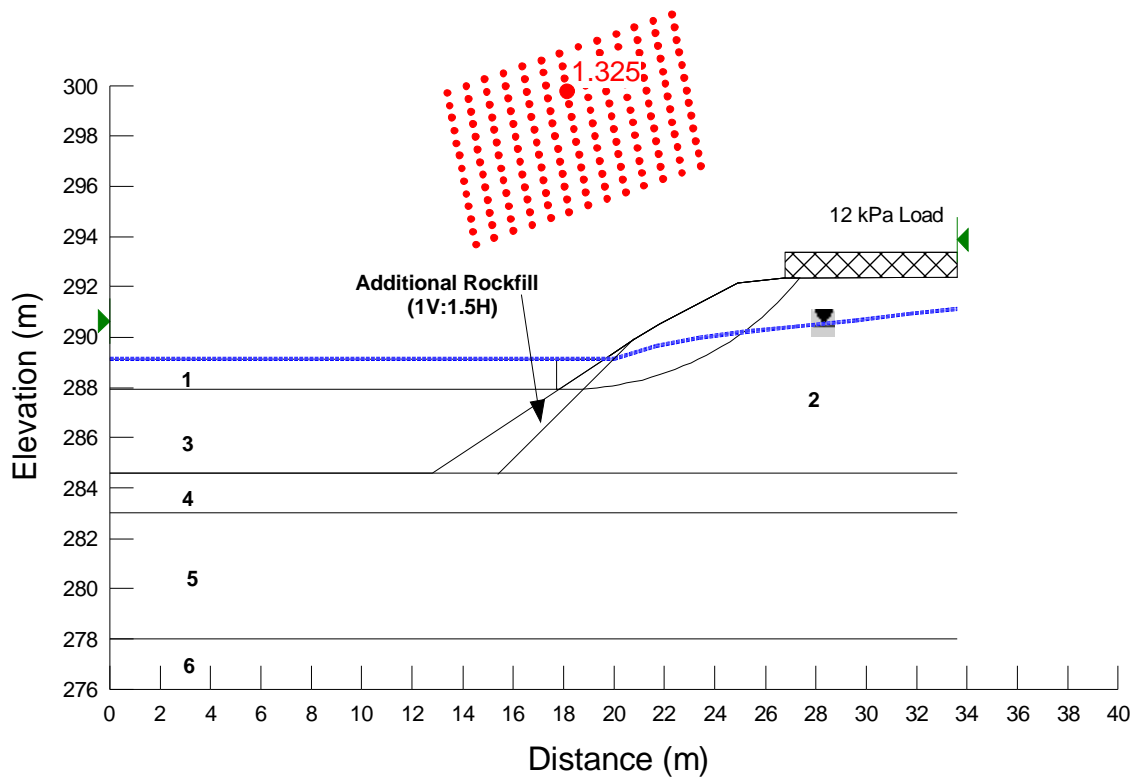


Figure D8.1 Stability of HWY11 Road Section at Sta. 14+900
 (Slip Surface within Rockfill with additional Rockfill in Lake)

Ref.: TB7206007
 STATION 14+900
 Total Stress Analysis
 (Based on Boreholes BH8, BH9, BH9A & BH10)

Soil Properties Used

Soil Layer No	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (deg.)
1 Water			
2 Rock Fill	21	0	35
3 Very Soft Clay	16	10	0
4 Soft Clay	17	20	0
5 Compact Sand	18	0	32
6 Bedrock			

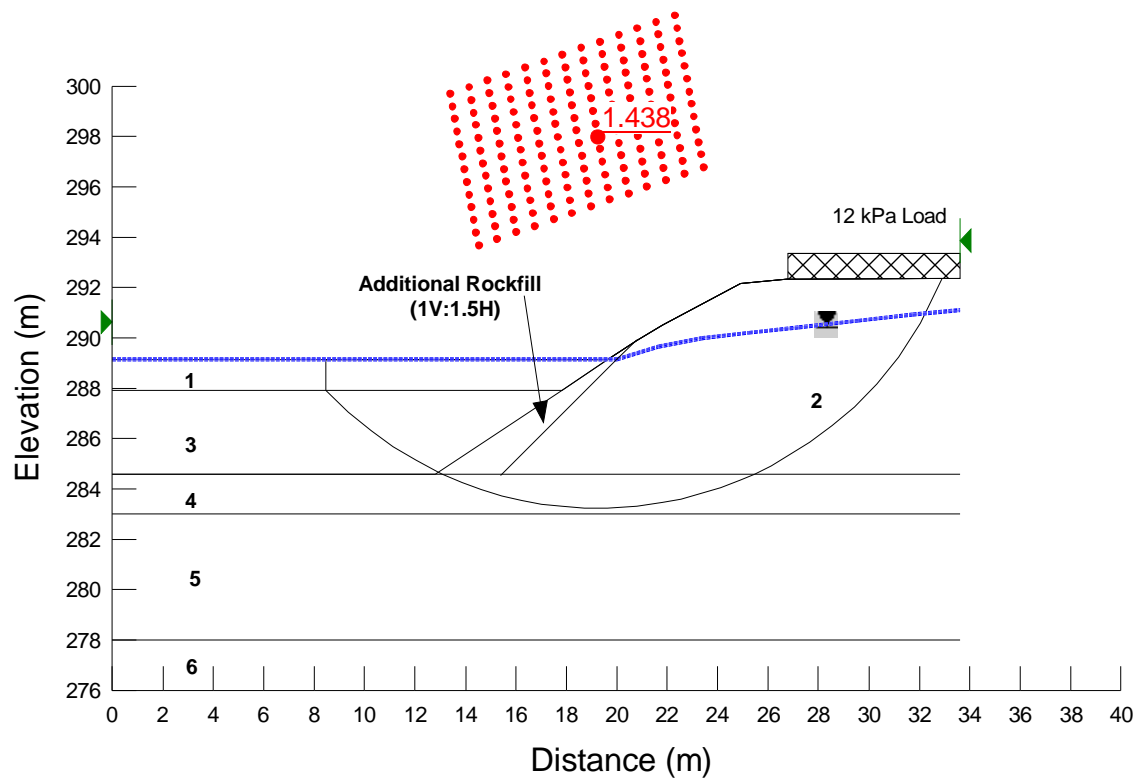


Figure D8.2 Stability of HWY11 Road Section at Sta. 14+900
 (Deep Seated Slip Surface with additional Rockfill in Lake)

Ref.: TB7206007
 STATION 14+900
 Total Stress Analysis
 (Based on Boreholes BH8, BH9, BH9A & BH10)

Soil Properties Used

Soil Layer No	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (deg.)
1 Water			
2 Rock Fill	21	0	35
3 Very Soft Clay	16	10	0
4 Soft Clay	17	20	0
5 Compact Sand	18	0	32
6 Bedrock			

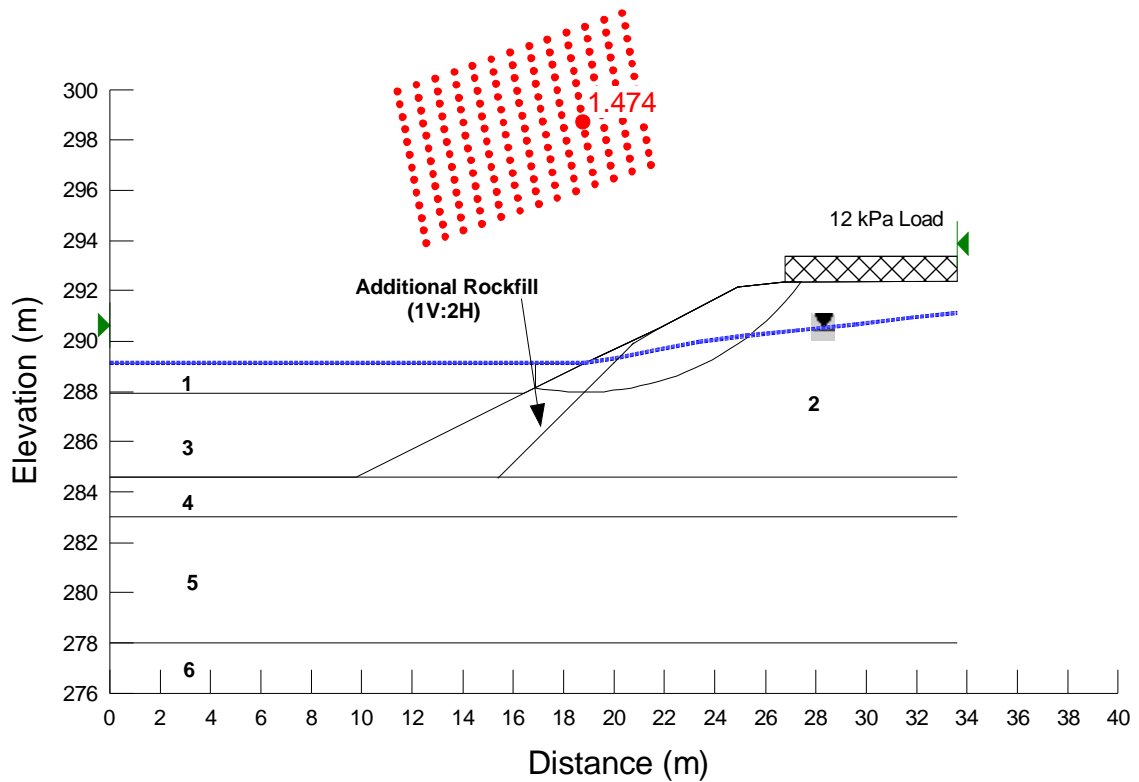


Figure D8.3 Stability of HWY11 Road Section at Sta. 14+900
 (Slip Surface within Rockfill with additional Rockfill in Lake)

Ref.: TB7206007
 STATION 14+900
 Total Stress Analysis
 (Based on Boreholes BH8, BH9, BH9A & BH10)

Soil Properties Used

Soil Layer No	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (deg.)
1 Water			
2 Rock Fill	21	0	35
3 Very Soft Clay	16	10	0
4 Soft Clay	17	20	0
5 Compact Sand	18	0	32
6 Bedrock			

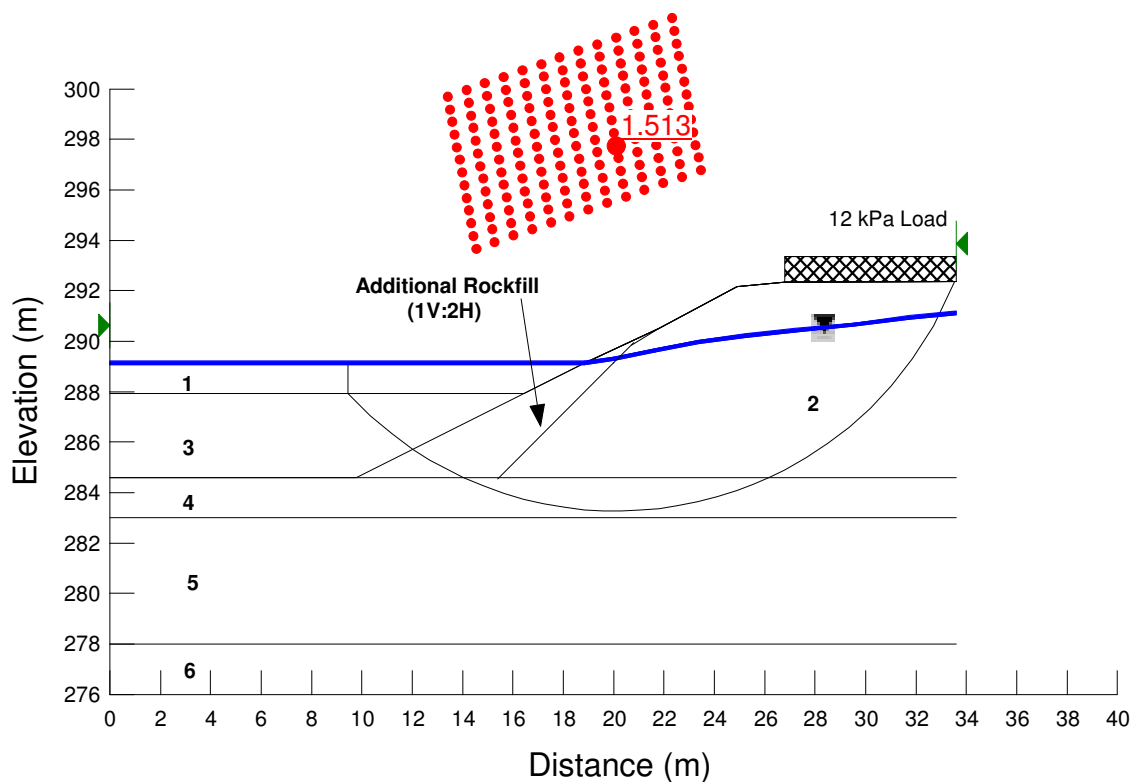
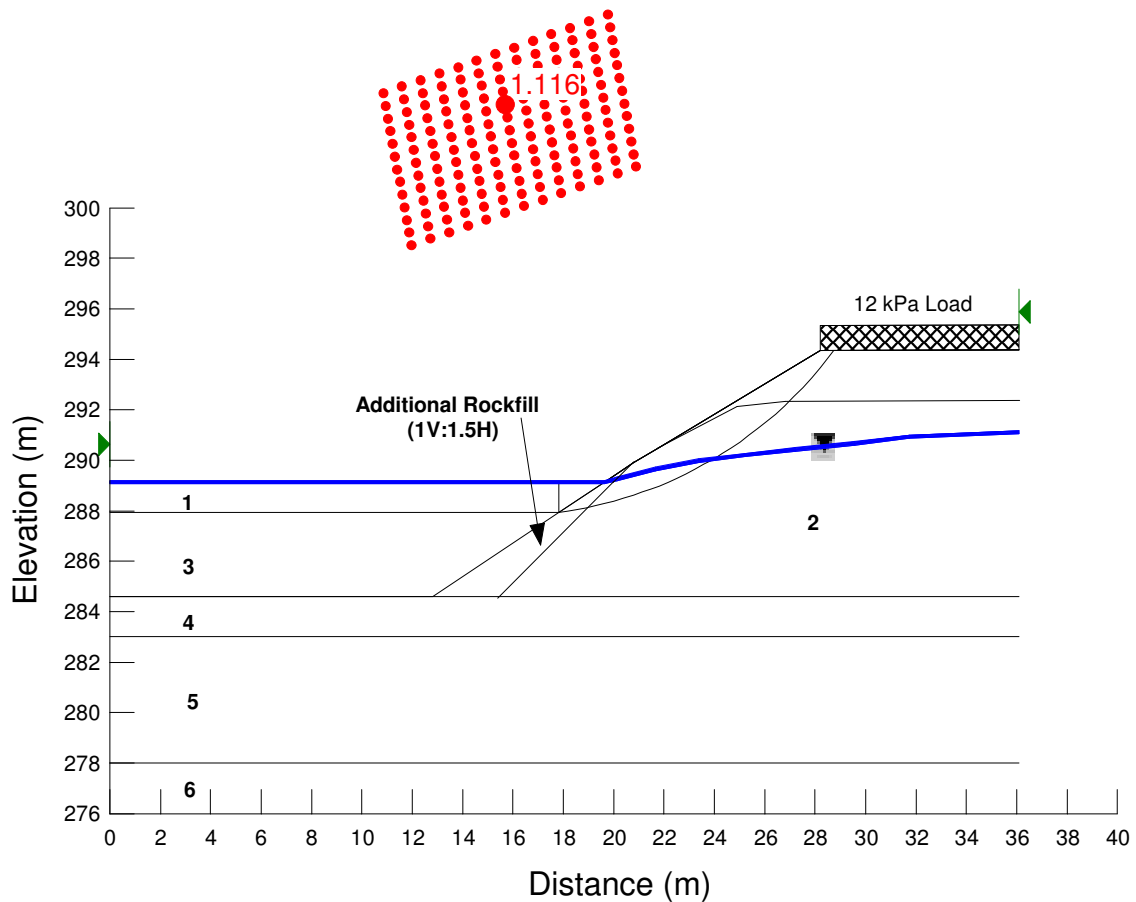


Figure D8.4 Stability of HWY11 Road Section at Sta. 14+900
 (Deep Seated Slip Surface with additional Rockfill in Lake)

Ref.: TB7206007
 STATION 14+900
 Total Stress Analysis
 (Based on Boreholes BH8, BH9, BH9A & BH10)

Soil Properties Used

Soil Layer No	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (deg.)
1 Water			
2 Rock Fill	21	0	35
3 Very Soft Clay	16	10	0
4 Soft Clay	17	20	0
5 Compact Sand	18	0	32
6 Bedrock			



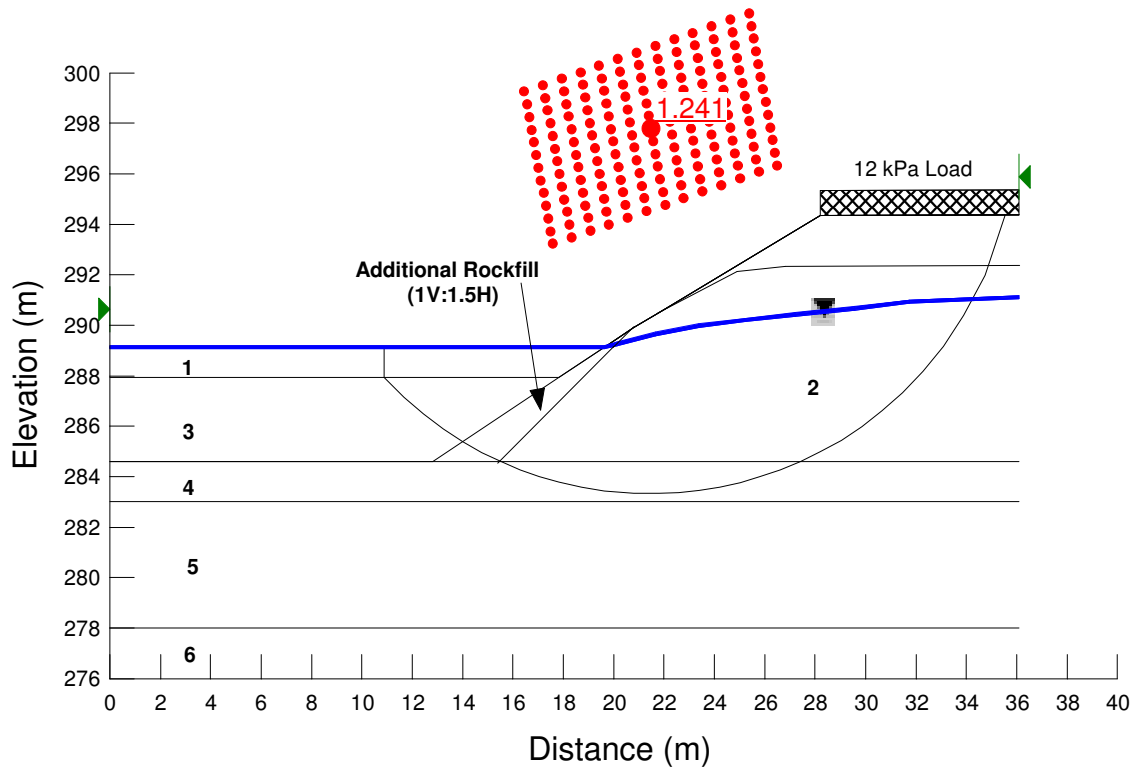
Embankment Widening - 2.5m horizontal alignment shift & a 2m grade raise

Figure D9.1 Stability of HWY11 Road Section at Sta. 14+900
 (Slip Surface within Rockfill with additional Rockfill in Lake)

Ref.: TB7206007
 STATION 14+900
 Total Stress Analysis
 (Based on Boreholes BH8, BH9, BH9A & BH10)

Soil Properties Used

Soil Layer No	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (deg.)
1 Water			
2 Rock Fill	21	0	35
3 Very Soft Clay	16	10	0
4 Soft Clay	17	20	0
5 Compact Sand	18	0	32
6 Bedrock			



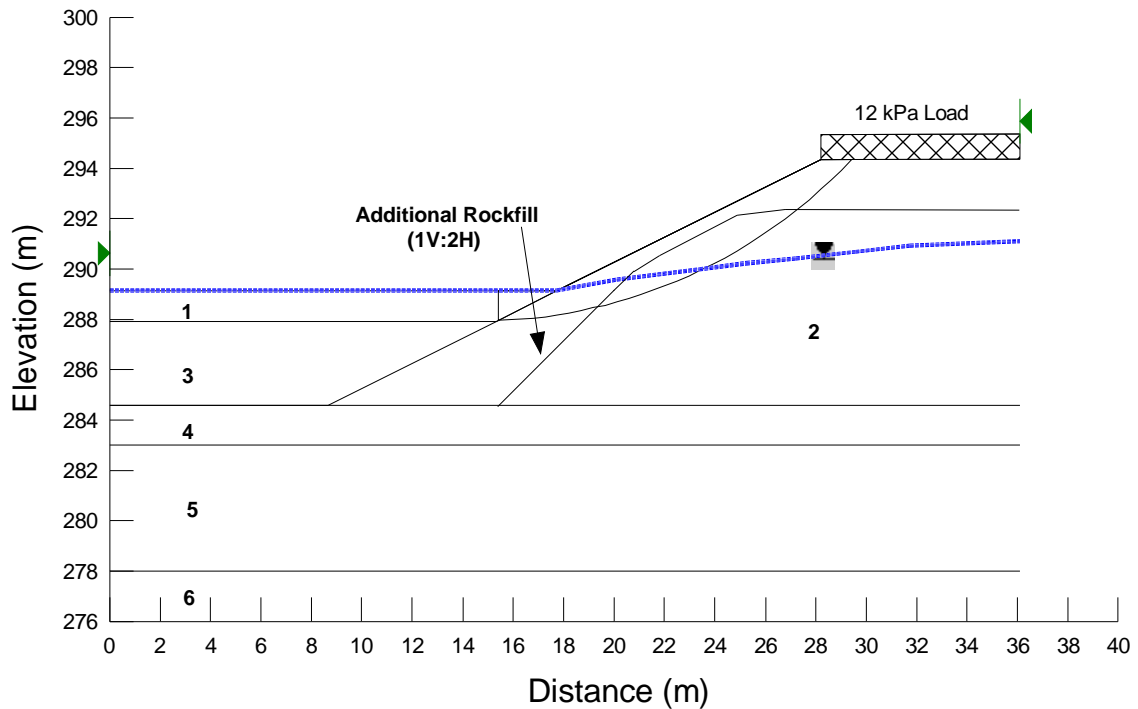
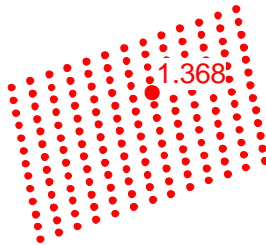
Embankment Widening - 2.5m horizontal alignment shift & a 2m grade raise

Figure D9.2 Stability of HWY11 Road Section at Sta. 14+900
 (Deep Seated Slip Surface with additional Rockfill in Lake)

Ref.: TB7206007
 STATION 14+900
 Total Stress Analysis
 (Based on Boreholes BH8, BH9, BH9A & BH10)

Soil Properties Used

Soil Layer No	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (deg.)
1 Water			
2 Rock Fill	21	0	35
3 Very Soft Clay	16	10	0
4 Soft Clay	17	20	0
5 Compact Sand	18	0	32
6 Bedrock			



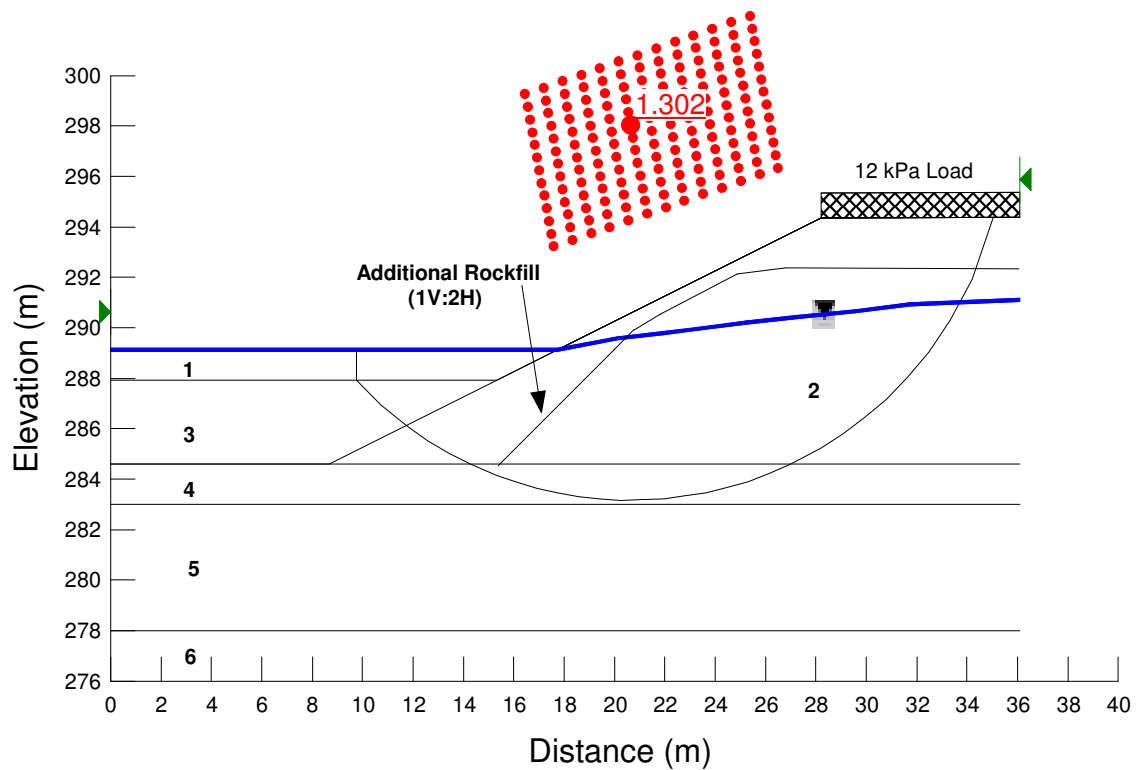
Embankment Widening - 2.5m horizontal alignment shift & a 2m grade raise

Figure D9.3 Stability of HWY11 Road Section at Sta. 14+900
 (Slip Surface within Rockfill with additional Rockfill in Lake)

Ref.: TB7206007
 STATION 14+900
 Total Stress Analysis
 (Based on Boreholes BH8, BH9, BH9A & BH10)

Soil Properties Used

Soil Layer No	Unit Weight (kN/m ³)	Cohesion (kN/m ²)	Friction Angle (deg.)
1 Water			
2 Rock Fill	21	0	35
3 Very Soft Clay	16	10	0
4 Soft Clay	17	20	0
5 Compact Sand	18	0	32
6 Bedrock			



Embankment Widening - 2.5m horizontal alignment shift & a 2m grade raise

Figure D9.4 Stability of HWY11 Road Section at Sta. 14+900
 (Deep Seated Slip Surface with additional Rockfill in Lake)