



THURBER ENGINEERING LTD.



**FOUNDATION INVESTIGATION AND DESIGN REPORT
SLOPE REHABILITATION ON HIGHWAY 118
0.5 KM NORTH OF HALIBURTON COUNTY ROAD 121
HUNTSVILLE DISTRICT
G.W.P. 5339-11-00**

GEOCRES No. 31E-369

Report

to

Englobe Corp.

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TABLE OF CONTENTS

PART 1: FACTUAL INFORMATION

1.	INTRODUCTION	1
2.	SITE DESCRIPTION	2
3.	FIELD INVESTIGATION PROCEDURES	3
4.	LABORATORY TESTING	4
5.	DESCRIPTION OF SUBSURFACE CONDITIONS	5
5.1	Area 1 (Sta. 16+730 to 16+830).....	5
5.1.1	Asphalt.....	5
5.1.2	Granular Fill.....	5
5.1.3	Silt.....	6
5.1.4	Sand to Gravelly Sand	7
5.1.5	Bedrock.....	7
5.1.6	Groundwater Conditions.....	8
5.2	Area 2 (Sta. 16+910 to 17+040).....	9
5.2.1	Asphalt.....	9
5.2.2	Granular Fill.....	9
5.2.3	Silt.....	9
5.2.4	Sand to Gravelly Sand	10
5.2.5	Bedrock.....	11
5.2.6	Groundwater Conditions.....	11
5.3	Area 3 (Sta. 17+040 to 17+100).....	12
5.3.1	Asphalt.....	12
5.3.2	Granular Fill.....	12
5.3.3	Silt.....	12
5.3.4	Sand to Gravelly Sand	13
5.3.5	Bedrock.....	13
5.3.6	Groundwater Conditions.....	14
6.	MISCELLANEOUS	14

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7.	GENERAL.....	16
8.	GEOTECHNICAL DESIGN PARAMETERS.....	17
9.	ASSESSMENT OF EXISTING CONDITIONS.....	18
10.	SLOPE REHABILITATION ALTERNATIVES	18
10.1	Slope Flattening and Toe Berm	20

10.1.1 Construction Considerations	21
10.2 Soil Nailing	22
10.2.1 Design Philosophy.....	22
10.2.2 Soil Nail Design.....	23
10.2.3 Installation Requirements.....	24
10.2.4 Quality Assurance	25
10.2.5 Scour and Erosion Protection.....	25
11. CONSTRUCTION CONCERNS.....	26
11.1 Soil Nailing	26
11.2 Slope Flattening and Toe Berm	26
12. CLOSURE	27

APPENDICES

Appendix A	Record of Borehole Sheets
Appendix B	Laboratory Test Results and Rock Core Photographs
Appendix C	Selected Site Photographs
Appendix D	Borehole Locations and Soil Strata Drawings
Appendix E	Factual Data from Previous Investigation (Geocres No. 31E-326)
Appendix F	Comparison of Slope Rehabilitation Alternatives
Appendix G	Select Stability Analysis Runs
Appendix H	Slope Flattening and Toe Berm Sketch (Figure 1)
	Soil Nail Configurations
Appendix I	List of OPSS and OPSD, and Suggested Text for Selected NSSP

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PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted for the proposed slope rehabilitation on Highway 118 approximately 0.5 km north of Haliburton County Road 121 in Huntsville District, Ontario.

The purpose of the investigation was to explore the subsurface conditions at the site, and based on the data obtained, to provide a borehole location plan, record of borehole sheets, a stratigraphic profiles and sections, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained in the course of the investigation.

Thurber carried out the investigation as a sub-consultant to Englobe Corp., under the Ministry of Transportation Ontario (MTO) Agreement Number 5014-E-0004.

A preliminary foundation investigation carried out at this site for the slope rehabilitation was documented in the report titled "Foundation Investigation and Design Report, Slope Instability Hwy 118, 0.5 km North of Haliburton County Road 121, District 52, Huntsville", prepared by exp Services Inc. (exp), dated April 10, 2013 (Geocres No. 31E-326). Reference should be made to the exp report for a written description of the subsurface conditions, borehole location plan, stratigraphic profiles and sections, records of borehole sheets and laboratory test results. It should be noted that exp is solely responsible for the subsurface information provided in their Foundation Investigation and Design Report. The factual subsurface information presented in the exp report was incorporated in the current report and their borehole logs are included in Appendix E.

2. SITE DESCRIPTION

The site is located on Highway 118 approximately 0.5 km north of Haliburton County Road 121 in the County of Haliburton, Ontario. The foundation investigation and design report prepared by exp indicates that some signs of instability in the embankment between Sta. 16+730 and Sta. 17+100 were noticed approximately during the last four years (2009 to 2012) and reported by MTO. The exp report has identified three areas of potentially unstable embankment sections that may require slope stabilization.

In the investigated areas, Highway 118 runs in a generally north-south direction with a mild turn to the northeast in the northerly portion. This section of highway is bordered by Head Lake to the west and bounded by wooded lands with sporadic residential properties to the east. The existing highway is a two-lane roadway with a declining grade towards the south at an approximately 1% gradient within the investigated section.

The topography in the area slopes westerly towards the lake. The existing highway platform cuts into the bedrock outcrop and intermittent bedrock cuts are evident on the east side of the highway. Vegetation consisting of frequent trees and small shrubs are present on the sloped lands adjacent to the highway.

The site is located within the physiographic region of Algonquin Highlands, as delineated in The Physiography of Southern Ontario by Chapman and Putnam (1984). This region is characterized by shallow sandy till soils overlying Precambrian bedrock.

Geological terrain mapping in the immediate vicinity of Head Lake suggests that the site is situated within a glaciolacustrine delta composed of coarse-textured glaciolacustrine deposits of sand and gravel with minor silt and clay. In the middle of the site, this undulating delta deposit of low local relief is separated by a bedrock knob of high local relief. The bedrock in this area is overlain by a thin drift veneer (OGS Map 5505).

The bedrock in the general area is mapped as tonalite, syenogranite and straight gneiss of the Dysart and Redstone Lake Gneiss Complexes (OGS Map P.3416).

Surface drainage generally flows westerly towards Head Lake. The surface water east of the roadway is collected through a shoulder swale and catch basins, and then channeled through culverts and discharged into the lake.

Photographs showing the general nature of the site are presented in Appendix C.

3. FIELD INVESTIGATION PROCEDURES

Three critical areas were identified in the exp report, i.e. Area 1: Sta. 16+730 to 16+830, Area 2: Sta. 16+910 to 17+040, and Area 3: 17+040 to 17+100. The current site investigation and field testing were strategically conducted between Sta. 16+730 and 17+100 as per the Contract RFP requirements. Two stages of investigations were carried out from October 26 to November 4, 2015 and from March 8 to 10, 2016, respectively. A total of eighteen (18) boreholes, denoted as 15-01 to 15-18, were advanced to depths ranging from 3.0 to 10.8 m below the ground surface. Boreholes 15-01, 15-02, 15-03, 15-05, 15-06, 15-08, 15-09, 15-11, 15-12 and 15-14 to 15-17 were advanced from the roadway pavement level. Boreholes 15-04, 15-07, 15-10, 15-13 and 15-18 were advanced at the toe of embankment slope near the shoreline of Head Lake.

The locations of the boreholes from the preliminary and current investigations are shown on the attached Borehole Location Plan Drawing included in Appendix D.

The boreholes drilled on the roadway were advanced using a CME75 truck-mounted drill rig in combination with hollow stem augers to advance the boreholes to bedrock surface. Upon encountering the bedrock, each borehole was cored a minimum 3.0 m into the bedrock using NQ coring equipment. The boreholes drilled along the edge of the water were advanced using a portable tripod drill rig in combination with steel casings to auger refusal upon probable bedrock. Samples of the overburden soils were obtained from the boreholes at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). Intact rock core samples were collected in all boreholes drilled from the roadway pavement. A summary of the borehole depths and bedrock elevations are provided in Table 3.1.

Table 3.1 – Borehole Depths and Bedrock Elevations

Borehole	Approximate Station	Termination Depth (m)	Bedrock Level (m)		Piezometer Installation
			Depth	Elevation	
15-01	16+729	5.0	1.9	323.8	No
15-02	16+769	8.0	4.9	320.6	Yes
15-03	16+769	9.4	6.3	319.2	No
15-04	16+769	9.1	-	-	No
15-05	16+807	7.2	3.7	321.3	No
15-06	16+807	9.7	6.6	318.7	Yes
15-07	16+807	3.0	-	-	No
15-08	16+907	9.7	5.6	318.7	Yes
15-09	16+907	10.8	7.0	317.3	No

Borehole	Approximate Station	Termination Depth (m)	Bedrock Level (m)		Piezometer Installation
			Depth	Elevation	
15-10	16+907	3.4	-	-	No
15-11	16+938	10.7	7.6	316.7	No
15-12	16+938	8.7	5.6	318.0	Yes
15-13	16+938	3.8	-	-	No
15-14	16+990	8.6	5.5	318.0	Yes
15-15	17+024	7.1	3.3	319.7	Yes
15-16	17+104	7.0	4.2	318.7	No
15-17	17+104	8.6	5.5	317.0	Yes
15-18	17+104	4.1	-	-	No

The drilling and sampling operations were supervised on a full-time basis by a member of Thurber's technical staff. The supervisor logged the boreholes and processed the recovered soil and rock samples for transport to Thurber's laboratory for further examination and testing.

Groundwater conditions in the open boreholes were observed during the drilling operations. Standpipe piezometers consisting of 19 mm diameter PVC pipe with slotted screen were installed in selected boreholes. Following the final water level reading, the piezometers were decommissioned in general accordance with MOE Regulation 903.

4. LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. The results of this testing are shown on the Record of Borehole sheets included in Appendix A. Selected samples were also subjected to gradation analysis and Atterberg Limits tests. The results of this laboratory testing program are summarized on the Record of Borehole sheets in Appendix A and shown on the figures included in Appendix B.

The recovered intact rock core samples were photographed and examined in the laboratory for weathering conditions, fracture/joint conditions, soil infills and to verify total core recovery (TCR), solid core recovery (SCR), rock quality designation (RQD) and fracture index (FI). Selected rock cores were subjected to Point Load Test (PLT) to allow correlations with unconfined compressive strength (UCS) of the rock. The results of the point load tests and rock core photographs are included in Appendix B.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendix A for details of the encountered soil stratigraphy. Borehole logs from a previous foundation investigation by exp in 2013 are included in Appendix E. A borehole location plan, stratigraphic profiles and cross sections are presented on the “Borehole Locations and Soil Strata” drawings (No. 1 through 7) in Appendix D.

An overall description of the stratigraphy for each area is given in the following sections. However, the factual data presented in the Record of Borehole sheets governs any interpretation of the site conditions. It must be recognized that soil conditions may vary between and beyond borehole locations.

The subsurface stratigraphy below the pavement structure encountered in each of the three areas generally consisted of silt to sandy silt underlain by sand to gravelly sand, occasional cobbles and boulders were encountered within the sand to gravelly sand layer or immediately above the granitic bedrock. Detailed descriptions of the individual strata for each area are presented below.

5.1 Area 1 (Sta. 16+730 to 16+830)

5.1.1 Asphalt

A 150 to 250 mm thick layer of asphalt was encountered in the boreholes drilled on the roadway except in boreholes 1-4 and 15-05.

5.1.2 Granular Fill

Brown granular fill was encountered at ground surface or below the asphalt pavement in the boreholes drilled on the roadway. The granular fill consisted of sand, some gravel to gravelly, and trace silt. The fill extended to depths ranging from 0.6 to 2.4 m (elevations ranging from 324.4 to 323.1 m) with thickness ranging from 0.5 to 2.2 m.

SPT ‘N’ values recorded in the fill ranged from 7 to 45 blows per 0.3 m penetration, indicating a loose to dense relative density. The higher ‘N’ values are probably indicative of increased gravel content in the fill.

Moisture contents of the fill ranged from 2 to 10%. Grain size analyses indicated that particle size distribution of the fill can be summarized as follows:

Soil Particle	Percentage (%)
Gravel	7 - 35
Sand	60 - 89
Silt & Clay	4 - 23

The results of the laboratory tests are provided on the Record of Borehole sheets in Appendix A. The results of the grain size analyses are illustrated in Figures B1 and B2 in Appendix B. The laboratory test results from the exp investigation in 2013 are included in Appendix E.

5.1.3 Silt

A layer of brown to grey silt to sandy silt containing trace to some clay was encountered either below the granular fill in the boreholes drilled on the roadway or at the toe of slope near the edge of Head Lake. The silt below the fill extended to depths ranging from 1.2 to 5.8 m (elevations ranging from 324.5 to 319.7 m) with thickness ranging from 0.4 to 2.9 m. The silt below the lakebed extended to depths ranging from 4.7 to 6.1 m (elevations ranging from 312.7 to 310.9 m) with layer thickness ranging from 4.7 to 6.1 m. A 0.7 m thick cobble zone was encountered and cored through below the silt at 1.2 m depth. Borehole 1-2 was terminated within the silt layer upon auger refusal.

SPT 'N' values recorded in the silt below the fill ranged from 10 to 38 blows per 0.3 m penetration, indicating a compact to dense relative density. SPT 'N' values recorded in the silt below the lakebed ranged from 2 to 36 blows per 0.3 m penetration, indicating a very loose to dense relative density.

Moisture contents of the silt ranged from 17 to 29% below the fill and from 22 to 36% below the lakebed, respectively. Atterberg Limits test results showed that the silt has Liquid Limits ranging from 26 to 29% and Plastic Limits in the order of 19%, respectively, indicating a marginal to low plasticity. Grain size analyses indicated that particle size distribution of the silt can be summarized as follows:

Soil Particle	Percentage (%)
Gravel	0 - 2
Sand	4 - 35
Silt	53 - 96
Clay	10 - 19

The results of the laboratory tests are provided on the Record of Borehole sheets in Appendix A. The results of the grain size analyses and Atterberg Limits are illustrated in Figures B8 to B12 in

Appendix B. The laboratory test results from the exp investigation in 2013 are included in Appendix E.

5.1.4 Sand to Gravelly Sand

A layer of brown sand to gravelly sand was encountered below the existing fill, silt or lakebed and extended to depths ranging from 2.6 to 9.1 m (elevations ranging from 322.9 to 308.3 m) with thickness ranging from 0.2 to 5.8 m. A 2.1 m thick boulder was encountered and cored through within the sand at 2.9 m depth in borehole 1-8. The sand was not encountered in exp's boreholes 1-2 and 1-6, and borehole 15-01. Boreholes 1-1, 1-3, 1-4, 15-04 and 15-07 were terminated within the sand layer upon auger refusal.

SPT 'N' values recorded in the sand ranged from 3 to more than 50 blows per 0.3 m penetration, indicating a very loose to very dense relative density. The higher 'N' values are probably indicative of increased gravel content in the sand. Moisture contents of the sand ranged from 2 to 19%. Grain size analyses indicated that particle size distribution of the sand can be summarized as follows:

Soil Particle	Percentage (%)	
	Sand, some Gravel	Gravelly Sand
Gravel	5 - 20	21 - 46
Sand	60 - 91	47 - 68
Silt & Clay	3 - 30	5 - 17

The results of the laboratory test are provided on the Record of Borehole sheets in Appendix A. The results of the grain size analyses are illustrated in Figures B3 to B8 in Appendix B. The laboratory test results from the exp investigation in 2013 are included in Appendix E.

5.1.5 Bedrock

Granitic Gneiss bedrock was encountered below the silt and sand to gravelly sand, and extended to the end of the boreholes. Where proven by coring, the bedrock depth ranged from 1.9 to 6.6 m (elevations ranging from 323.8 to 318.7 m) below the embankment and from 6.1 to 6.7 m (elevations 311.6 to 311.7 m) below the lakebed.

Generally, Total Core Recovery (TCR) in the bedrock ranged from 56 to 100%. The Rock Quality Designation (RQD) ranged typically from 48 to 98%, indicating poor to excellent rock mass quality. The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, ranged from 0 to greater than 10. The Point Load Index (Is)₅₀ ranged from 2.0 to 8.4 MPa, which correlates to

unconfined compressive strength (UCS) ranging from 48 to 201 MPa using an assumed conversion factor of 24, indicating a medium strong to very strong rock.

The bedrock was significantly more fractured in borehole 15-05 between 3.7 m and 5.7 m depths where RQD values ranged from 18 to 25%, indicating very poor rock mass quality.

The results of the TCR, RQD and $(I_s)_{50}$ are provided on the Record of Borehole sheets in Appendix A. Rock core photographs and point load test results are included in Appendix B.

5.1.6 Groundwater Conditions

Standpipe piezometers were installed in two boreholes (15-02 and 15-06) in Area 1 to monitor stabilized (long term) groundwater levels. The water levels measured in the piezometers in addition to those recorded during the exp investigation in 2013 are summarized as follows:

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
1-1	Jan. 24, 2013	4.6	320.9	Open borehole
1-2	Jan. 24, 2013	2.1	323.4	Open borehole
1-3	Jan. 24, 2013	1.8	323.7	Open borehole
1-4	Jan. 24, 2013	3.0	322.2	Open borehole
1-5	Feb. 6, 2013	5.6	319.7	Standpipe Piezometer
15-02	Mar. 15, 2016	0.6	324.9	Standpipe Piezometer
15-06	Mar. 15, 2016	2.8	322.5	Standpipe Piezometer

The water level in the Head Lake was at elevation 317.7 m during the investigations.

The water level in the Head Lake and groundwater levels are expected to fluctuate seasonally and are subject to precipitation patterns, and may vary from the levels presented above.

5.2 Area 2 (Sta. 16+910 to 17+040)

5.2.1 Asphalt

A 200 to 300 mm thick layer of asphalt was encountered in each borehole drilled on the roadway.

5.2.2 Granular Fill

Brown sand to gravelly sand fill was encountered at ground surface or below the asphalt in the boreholes drilled within the roadway. The fill extended to depths ranging from 0.8 to 1.5 m (elevations ranging from 322.1 to 323.7 m) with thickness ranging from 0.6 to 1.3 m.

SPT 'N' values recorded in the fill ranged from 9 to 32 blows per 0.3 m penetration, indicating a loose to compact relative density.

Moisture contents of the fill ranged from 3 to 5%. Grain size analyses indicated that particle size distribution of the fill can be summarized as follows:

Soil Particle	Percentage (%)
Gravel	8 - 27
Sand	50 - 86
Silt & Clay	5 - 35

The results of the laboratory test are provided on the Record of Borehole sheets in Appendix A. The results of the grain size analyses are illustrated in Figures B1 to B2 in Appendix B. The laboratory test results from the exp investigation in 2013 are included in Appendix E.

5.2.3 Silt

A layer of brown to grey silt to sandy silt, trace to some clay was encountered either below the granular fill in the boreholes drilled on the roadway or immediately on the lakebed. The silt below the fill extended to depths ranging from 1.4 to 4.6 m (elevations ranging from 319.0 to 321.6 m) with thickness ranging from 0.5 to 3.0 m. The silt below the lakebed extended to depths ranging from 2.1 to 2.5 m (elevations ranging from 315.6 to 315.2 m) with thickness ranging from 1.8 to 2.2 m.

SPT 'N' values recorded in the silt ranged from 2 to 31 blows per 0.3 m penetration, indicating a very loose to dense relative density.

Moisture contents of the silt ranged from 6 to 40%. Atterberg Limits testing results showed that the Liquid Limit and Plastic Limit of the silt were in the order of 30 and 22%, respectively, indicating

a marginal to low plasticity. Grain size analyses indicated that the silt consisted of the following:

Soil Particle	Percentage (%)
Gravel	0 - 2
Sand	0 - 42
Silt	63 - 93
Clay	6 - 22

The results of the laboratory test are provided on the Record of Borehole sheets in Appendix A. The results of the grain size analyses and Atterberg Limits are illustrated in Figures B9 to B12 in Appendix B. The laboratory test results from the exp investigation in 2013 are included in Appendix E.

5.2.4 Sand to Gravelly Sand

A deposit of sand to gravelly sand was encountered below the fill, silt or lakebed, and extended to depths ranging from 2.4 to 7.6 m (elevations ranging from 320.5 to 316.7 m) with thickness ranging from 0.3 to 3.9 m. A 1.4 m thick layer of cobbles and boulders was encountered and cored through below the sand at 2.4 m depth in borehole 2-6. A 0.4 m thick cobble zone was encountered below the sand at 5.2 m depth in borehole 15-8. Boreholes 2-2, 2-3, 2-5, 15-10 and 15-13 were terminated within the sand layer upon auger refusal.

SPT 'N' values recorded in the sand to gravelly sand ranged from 5 to more than 50 blows per 0.3 m penetration, indicating a loose to very dense relative density. The higher 'N' values are probably indicative of increased gravel content in the sand.

Moisture contents of the sand to gravelly sand ranged from 2 to 29%. Grain size analyses indicated that grain size distribution of the sand to gravelly sand can be summarized as follows:

Soil Particle	Percentage (%)	
	Sand, Some Gravel	Gravelly Sand
Gravel	0 - 17	22 - 44
Sand	66 - 98	43 - 74
Silt & Clay	2 - 18	5 - 13

The results of the laboratory test are provided on the Record of Borehole sheets in Appendix A. The results of the grain size analyses are illustrated in Figures B3 to B8 in Appendix B. The laboratory test results from the exp investigation in 2013 are included in Appendix E.

5.2.5 Bedrock

Granitic Gneiss bedrock was encountered below the sand and gravelly sand, and extended to the end of the boreholes. Where proven by coring, the depth to bedrock below the roadway ranged from 3.3 to 7.6 m (elevations ranging from 319.7 to 316.7 m) whereas the depth to bedrock below the lakebed was 3.8 m (elevation 313.9 m).

Generally, Total Core Recovery (TCR) in the bedrock ranged from 29 to 100%. The Rock Quality Designation (RQD) ranged from 0 to 95%, indicating very poor to excellent rock mass quality. The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, ranged from 0 to greater than 10. The Point Load Index $(Is)_{50}$ ranged from 2.5 to 9.1 MPa, which correlates to unconfined compressive strength (UCS) ranging from 60 to 219 MPa using an assumed conversion factor of 24, indicating a strong to very strong rock.

The results of the TCR, RQD and $(Is)_{50}$ are provided on the Record of Borehole sheets in Appendix A. Rock core photographs and point load test results are included in Appendix B.

5.2.6 Groundwater Conditions

Standpipe piezometers were installed in four boreholes (15-08, 15-12, 15-14, and 15-15) in Area 2 to monitor stabilized (long term) groundwater levels. The water levels measured in the piezometers in addition to those recorded during the exp investigation in 2013 can be summarized as follows:

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
2-1	Jan. 18, 2013	3.3	319.6	Open borehole
2-3	Jan. 30, 2013	4.7	318.6	Open borehole
2-4	Feb. 6, 2013	3.9	319.6	Standpipe Piezometer
15-08	Mar. 15, 2016	4.5	319.8	Standpipe Piezometer
15-12	Mar. 15, 2016	3.0	320.6	Standpipe Piezometer
15-14	Mar. 15, 2016	3.8	319.7	Standpipe Piezometer
15-15	Mar. 15, 2016	0.7	322.3	Standpipe Piezometer

The water level in the Head Lake was at elevation 317.7 m during the field works.

The water level in the Head Lake and groundwater levels are expected to fluctuate seasonally and are subject to precipitation patterns, and may vary from the levels presented above.

5.3 Area 3 (Sta. 17+040 to 17+100)

5.3.1 Asphalt

A 150 mm to 275 mm thick layer of asphalt was encountered in each borehole drilled on the roadway.

5.3.2 Granular Fill

Brown granular fill was encountered at ground surface or below the roadway asphalt in the boreholes drilled on the roadway. The granular fill consisted of sand, some gravel to gravelly and trace silt. The fill extended to depths ranging from 0.6 to 1.1 m (elevations ranging from 321.9 to 321.7 m) with thickness ranging from 0.4 to 0.9 m.

SPT 'N' values recorded in the fill ranged from 15 to 26 blows per 0.3 m penetration, indicating a compact relative density. Moisture contents of the fill ranged typically from 2 to 16%. Grain size analyses indicated that the fill consisted of the following:

Soil Particle	Percentage (%)
Gravel	10 - 20
Sand	53 - 82
Silt & Clay	8 - 27

The results of the laboratory test are provided on the Record of Borehole sheets in Appendix A. The results of the grain size analyses are illustrated in Figure B1 in Appendix B. The laboratory test results from the exp investigation in 2013 are included in Appendix E.

5.3.3 Silt

Silt was encountered either below the granular fill in the boreholes drilled on the roadway or immediately at the lakebed. The silt below the fill extended to depths ranging from 1.8 to 5.2 m (elevations ranging from 321.0 to 317.3 m) with thickness ranging from 0.7 to 4.6 m. The silt below the lakebed extended to depths ranging from 2.8 to 3.7 m (elevations ranging from 315.5 to 314.0 m) with thickness ranging from 1.1 to 3.7 m.

SPT 'N' values recorded in the silt ranged from 2 to 20 blows per 0.3 m penetration, indicating a very loose to compact relative density. Moisture contents of the silt ranged from 17 to 32%.

Atterberg Limits test results showed that the silt was marginally plastic with a Liquid Limit of 23% and a Plastic Limit of 18%. Grain size analyses indicated that the silt consisted of the following:

Soil Particle	Percentage (%)
Gravel	0 - 4
Sand	1 - 26
Silt	65 - 89
Clay	4 - 16

The results of the laboratory test are provided on the Record of Borehole sheets in Appendix A. The results of the grain size analyses and Atterberg Limits are illustrated in Figures B8 to B12 in Appendix B. The laboratory test results from the exp investigation in 2013 are included in Appendix E.

5.3.4 Sand to Gravelly Sand

Sand to gravelly sand was encountered below the silt and extended to depths ranging from 3.4 to 5.5 m (elevations ranging from 317.1 to 319.4 m below the roadway and 313.3 to 313.6 m below the lakebed) with thickness ranging from 0.4 to 2.2 m. The sand becomes silty above the bedrock surface in boreholes 15-16 and 15-17. Boreholes 3-3, 3-4 and 15-18 were terminated within the sand layer upon auger refusal.

SPT 'N' values recorded in the sand ranged from 8 to greater than 50 blows per 0.3 m penetration, indicating a loose to very dense relative density. Moisture contents of the sand ranged from 4 to 21%. Grain size analyses indicated that this deposit consisted of the following:

Soil Particle	Percentage (%)	
	Sand	Silty Sand
Gravel	2 - 22	2
Sand	65 - 95	60
Silt & Clay	3 - 13	-
Silt	-	34
Clay	-	4

The results of the laboratory test are provided on the Record of Borehole sheets in Appendix A. The results of the grain size analyses are illustrated in Figures B3 to B8 in Appendix B. The laboratory test results from the exp investigation in 2013 are included in Appendix E.

5.3.5 Bedrock

Granitic Gneiss bedrock was encountered below the sand to gravelly sand and extended to the end of the boreholes. Where proven by coring, the depth to bedrock ranged from 4.2 to 8.1 m (elevations ranging from 318.7 to 314.6 m).

Generally, Total Core Recovery (TCR) in the bedrock was 100%. The Rock Quality Designation (RQD) ranged from 37 to 95%, indicating poor to excellent rock mass quality. The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, ranged from 0 to greater than 10. The Point Load Index $(Is)_{50}$ ranged from 1.6 to 7.1 MPa, which correlates to unconfined compressive strength (UCS) ranging from 39 to 170 MPa using an assumed conversion factor of 24, indicating a medium strong to very strong rock.

The results of the TCR, RQD and $(Is)_{50}$ are provided on the Record of Borehole sheets in Appendix A. Rock core photographs and point load test results are included in Appendix B.

5.3.6 Groundwater Conditions

Standpipe piezometers were installed in one borehole (15-17) in Area 3 to monitor stabilized (long term) groundwater levels. The water levels measured in the piezometers in addition to those recorded during the exp investigation in 2013 can be summarized as follows:

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
3-1	Jan. 16, 2013	4.0	318.6	Open borehole
3-2	Jan. 17, 2013	3.4	319.3	Open borehole
3-3	Jan. 27, 2013	3.2	319.6	Open borehole
3-4	Jan. 31, 2013	0.6	317.7	Open borehole
15-17	Mar. 15, 2016	0.7	321.8	Standpipe Piezometer

The water level in the Head Lake was at elevation 317.7 m during the field works.

The water level in the Head Lake and groundwater levels are expected to fluctuate seasonally and are subject to precipitation patterns, and may vary from the levels presented above.

6. MISCELLANEOUS

The borehole locations were staked and/or marked in the field and utility clearances obtained prior to drilling. Thurber obtained the northing and easting coordinates (MTM) and ground surface elevations of all boreholes from a digital terrain model (DTM) provided by Callon Dietz.

Downing Drilling Ltd. of Hawkesbury, Ontario supplied and operated a truck-mounted CME75 drill rig for the first phase of the field investigation. OGS Drilling Inc. of Almonte, Ontario supplied and operated a portable tripod drill for the second phase of the investigation.

Fowler Construction of Huntsville, Ontario provided traffic control services during the field investigations.

The drilling and sampling operations in the field were supervised on a full time basis by an experienced Thurber drilling supervisor. Geotechnical laboratory testing was carried out by Thurber in its MTO-approved laboratory. Overall supervision of the field program was carried out by Mr. Stephane Loranger, CET.

Dr. Tamer Elkateb and Mr. Keli Shi, P.Eng., interpreted the data and prepared the report. The report was reviewed by Jason Lee, P.Eng., and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.



Keli Shi, P.Eng.
Foundations Engineer



Jason Lee, P.Eng.
Principal, Senior Geotechnical Engineer



Dr. P.K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact

**FOUNDATION INVESTIGATION AND DESIGN REPORT
SLOPE REHABILITATION ON HIGHWAY 118
0.5 KM NORTH OF HALIBURTON COUNTY ROAD 121
HUNTSVILLE DISTRICT
G.W.P. 5339-11-00**

GEOGRES No. 31E-369

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7. GENERAL

This report presents interpretation of the geotechnical data provided in the factual report, as well as discussions and geotechnical design recommendations for the proposed slope rehabilitation on Highway 118 approximately 0.5 km north of Haliburton County Road 121 in Huntsville District, Ontario.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation, and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. The contractor must make their own interpretation based on the factual data in Part 1 of the report. Where comments are made on construction, they are provided only in order to highlight those aspects which could affect the design of the project. Contractors must make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

Foundation investigation and design report prepared by exp, dated April 10, 2013, indicates some evidence of slope instability such as tilted guardrail, pavement cracks in the paved shoulder and southbound lane, a tilted utility pole and some tilted trees. The report has also indicated, based on MTO documentation, that Hwy 118 in this area was subjected to rehabilitation in 2004, i.e., an in-place full depth reclamation was applied to the pavement north of Sta. 16+727 and a 50 mm resurfacing treatment was applied to the pavement south of Sta. 16+727. The results of stability analyses discussed in the exp report suggest that the slopes of the highway embankment within the investigated areas are presently at limit equilibrium and there is a potential for deeply seated failures and shallow slippages. The report has concluded that in all three areas between Stations 16+730 to 17+100 the slopes should be stabilized to prevent further movement and endangering the traffic on Hwy 118.

A site visit was conducted by a member of Thurber's engineering staff in March 2015 prior to the current field investigations. During the site visit, pavement tension cracks, tilted hydro pole and trees, guardrail sagging and curving, steep lakeside slopes, and slope erosion protection including gravel sheeting and toe rip-rap were observed in the three areas identified in exp's report and shown in the site photographs included in Appendix C.

The discussions and recommendations presented in this report are based on the factual data obtained during the course of the current investigations. The existing subsurface information collected for the preliminary design of the slope rehabilitation (Geocres 31E-326, Appendix E) was reviewed and incorporated in this report, where appropriate.

8. GEOTECHNICAL DESIGN PARAMETERS

Design geotechnical parameters have been developed for different soil layers encountered in the three areas where signs of distress were observed (Areas 1, 2 and 3) and are shown on the stratigraphic sections presented in Drawings D-2 to D-6 in Appendix D. These parameters were derived mainly based on empirical correlations with the results of the field and laboratory tests and on previous experience with similar materials. Summaries of the design parameters are presented in Table 8-1 below.

Table 8-1 Summary of Soil Design Parameters

Soil Type	Unit Weight (kN/m ³)	Friction Angle (degree)	Cohesion (kPa)
Area 1			
Sand Fill	20	32	0
Sand	19	32	0
Silt	18	29	0
Clayey Silt	18	28	2
Area 2			
Sand & Gravel Fill	21	32	0
Silt to Clayey Silt	18	28	0
Sand	19	32	0
Area 3			
Sand & Gravel Fill	21	32	0
Silt	18	29	0

9. ASSESSMENT OF EXISTING CONDITIONS

In light of the steep inclination of the existing slopes (1H:1V to 1.6H:1V) within the investigated areas, slope stability analyses have been carried out to evaluate the conditions of the existing roadway embankment. The analyses were undertaken using the SLOPE/W module of the GeoStudio 2012 software and adopting the Morgenstern and Price method of analysis. The analyses were conducted on the most critical embankment sections (Sections C-C, E-E, F-F, I-I, and L-L shown in Drawings D-2 to D-6 in Appendix D) under static conditions. The critical sections were selected in each area based on slope inclinations, subsurface conditions and observed surface distresses. Water levels in the Head Lake was taken at elevation 317.7 m.

The results of the slope stability analysis are presented in Figures G1 to G5 in Appendix G and a summary of these results is presented in Table 9-1 below. The calculated factors of safety are close to unity in each of the three areas suggesting that the highway embankment is marginally stable under the existing conditions and that appropriate remedial measures are needed to improve the embankment stability and mitigate future movement. Without slope stabilization, the marginally stable slope will become unstable under certain unfavorable conditions, e.g., extended period of precipitation, toe erosion over time.

Table 9-1 Summary of Factors of Safety for Existing Conditions

Area	Section	Approximate Average Slope Inclination	Factor of Safety	Figure No.
1	C-C	1.4H:1V	0.92	G1
	E-E	1.6H:1V	1.03	G2
2	F-F	1.5H:1V	0.95	G3
	I-I	1.3H:1V	1.00	G4
3	L-L	1.2H:1V	0.93	G5

10. SLOPE REHABILITATION ALTERNATIVES

The results of the assessment of the existing conditions suggest that the existing embankment slopes may have experienced creep movement possibly due to a number of factors such as steep inclination of the existing slopes (1H:1V to 1.6H:1V), shallow plastic silt deposit, poor surface water drainage, and sloping bedrock surface underlying the sand deposit.

Prior to any slope rehabilitation work, it is recommended that an instrumentation and monitoring program be implemented, from a geotechnical perspective, to confirm the slope movement and

to determine the depths and rates of the movement. The instrumentation and monitoring program should consist of 1 to 2 slope inclinometers in each area. If the slope movement is confirmed, the monitoring results can be used to help determine the timing for rehabilitation and potentially optimize the design of the rehabilitation work. A draft NSSP of the instrumentation and monitoring program was provided to AECOM and MTO in March 2017 and is included in Appendix I.

Photograph 1 presented in Appendix C, dated April 9, 2014, provided by AECOM shows multiple significant tension cracks on the pavement surface traversing the entire roadway in Area 1. Development of the pavement tension cracks suggests potential slope movement at depths which would make soil nailing an ineffective slope stabilization option. As a result, a detailed geotechnical instrumentation and monitoring program was proposed by Thurber on March 31, 2017 and approved by MTO in May 2017. The detailed program consisted of slope inclinometers, vibrating wire piezometers and standpipe piezometers installed at four (4) strategically selected locations to monitor the slope movement and groundwater fluctuation. Installation and baselining of the monitoring instruments was completed in June 2017. The monitoring program is currently underway with monitoring data collected on a monthly basis.

The following alternatives have been considered in the process of developing a suitable slope rehabilitation option from both cost and constructability perspectives. It should be noted that the main constraint when comparing different alternatives and selecting the preferred one is the requirement to keep the highway open for traffic during construction.

- Slope flattening and toe berm
- Soil nailing
- Reinforced Soil Systems (RSS)
- Caisson wall
- Micropiles
- Light-weight fill replacement
- Permeation grouting

Discussions of the various rehabilitation alternatives are presented in the following paragraphs. A summary of comparison of the above alternatives is provided in a table in Appendix F.

Reinforced soil systems (RSS) and light-weight fill replacement will require deep excavation through the existing embankment and a robust roadway protection system. Maintaining the highway open for traffic during construction will be difficult and full closure of the roadway will be likely necessary. Therefore, these two alternatives have not been further developed.

Structural solutions such as rigid caisson wall (tangent or secant) and micropiles have been considered. Installation cost of a caisson wall will be high and disruption of the highway traffic will be inevitable. A large quantity of structurally flexible micropiles is likely required to stabilize the steep embankment slopes at this site, and the effectiveness of this alternative is questionable. Therefore, the two structural solutions have not been pursued further.

Improvement of the existing soil matrix using permeation grouting has also been considered. However, permeation grouting in silty materials will likely be ineffective. Potential negative environmental impact such as grout seeping into the lake through the gravelly sand above the bedrock and the bedrock fracture zone must be addressed. This alternative has also not been developed further.

Slope flattening and toe berm construction is deemed an effective option in improving the stability of the current steep slopes. Use of rock fill or sand & gravel fill with proper erosion protection may be considered for construction of slope flattening and toe berm. Fill placement into the water will be required to construct a stable slope and stabilizing toe berm.

Use of soil nails to improve stability and limit movement of the existing slopes will require installation of nails in multiple levels. The nail spacing, penetration depth and number of levels will depend on the mechanism of the slope movement. The slope stabilization system consisting of soil nails and high-tensile steel wire mesh can accommodate challenging site conditions such as uneven slope face (e.g. existing trees, tree stumps, varying slope inclinations), limited construction easement and stringent environmental requirements. This alternative is anticipated to cause minimum disruption to the highway traffic and is considered feasible.

At the MTO's request, AECOM/Englobe/Thurber have further reviewed the two options, i.e. slope flattening and toe berm option and soil nailing option, and conducted a detailed cost estimate comparison in March 2017. It is our understanding that, based on cost, service life, local contractor experience and technical merits, AECOM has recommended to MTO the slope flattening and toe berm construction as the preferred option and advanced the design of slope flattening and rock fill berm based on Thurber's recommendations outlined below.

Stability analyses have been carried out for two alternatives, i.e. slope flattening and soil nailing. Detailed discussions of the two alternatives are presented in the following sections.

10.1 Slope Flattening and Toe Berm

Slope stability improvement using various fill configurations for slope flattening was evaluated for Section C-C, which was considered the most critical section among the three areas.

The selected fill configurations consisted of a fill wedge placed in front of the existing roadway embankment at a side slope of 2H:1V in combination with a 6 m wide toe berm with the top at elevation 319.5 m or about 1.8 m above the normal water level in the Head Lake. Two types of fill material were considered for the slope flattening and toe berm:

1. Sand and Gravel fill (OPSS Granular A or B Type II) with a friction angle of 35°; or
2. Rock Fill with a friction angle of 42°.

The results of the stability analysis are presented in Figures G6 to G9 and are summarized in Table 10-1. The calculated factors of safety meet the target values for long term stability, i.e. 1.5 and 1.1 for static and seismic conditions, respectively.

Table 10-1 Summary of Factors of Safety - Slope Flattening and Toe Berm

Area	Section	Fill Material	Factor of Safety (Figure No.)	
			Static Conditions	Seismic Conditions
1	C-C	Sand and Gravel	1.46 (G6)	1.29 (G7)
1	C-C	Rock fill	1.48 (G8)	1.28 (G9)

The design seismic coefficient of 0.045 g used in the stability analyses for seismic conditions is based on the Peak Ground Acceleration (PGA) for a 475-year return period earthquake and the soil amplification effect at this site.

10.1.1 Construction Considerations

In order to reduce the potential of destabilizing the existing slope, it is recommended that the toe berm be constructed prior to placing fill on the existing slope and rock fill for flattening the slope be placed from the toe up towards the highway. The existing trees on the slope surface shall be trimmed and cut down, i.e. close-cut clearing, but all existing stumps and root masses shall be left in place, and no stripping or grubbing of the slope must be carried out. Complete removal of vegetation and root masses could result in slope instability and is therefore not recommended.

A layer of granular material consisting of OPSS Granular 'A' material with a minimum thickness of 300 mm should be placed between the rock fill and the existing slope to prevent migration of fines from the existing embankment into the rock fill. The granular filter and rock fill should be built in lifts simultaneously such that the potential for new fill sliding on the existing slope is minimized. Geotextile should be used to separate the granular fill from the rock fill. The geotextile shall be Class II non-woven type as per OPSS 1860 with filtration opening size (FOS) range of 105-210 µm and placed as per OPSS 511. Rock fill placement, lift thickness and layer compaction shall be as per OPSS.PROV 206 amended by SP102S05. Granular filter material shall be placed and

compacted in layers not exceeding 300 mm in thickness prior to compaction as per OPSS.PROV 501. A suggested sequence of fill placement is schematically shown in Figure 1 of Appendix H. Suggested wording for an NSSP is included in Appendix I.

Positive control and discharge of all surface water that will adversely affect slope stability shall be provided throughout construction. All the existing ditches, drainage pipes, culverts, or conduits used to control surface water shall be maintained operational during construction. The contractor shall provide effective sediment control measures during construction.

Upon completion of the slope stabilization system, temporary surface water control and sediment control measures may be removed from the site as approved by the contract administrator. Considerations may be given to the use of 100% RAP (reclaimed asphalt pavement) or granular sealing of rounding at shoulders to prevent roadway surface runoff from flowing down the slope.

10.2 Soil Nailing

10.2.1 Design Philosophy

Improvement of slope stability using various soil nail configurations were evaluated for the critical embankment sections assessed to be marginally stable under current conditions.

In slope areas where the existing factor of safety was marginal, reinforcement using soil nails was then introduced to improve the overall factor of stability of the subject slope. The number of soil nails and nail diameter, length, and spacing were determined by achieving the predefined target factor of safety for the reinforced slope.

The soil nail end (head) plate was sized to avoid bearing capacity failure at the slope face in accordance with procedure of the Ministry of Transportation of Ontario (MTO) Report HIIFP-120: Soil Nailing for Highway Construction in Ontario (Section 5).

The stability analysis results for the selected soil nail configurations are presented in Figures G10 to G19 and are summarized in Table 10-2. The calculated factors of safety meet the target values for long term stability, i.e. 1.5 and 1.1 for static and seismic conditions, respectively.

Table 10-2 Summary of Factors of Safety - Soil Nailing

Area	Section	Factor of Safety (Figure No.)	
		Static Conditions	Seismic Conditions
1	C-C	1.76 (G10)	1.57 (G11)
	E-E	2.30 (G12)	1.98 (G13)

Area	Section	Factor of Safety (Figure No.)	
		Static Conditions	Seismic Conditions
2	F-F	2.24 (G14)	1.96 (G15)
	I-I	1.93 (G16)	1.71 (G17)
3	L-L	1.56 (G18)	1.29 (G19)

10.2.2 Soil Nail Design

The results of the stability assessment indicate that soil nails will significantly improve the stability conditions of the existing slopes. The design of soil nails was carried out based on the minimum reinforcement length required to extend beyond the potential slip surface as determined from the slope stability analyses. In consideration of the uncertainty in the slope movement mechanism and the potential behaviour that the very loose to loose silt may be slipping on the steep bedrock surface, all soil nails have been designed with a minimum socket of 1.5 m into the granitic bedrock to account for potential slope movement along the sloping soil-rock interface. Table 10-3 provides a summary of the soil nail design.

Table 10-3 Summary of Soil Nails Design

ELEMENTS	DESCRIPTION	DESIGN VALUE
Nail Pattern	Staggered in Triangular Pattern	-
Nail Spacing	Horizontal	1.5 m
	Vertical	1.5 m
Nail Inclination	From the Horizontal	20°
Rows of Soil Nails	Varies	2 – 5 Rows (See Table 10-4)
Nail Length	Varies	7.0 – 14.0 m with 1.5 m minimum socket in bedrock (See Table 10-4)
Nail Bar	DYWIDAG THREADBAR	nominal diameter of 32 mm (#10 Steel Grade 75)
Nail Hole	Minimum Diameter	150 mm
Head Plate	Minimum Dimensions	700 mm x 700 mm

Ultimate and factored soil nail bond strengths of 500 kPa and 300 kPa were assumed in slope stability analyses for the slope stabilization design. A geotechnical resistance factor of 0.6 was used in the design as per Table 6.2 of CHBDC (2014). It is therefore required that verification

tests be performed before commencement of construction to verify the nail pullout resistance. The design nail size and length may need to be adjusted based on the results of the verification tests.

Flexible facing consisting of high-tensile steel wire mesh is recommended to accommodate the existing slope conditions including uneven surface, varying slope inclinations and trees, and to facilitate re-vegetation of the slope after rehabilitation. The grade of the high-tensile steel wire mesh including punching resistance, structural capacity of connections, mesh durability, etc. should be selected to be compatible with design nail load, nail spacing and head plate dimensions. The plan dimensions of the head plate provided in Table 10-3 is sized based on bearing capacity of the supporting soil. Thickness of the head plate needs to be designed to avoid overstressing the head plate in bending under the soil nail load. If a proprietary product is selected, the dimensions of the head plates should be adequately designed to resist the design service nail load of 210 kN per nail.

The proposed configurations of soil nails are shown in Appendix H and are summarized in Table 10-4. The actual nail lengths may vary beyond the ranges indicated in the table. The extents of the stabilizing treatment in each area have been adjusted to account for the embankment sections with similar embankment height, average slope inclination and surface vegetation conditions.

Table 10-4 Summary of Soil Nail Configurations

Area	Stationing	No. of Rows	Approximate Nail Length
1	16+725 to 16+775	5	9.5 – 13.0
	16+775 to 16+825	5	7.0 – 12.0
2	16+875 to 16+975	4	7.5 – 14.0
	16+975 to 17+050	3	9.0 – 13.0
3	17+050 to 17+125	2	8.5 – 10.5

10.2.3 Installation Requirements

Installation of soil nails shall be carried out in accordance with the guidelines of the Ministry of Transportation of Ontario (MTO) Report HIIFP-120: Soil Nailing for Highway Construction in Ontario and the Federal Highway Administration (FHWA) Publication No. FHWA-NHI-14-007: Soil Nail Walls Reference Manual. The following minimum requirements shall also apply:

- Double corrosion protection shall be provided for all soil nails against ground corrosive environment arising from winter road salting, which is significant for highways in Ontario;

- Steel wire mesh used in flexible facing shall be zinc-coated or galvanized to improve its durability. Alternatively, plastic coating may be used subject to fulfilling durability requirements under long-term ultraviolet exposure;
- Nail heads shall be recessed a minimum 100 mm below the slope surface to allow for pre-stressing of the mesh, if required; and
- Eroded areas on the slope shall be re-graded followed by replanting/re-vegetation.

It is recommended that a specialist contractor experienced in construction of soil nailing systems be retained to carry out the rehabilitation work. A draft NSSP for slope stabilization by soil nailing is provided in Appendix I.

10.2.4 Quality Assurance

It is recommended that verification tests be performed on sacrificial test nails before commencement of construction to verify the nail pullout resistance. In addition, proof tests should be performed during construction on the production soil nails installed. The details of the static tensile load tests on the installed soil nails are as follows:

- Verification tests to a maximum tensile load at 420 kN (2 times design test load) on non-production nails with a total number of tests equal to 2% of the total number of production tests. The design nail size and length may need to be adjusted based on the results of the verification tests; and
- Proof tests to a maximum tensile load at 315 kN (1.5 times design test load) on 5% of the production nails.

It is recommended that a ground monitoring program be implemented at the project location to observe the long term behaviour of the rehabilitated slopes. The program may consist of survey monuments installed on the crest of the rehabilitated embankment and spaced at a distance of 50 m, with a minimum of two (2) monuments in each of the three areas.

10.2.5 Scour and Erosion Protection

Erosion protection should be provided where lake water will be in contact with the slope. Design of the erosion protection measures should coordinate with that of the culverts within the rehabilitated areas and should be carried out by specialists experienced in this field.

Typically, rock protection should be provided over all surfaces with which lake water is likely to be in contact. The design of the rock protection system should be carried out by a qualified hydrologist. Construction of the rock protection should be in accordance with OPSS 511. A

vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS 804.

11. CONSTRUCTION CONCERNS

Potential construction concerns include, but are not necessarily limited to, the following:

11.1 Slope Flattening and Toe Berm

- If selected, fill placement near the shoreline for slope flattening and toe berm construction must ensure stability of the fill placed over the weak lakebed deposit with heavy equipment operating above.
- During and after construction of the slope flattening and toe berm, experienced geotechnical staff should be made available to monitor the existing geotechnical instruments and verify whether the slope displacement has slowed down or ceased.

11.2 Soil Nailing

- Installation of soil nails may encounter cobbles and boulders in the fill and native deposit.
- Socketing of soil nails into the strong to very strong granitic bedrock may be difficult and time-consuming if inappropriate equipment is used. The contractor must supply appropriate equipment in conjunction with suitable drilling method to facilitate overcoming obstructions and socketing into bedrock.
- Steel liners/casings will be required to install soil nails through water bearing cohesionless deposit. Installation of nails should be carried out in such a way that borehole stability is maintained until the borehole is fully grouted.
- Installation of facing element for soil nails on the existing steep slope may be difficult.

12. CLOSURE

Engineering analysis and preparation of the report were carried out by Dr. Tamer Elkateb and Mr. Keli Shi, P.Eng. The report was reviewed by Mr. Jason Lee, P.Eng., and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT ⁽¹⁾ 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample	TP Thin Wall Piston Sample	
	PH Sampler Advanced by Hydraulic Pressure	PM Sampler Advanced by Manual Pressure	
	WH Sampler Advanced by Self Static Weight	RC Rock Core	SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$


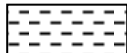



 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS W _L < 50%	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. (W _L < 30%).
		CI	Inorganic clays of medium plasticity, silty clays. (30% < W _L < 50%).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS W _L > 50%	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

EXPLANATION OF ROCK LOGGING TERMS

<u>ROCK WEATHERING CLASSIFICATION</u>		<u>SYMBOLS</u>	
Fresh (FR)	No visible signs of weathering.		
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.		CLAYSTONE
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.		SILTSTONE
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.		SANDSTONE
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.		COAL
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.		Bedrock (general)

<u>DISCONTINUITY SPACING</u>		<u>STRENGTH CLASSIFICATION</u>			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Very thinly bedded	20 to 60mm				
Laminated	6 to 20mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Thinly Laminated	Less than 6mm				

<u>TERMS</u>		Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.				
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.				
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.				
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen				
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.				

RECORD OF BOREHOLE No 15-01

1 OF 1

METRIC

W.P. 5339-11-00 LOCATION Sta. 16+729 N 4 990 897.1 E 382 437.9 ORIGINATED BY AHF
 HWY 118 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2015.11.02 - 2015.11.02 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa												
325.7	GROUND SURFACE							20	40	60	80	100								
0.0	ASPHALT: (225mm)																			
0.2	SAND, some gravel, trace silt Compact Brown Moist		1	SS	15		325													
324.9	(FILL)		2	SS	11															
0.8	Sandy SILT, some clay Compact Grey Moist																			
324.5																				
1.2																				
323.8	Cobble zone Start coring at 1.9m						324													
1.9	GRANITIC GNEISS, slightly weathered to fresh, strong to very strong, dark grey/pink		1	RUN			323													
	Horizontal joints at 2.0m, 2.5m, 3.0m and 3.3m																			
	Highly broken zone 125mm at 2.1m																			
	Sub-veritcal joint 250mm at 3.7m, 125mm at 3.9m, 275mm at 4.1m and 125mm at 4.6m		2	RUN			322													
	Sub-horizontal joint 50mm at 4.5m																			
320.7							321													
5.0	END OF BOREHOLE AT 5.0m. BOREHOLE BACKFILLED WITH BENTONITE/CUTTINGS TO 0.6m, THEN WITH SAND TO 0.3m AND COLD PATCH ASPHALT TO SURFACE.																			

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 15-02

1 OF 1

METRIC

W.P. 5339-11-00 LOCATION Sta. 16+769 N 4 990 862.4 E 382 420.2 ORIGINATED BY AHF
 HWY 118 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2015.11.02 - 2015.11.02 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
325.5	GROUND SURFACE							20	40	60	80	100				
0.0	ASPHALT: (250mm)							20	40	60	80	100				
0.3	SAND, trace silt, trace gravel Compact Brown Moist (FILL) Sandy SILT, some clay Loose to Compact Grey Moist		1	SS	10		325								7 89 4 (SI+CL)	
324.7			2	SS	9										0 35 53 12	
0.8																
			3	SS	27		324									
323.3																
2.2	SAND, some silt, trace to some gravel Compact to Dense Brown Moist to Wet Becoming gravelly		4	SS	30		323								7 76 17 (SI+CL)	
			5	SS	21		322									
			6	SS	27		321								20 60 17 3	
			7	SS	70/ 0.300											
320.6	GRANITIC GNEISS, moderately weathered to fresh jointed, medium strong to very strong, dark grey Sub-vertical joint 25mm at 5.0m, 5.2m and 75mm at 5.4m Horizontal joint at 5.5m, 5.6m, 5.8m, 5.9m and 6.0m 50mm highly broken zone at 6.3m Horizontal joints at 6.9m, 7.0m, 7.1m, 7.2m and 7.6m Subhorizontal joints 50mm at 7.0m and 75mm at 7.4m		1	RUN			320								RUN #1 TCR=100% SCR=63% RQD=48% Is50 (A)=6.0 MPa Is50 (D)=3.5 MPa	
4.9																
				2	RUN			319								RUN #2 TCR=100% SCR=77% RQD=78% Is50 (A)=8.4 MPa Is50 (D)=5.3 MPa
317.5																
8.0	END OF BOREHOLE AT 8.0m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2016.03.15 0.6 324.9															

ONTMT4S 8870.GPJ 2017TEMPLATE(MTO).GDT 9/29/17

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 15-03

1 OF 2

METRIC



W.P. 5339-11-00 LOCATION Sta. 16+769 N 4 990 864.0 E 382 414.4 ORIGINATED BY AHF
 HWY 118 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2015.11.03 - 2015.11.03 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					
325.5	GROUND SURFACE												
0.0	ASPHALT: (200mm)												
0.2	SAND, some gravel, some silt, trace clay Dense to Loose Brown Moist (FILL)		1	SS	28		325						
			2	SS	45								
			3	SS	7		324						10 67 19 4
			4	SS	11								
323.1													
2.4	Sandy SILT, some clay Compact to Dense Brown Moist		5	SS	20		323						0 24 66 10
			6	SS	38								
							322						
			7	SS	22								
320.9													
4.6	SAND, some gravel, occasional rock fragments Compact to Very Dense Brown Moist		8	SS	14		321						21 62 17 (SI+CL)
			9	SS	33		320						
319.2			10	SS	50/								
6.3	GRANITIC GNEISS, slightly weathered to fresh, strong to very strong, dark grey				0.050		319					FI	RUN #1 TCR=100% SCR=93% RQD=98% Is50 (A)=6.1 MPa Is50 (D)=3.4 MPa
	Horizontal joint at 6.7m, 6.8m, 7.2m, 7.3m, 7.5m and 7.7m		1	RUN								0 2 0 2	
	Horizontal joint from 8.1m to 8.5m						318					2	
			2	RUN								1 2	RUN #2 TCR=100% SCR=98% RQD=88% Is50 (A)=6.0 MPa Is50 (D)=3.6 MPa
	Horizontal joints at 8.8m and from 9.0m to 9.3m		3	RUN			317					2	
316.1												5 3	RUN #3 TCR=100% SCR=74% RQD=48% Is50 (A)=7.5 MPa Is50 (D)=4.6 MPa
9.4	END OF BOREHOLE AT 9.4m. BOREHOLE BACKFILLED WITH BENTONITE/CUTTINGS TO 0.6m, THEN WITH SAND TO 0.3m AND												

Continued Next Page

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 10 (%) STRAIN AT FAILURE

METRIC

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE			"N" VALUES	20 40 60 80 100	W _P W W _L	10 20 30		
	Continued From Previous Page											
							SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100					

[illegible]

RECORD OF BOREHOLE No 15-04

1 OF 1

METRIC

W.P. 5339-11-00 LOCATION Sta. 16+769 N 4 990 871.8 E 382 401.0 ORIGINATED BY TM
 HWY 118 BOREHOLE TYPE Tripod COMPILED BY AN
 DATUM Geodetic DATE 2016.03.08 - 2016.03.08 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)				
								<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>							<div><div>PLASTIC LIMIT</div><div>NATURAL MOISTURE CONTENT</div><div>LIQUID LIMIT</div><div>W P W W L</div></div>				
317.4	GROUND SURFACE																		
0.0	Sandy SILT , trace clay, trace to some organics, decayed wood		1	SS	2		317												
316.8	Loose Grey Wet		2	SS	10		316												
0.6	SILT , some clay, trace to some sand Loose to Compact Grey Moist to Wet		3	SS	15		315												
			4	SS	7		314												
			5	SS	6		313												
			6	SS	10		312												
			7	SS	19		311												
			8	SS	13		310												
312.7	Trace gravel																		
4.7	SAND , some gravel Compact to Very Dense Brown Wet	9	SS	16		309													
	Becoming gravelly	10	SS	14															
		11	SS	10															
		12	SS	52															
		13	SS	67															
		14	SS	60															
		15	SS	88/ 0.275															
308.3																			
9.1	END OF BOREHOLE AT 9.1m UPON AUGER REFUSAL. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.																		

ONTMT4S 8870.GPJ 2017TEMPLATE(MTO).GDT 9/29/17

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 15-05

1 OF 1

METRIC

W.P. 5339-11-00 LOCATION Sta. 16+807 N 4 990 827.8 E 382 409.1 ORIGINATED BY AHF
 HWY 118 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2015.10.29 - 2015.10.29 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
325.0	GROUND SURFACE							20 40 60 80 100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
0.0	SAND , some gravel, trace silt, trace organics Compact Brown Moist (FILL) SAND , some gravel, trace silt, occasional cobbles Compact to Dense Brown Moist		1	SS	10		324																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 15-06

1 OF 2

METRIC

W.P. 5339-11-00 LOCATION Sta. 16+807 N 4 990 835.4 E 382 402.9 ORIGINATED BY AHF
 HWY 118 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2015.11.04 - 2015.11.04 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
325.3	GROUND SURFACE													
0.0	ASPHALT: (175mm)													
0.2	SAND, gravelly to some gravel, trace silt Compact Brown Moist (FILL)		1	SS	26		325							35 60 5 (SI+CL)
			2	SS	23									
			3	SS	25		324							10 85 5 (SI+CL)
323.5			4	SS	28		323							
1.8	SAND, some gravel, trace silt, occasional rock fragments Compact to Very Dense Brown Moist		5	SS	15		322							14 83 3 (SI+CL)
			6	SS	20		321							
			7	SS	50/ 0.025									
	Becoming gravelly		8	SS	28		320							45 48 7 (SI+CL)
			9	SS	56/ 0.300		319							
318.7													FI	
6.6	GRANITIC GNEISS, slightly weathered to fresh jointed, strong to very strong, mottled grey/pink Horizontal joints from 6.6m to 6.8m, 7.4m to 7.5m and 8.0m Sub-vertical joint 225mm at 7.7m Horizontal joints at 8.1m, 8.3m, 8.4m, 8.5m, 8.7m, 8.8m, 9.0m, 9.1m, 9.2m, 9.4m and 9.6m		1	RUN			318							RUN #1 TCR=98% SCR=70% RQD=67% Is50 (A)=4.8 MPa Is50 (D)=3.6 MPa
			2	RUN			317							RUN #2 TCR=100% SCR=90% RQD=73% Is50 (A)=7.5 MPa Is50 (D)=3.8 MPa
							316							
315.6														
9.7	END OF BOREHOLE AT 9.7m. Piezometer installation consists of													

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 15-07

1 OF 1

METRIC

W.P. 5339-11-00 LOCATION Sta. 16+807 N 4 990 834.4 E 382 389.2 ORIGINATED BY TM
 HWY 118 BOREHOLE TYPE Tripod COMPILED BY AN
 DATUM Geodetic DATE 2016.03.09 - 2016.03.09 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
317.7	GROUND SURFACE							<div><div>20406080100</div><div></div></div>						GRSA SILCL
0.0	ICE: (200mm)							<div><div>20406080100</div><div></div></div>						
0.2	WATER												10855 (SI+CL)	
317.2														
0.5	SAND, trace to some gravel, trace rootlets Loose to Dense Brown Wet		1	SS	8		317							
			2	SS	32									
			3	SS	24		316							
			4	SS	13		315							
314.7	Becoming silty		5	SS	50/								466246	
3.0	END OF BOREHOLE AT 3.0m UPON AUGER REFUSAL. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE. TWO ADDITIONAL BOREHOLES WERE DRILLED WITH IN 5.0m OF THIS BOREHOLE. THE TWO ADDITIONAL BOREHOLES ALSO ENCOUNTERED REFUSAL AT A DEPTH OF 2.5m BELOW LAKEBED.				0.100									

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 15-08

1 OF 2

METRIC

W.P. 5339-11-00 LOCATION Sta. 16+907 N 4 990 731.5 E 382 404.9 ORIGINATED BY AHF
 HWY 118 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2015.10.27 - 2015.10.27 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
324.3	GROUND SURFACE							20	40	60	80	100						
0.0	ASPHALT: (200mm)							20	40	60	80	100						
0.2	SAND, some gravel Compact Brown Moist (FILL)		1	SS	16		324											
323.4			2	SS	14													15 50 35 (SH+CL)
0.9	SILT, some clay, trace to some sand Compact Brown/Grey Moist						323											0 6 72 22
			3	SS	11													
322.1							322											
2.2	SAND, gravelly to some gravel, trace silt, occasional rock fragments Compact to Very Dense Brown Moist		4	SS	25													22 70 8 (SH+CL)
			5	SS	16		321											
			6	SS	23		320											
	Granitic rock pieces		7	SS	64													17 74 9 (SH+CL)
319.1							319											
5.2	Cobble zone		1	RUN														RUN #1 TCR=67% SCR=0% RQD=0%
318.7							318											RUN #2 TCR=35% SCR=0% RQD=0%
5.6	GRANITIC GNEISS, moderately to slightly weathered, strong to very strong, grey Horizontal joints at 6.4m, 6.5m and 6.6m Horizontal joint at 7.1m Sub-horizontal joints 75mm at 7.7m and 50mm at 8.1m Horizontal joints at 8.0m, 8.2m and 8.5m Highly broken zones 100mm at 7.6m, 75mm at 8.7m and 300mm at 9.4m Horizontal joints (7) from 8.8m to 9.3m		2	RUN														RUN #3 TCR=29% SCR=29% RQD=0% Is50 (A)=5.6 MPa
			3	RUN			317											
			4	RUN			316											RUN #4 TCR=100% SCR=67% RQD=53% Is50 (A)=8.5 MPa
			5	RUN			315											RUN #5 TCR=100% SCR=53% RQD=36% Is50 (A)=8.0 MPa
314.6																		
9.7	END OF BOREHOLE AT 9.7m. Piezometer installation consists of																	

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 15-08

2 OF 2

METRIC

W.P. 5339-11-00 LOCATION Sta. 16+907 N 4 990 731.5 E 382 404.9 ORIGINATED BY AHF
 HWY 118 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2015.10.27 - 2015.10.27 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
	Continued From Previous Page 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2016.03.15 4.5 319.8						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	10 20 30						

RECORD OF BOREHOLE No 15-09

1 OF 2

METRIC

W.P. 5339-11-00 LOCATION Sta. 16+907 N 4 990 730.3 E 382 398.6 ORIGINATED BY AHF
 HWY 118 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2015.11.03 - 2015.11.03 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
324.3	GROUND SURFACE												
0.0	ASPHALT: (225mm)												
0.2	Gravelly SAND , trace silt Compact Brown Moist (FILL)		1	SS	11		324						27 68 5 (SI+CL)
323.4			2	SS	14								
0.9	Sandy SILT , some clay Compact Brown/Grey Moist						323						
			3	SS	9								0 22 63 15
			4	SS	12		322						
321.4													
2.9	SILT , trace to some clay, occasional rock fragments Loose to Compact Grey Wet		5	SS	50/ 0.025		321						0 0 90 10
320.5													
3.8	Gravelly SAND , trace silt Compact to Dense Brown Moist		6	SS	19		320						
			7	SS	34								
			8	SS	31		319						
			9	SS	45		318						34 61 5 (SI+CL)
317.3	Becoming silty		10	SS	55/ 0.200		317						
7.0	GRANITIC GNEISS , slightly weathered to fresh, strong to very strong, mottled grey/pink 50mm sub-horizontal joint at 7.0m 75mm highly broken zone at 7.4m and 8.0m Horizontal joints at 7.6m and 7.9m Horizontal joints at 8.4m, 8.5m, 8.6m, 8.8m and 9.2m Sub-horizontal joints 25mm at 8.6m and 75mm at 8.7m		1	RUN									RUN #1 TCR=78% SCR=52% RQD=52% Is50 (A)=6.9 MPa Is50 (D)=5.0 MPa
			2	RUN			316						RUN #2 TCR=98% SCR=71% RQD=71% Is50 (A)=8.1 MPa Is50 (D)=4.1 MPa
							315						

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 15-10

1 OF 1

METRIC

W.P. 5339-11-00 LOCATION Sta. 16+907 N 4 990 728.2 E 382 390.4 ORIGINATED BY TM
 HWY 118 BOREHOLE TYPE Tripod COMPILED BY AN
 DATUM Geodetic DATE 2016.03.09 - 2016.03.09 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT							UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL									
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa																	
317.7	GROUND SURFACE							<div>20406080100</div> <div>○ UNCONFINED + FIELD VANE</div> <div>● QUICK TRIAXIAL × LAB VANE</div>							<div>PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT</div> <div>W_P W W_L</div> <div>WATER CONTENT (%)</div> <div>102030</div>										
0.0	ICE: (200mm)																								
0.2	WATER																								
317.2																									
0.5	SAND, some gravel Compact to Very Dense Brown Wet		1	SS	24		317																		
			2	SS	18																				
			3	SS	60		316																		
			4	SS	38																				
			5	SS	73/ 0.250		315																		
314.3																									
3.4	END OF BOREHOLE AT 3.4m UPON AUGER REFUSAL ON PROBABLE BEDROCK. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE. TWO ADDITIONAL BOREHOLES WERE DRILLED WITH IN 5.0m OF THIS BOREHOLE. THE TWO ADDITIONAL BOREHOLES ALSO ENCOUNTERED REFUSAL AT A DEPTH OF 2.8m BELOW LAKEBED.																								

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 15-11

1 OF 2

METRIC

W.P. 5339-11-00 LOCATION Sta. 16+938 N 4 990 701.6 E 382 410.2 ORIGINATED BY AHF
 HWY 118 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2015.10.27 - 2015.10.27 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
324.3	GROUND SURFACE												
0.0	ASPHALT: (300mm)												
324.0													
0.3	SAND, some gravel, trace silt Compact Brown Moist (FILL)		1	SS	18								
			2	SS	21								
323.1													
1.2	Sandy SILT, trace to some clay, occasional rock fragments Loose to Compact Brown/Grey Moist to Wet		3	SS	12								
			4	SS	6								
			5	SS	31								
320.6													
3.7	SAND, gravelly to some gravel, trace to some silt, occasional rock fragments Compact to Very Dense Brown Moist		6	SS	56								
			7	SS	28								
			8	SS	41								
			9	SS	44								
			10	SS	41								
316.7													
7.6	GRANITIC GNEISS, slightly weathered to fresh, strong to very strong, grey Highly broken zones 100mm at 7.6m and 25mm at 8.4m Sub-horizontal joints 25mm at 7.8m and 7.9m Horizontal joint at 9.2m Sub-horizontal joints 25mm at 9.4m, 9.7m, 10.0m and 10.2m		1	RUN									

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 15-11

2 OF 2

METRIC

W.P. 5339-11-00 LOCATION Sta. 16+938 N 4 990 701.6 E 382 410.2 ORIGINATED BY AHF
 HWY 118 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2015.10.27 - 2015.10.27 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
							20	40	60	80	100	W _p	W	W _L			
	Continued From Previous Page																
313.6							314										
10.7	END OF BOREHOLE AT 10.7m. BOREHOLE BACKFILLED WITH BENTONITE/CUTTINGS TO 0.6m, THEN WITH SAND TO 0.3m AND COLD PATCH ASPHALT TO SURFACE.																

ONTMT4S 8870.GPJ 2017TEMPLATE(MTO).GDT 9/29/17

RECORD OF BOREHOLE No 15-12

1 OF 1

METRIC

W.P. 5339-11-00 LOCATION Sta. 16+938 N 4 990 696.4 E 382 403.9 ORIGINATED BY AHF
 HWY 118 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2015.11.04 - 2015.11.04 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
323.6	GROUND SURFACE														
0.0	ASPHALT: (200mm)														
0.2	SAND, trace silt, trace gravel Loose Brown Moist (FILL)		1	SS	9		323							9 86 5 (SI+CL)	
322.7		2	SS	8											
0.9	SILT, trace to some clay, trace to some sand, occasional sand seams Compact Brown/Grey Moist						322								
		3	SS	7										0 6 76 18	
		4	SS	12				321							0 0 90 10
		5	SS	12				320							
			6	SS	10									0 0 93 7	
319.0							319								
4.6	SAND, some gravel, some silt, occasional rock fragments Dense Brown Moist		7	SS	42									16 66 18 (SI+CL)	
318.0															
5.6	GRANITIC GNEISS, fresh jointed to fresh, strong to very strong, mottled grey/pink 75mm sub-horizontal joint at 5.6m Horizontal joints at 5.9m, 6.1m, 6.6m, 6.9m and 7.1m Horizontal joints at 7.2m, 7.6m, 7.7m, 7.8m, 7.9m and 8.2m		1	RUN			318								
								317							
				2	RUN			316							
314.9							315								
8.7	END OF BOREHOLE AT 8.7m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2016.03.15 3.0 320.6														

ONTMT4S 8870.GPJ 2017TEMPLATE(MTO).GDT 9/29/17

+³, ×³: Numbers refer to
Sensitivity 20
15 10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 15-13

1 OF 1

METRIC

W.P. 5339-11-00 LOCATION Sta. 16+938 N 4 990 696.6 E 382 394.0 ORIGINATED BY TM
 HWY 118 BOREHOLE TYPE Tripod COMPILED BY AN
 DATUM Geodetic DATE 2016.03.10 - 2016.03.10 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>							
317.7	GROUND SURFACE														
0.0	ICE: (200mm)														
0.2	<div>WATER</div> <div>SAND, some gravel, trace silt Loose to Dense Brown Wet</div> <div>Becoming gravelly</div>		1	SS	5		317								
0.2			2	SS	40										
			3	SS	48		316								
			4	SS	17										
			5	SS	41		315								
			6	SS	66										
			7	SS	50/		314								
313.7	END OF BOREHOLE AT 4.0m UPON AUGER REFUSAL. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.				0.125										
4.0															

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 5 10 15 20 (%) STRAIN AT FAILURE

METRIC

SOIL PROFILE						SAMPLES	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
323.5	GROUND SURFACE						DYNAMIC CONE PENETRATION RESISTANCE PLOT
0.0	ASPHALT: (200mm)						SHEAR STRENGTH kPa
0.2	SAND, some gravel, trace silt Compact Brown Moist (FILL)		1	SS	14		UNCONFINED + FIELD VANE QUICK TRIAXIAL X LAB VANE
322.3			2	SS	20		
1.2	SILT, trace to some clay Compact Grey Wet		3	SS	11		
320.9							
2.6	SAND, trace silt, occasional rock fragments Compact Brown Moist		4	SS	27		
			5	SS	19		
			6	SS	21		
			7	SS	14		
318.0							
5.5	GRANITIC GNEISS, slightly weathered to fresh jointed, medium strong to very strong, grey Horizontal joints 25mm at 5.9m, 6.0m, 6.2m and 6.3m Sub-horizontal joints 25mm at 5.6m, 5.7m, 5.9m, 6.1m and 6.7m Horizontal joints from 7.2m to 7.5m, 7.7m to 7.9m, 8.2m and 8.4m Sub-horizontal joints 25mm at 7.0m, 7.5m, 7.7m, 7.8m, 8.0m and 8.3m		1	RUN			
			2	RUN			
314.9							
8.6	END OF BOREHOLE AT 8.6m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.						
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2016.03.15 3.8 319.7						

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 15-15

1 OF 1

METRIC

W.P. 5339-11-00 LOCATION Sta. 17+024 N 4 990 615.8 E 382 427.4 ORIGINATED BY AHF
 HWY 118 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2015.10.27 - 2015.10.27 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa												
323.0	GROUND SURFACE							20	40	60	80	100								
0.0	ASPHALT: (200mm)							20	40	60	80	100								
0.2	SAND, trace silt, trace to some gravel Dense Brown Moist (FILL)		1	SS	32															
322.1			2	SS	26															
0.9	Sandy SILT, trace to some clay Compact Brown Moist																			
321.6																				
1.4	SAND, trace silt, trace gravel, occasional rock fragments Compact to Dense Brown/Grey Moist		3	SS	16															
			4	SS	22															
			5	SS	59/															
319.7					0.075															
3.3	GRANITIC GNEISS, moderately weathered to fresh, strong to very strong, grey/pink Highly broken zones 75mm at 3.3m and 4.0m Highly broken zones 50mm at 4.2m, 150mm at 4.3m, 50mm at 4.7m and 275mm at 4.8m Horizontal joints at 4.2m, 4.3m, 4.5m, 4.6m, 4.7m and 4.8m Sub-horizontal joint 25mm at 4.5m Horizontal joint at 5.4m Sub-vertical joint 75mm at 5.4m Horizontal joints at 5.7m and 6.9m Sub-horizontal joints 25mm at 5.7m and 6.1m		1	RUN																
			2	RUN																
			3	RUN																
			4	RUN																
315.9																				
7.1	END OF BOREHOLE AT 7.1m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2016.03.15 0.7 322.3																			

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 15-16

1 OF 1

METRIC

W.P. 5339-11-00 LOCATION Sta. 17+104 N 4 990 538.1 E 382 442.1 ORIGINATED BY AHF
 HWY 118 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2015.10.26 - 2015.10.26 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT							UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
322.9	GROUND SURFACE							<div>20406080100</div> <div>○ UNCONFINED + FIELD VANE</div> <div>● QUICK TRIAXIAL × LAB VANE</div> <div>20406080100</div>							<div>PLASTIC LIMIT</div> <div>NATURAL MOISTURE CONTENT</div> <div>LIQUID LIMIT</div> <div>W P W L</div>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 15-17

1 OF 1

METRIC

W.P. 5339-11-00 LOCATION Sta. 17+104 N 4 990 536.3 E 382 432.5 ORIGINATED BY AHF
 HWY 118 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2015.11.04 - 2015.11.04 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
322.5	GROUND SURFACE													
0.0	ASPHALT: (200mm)													
0.2	SAND, some gravel, trace silt Compact		1	SS	20									
321.9	Brown Moist (FILL)		2	SS	19									
0.6	SILT, trace to some sand, trace to some clay Very Loose to Compact Grey Moist													
			3	SS	7									
			4	SS	2									
			5	SS	5									
			6	SS	4									
			7	SS	3									
317.3														
5.2	Silty SAND, trace gravel		8	SS	50/									
317.0	Brown Wet				0.125									
5.5	GRANITIC GNEISS, fresh jointed to fresh, strong to very strong, grey/pink		1	RUN										
	Horizontal joints (7) from 5.7m to 6.3m and 6.9m													
	Horizontal joints at 7.3m, 7.9m, 7.1m and 8.3m		2	RUN										
313.9														
8.6	END OF BOREHOLE AT 8.6m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.													
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2016.03.15 0.7 321.8													

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 15-18

1 OF 1

METRIC

W.P. 5339-11-00 LOCATION Sta. 17+104 N 4 990 534.4 E 382 422.6 ORIGINATED BY TM
HWY 118 BOREHOLE TYPE Tripod COMPILED BY AN
DATUM Geodetic DATE 2016.03.10 - 2016.03.10 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
317.7	GROUND SURFACE													
0.0	ICE: (325mm)													
317.4														
319.3	WATER													
0.5	SILT, trace sand, trace clay, some organics, decayed wood, rootlets Very Loose to Compact Grey Wet		1	SS	18		317							
			2	SS	14									0 6 87 7
			3	SS	3		316							
			4	SS	6									
			5	SS	10		315							0 5 89 6
	Trace gravel		6	SS	75		314							
313.6														
4.1	Gravelly SAND, some silt Very Dense		7	SS	98/ 0.250									22 65 13 (SI+CL)
313.2	Brown													
4.5	Wet													
	END OF BOREHOLE AT 4.5m UPON AUGER REFUSAL. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.													

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE



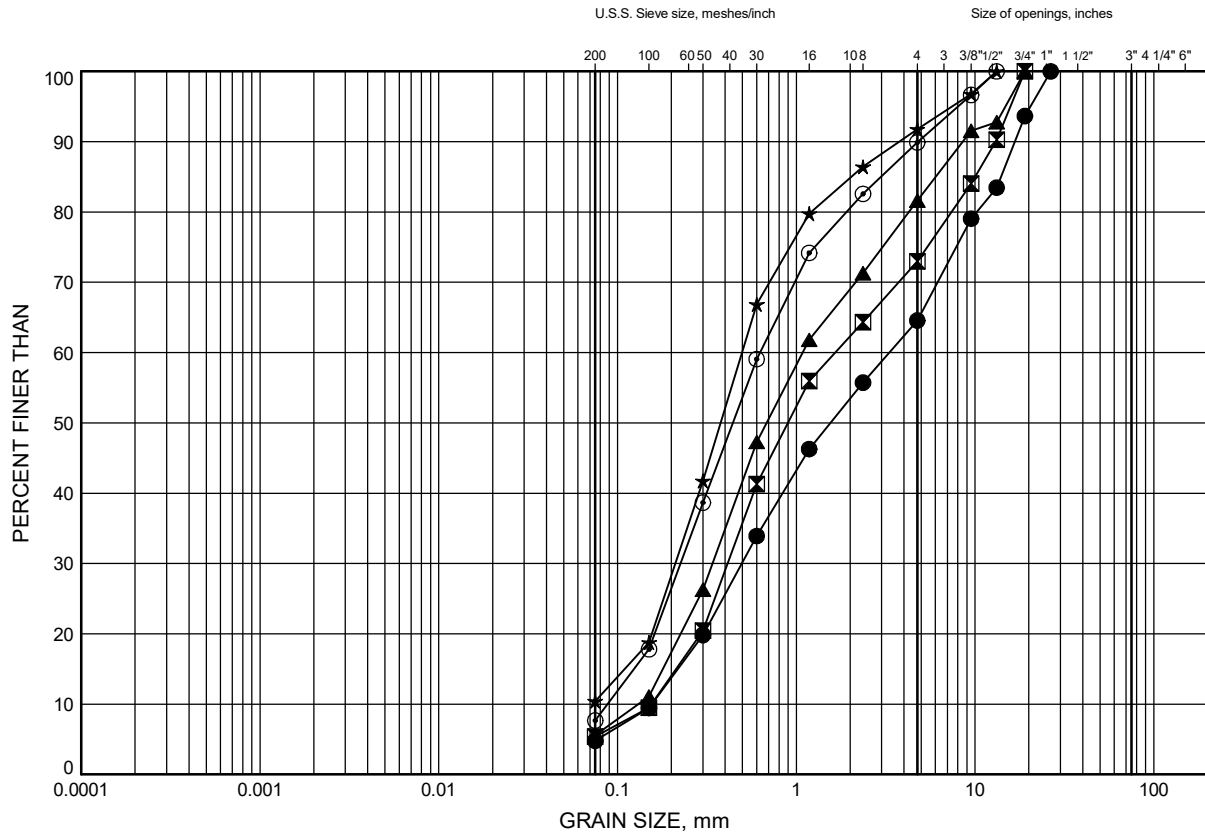
Appendix B

Laboratory Test Results and Rock Core Photographs

Hwy 118 Soil Nailing GRAIN SIZE DISTRIBUTION

FIGURE B1

SAND, Gravelly to Some Gravel FILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-06	0.5	324.8
⊠	15-09	0.5	323.8
▲	15-11	0.9	323.4
★	15-15	0.7	322.3
⊙	15-16	0.5	322.4

Date September 2017
W.P. 5339-11-00

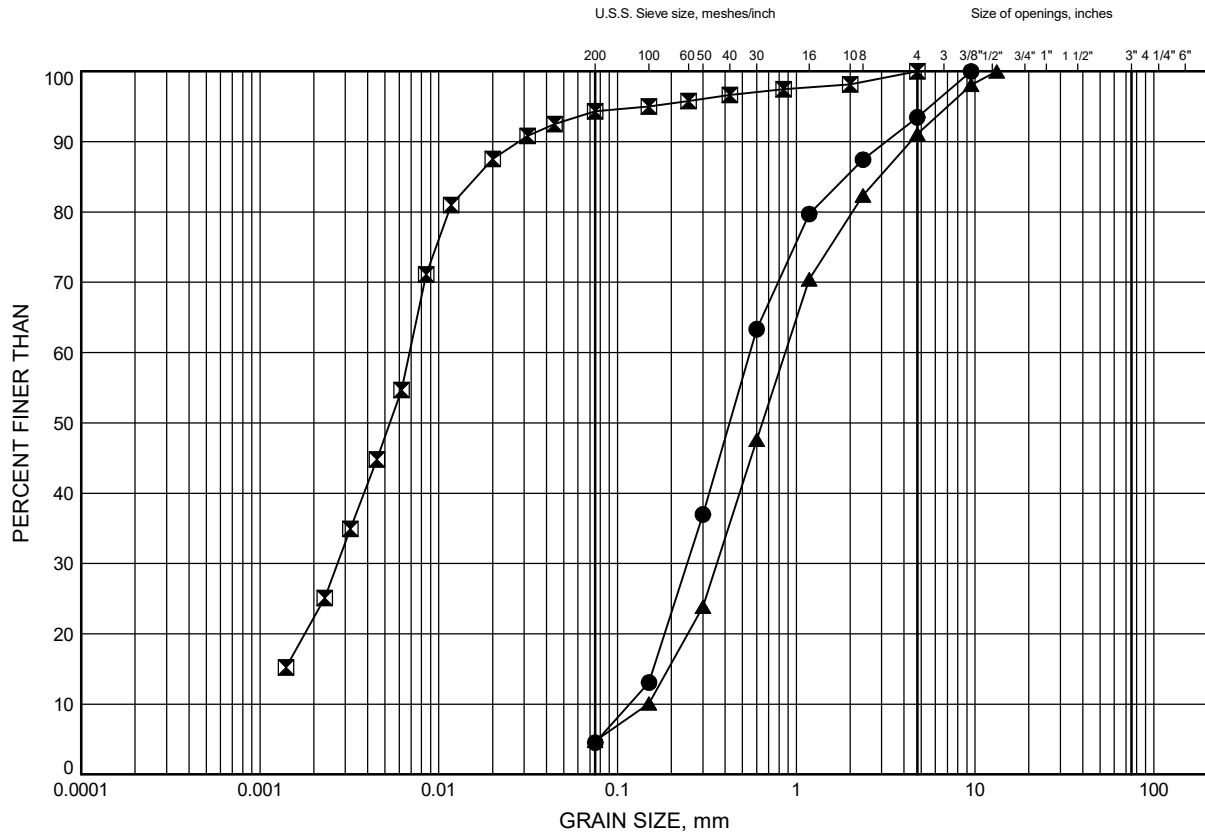


Prep'd MFA
Chkd. KS

Hwy 118 Soil Nailing GRAIN SIZE DISTRIBUTION

FIGURE B2

SAND FILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-02	0.5	325.0
⊠	15-08	1.1	323.2
▲	15-12	0.5	323.1

Date September 2017
W.P. 5339-11-00



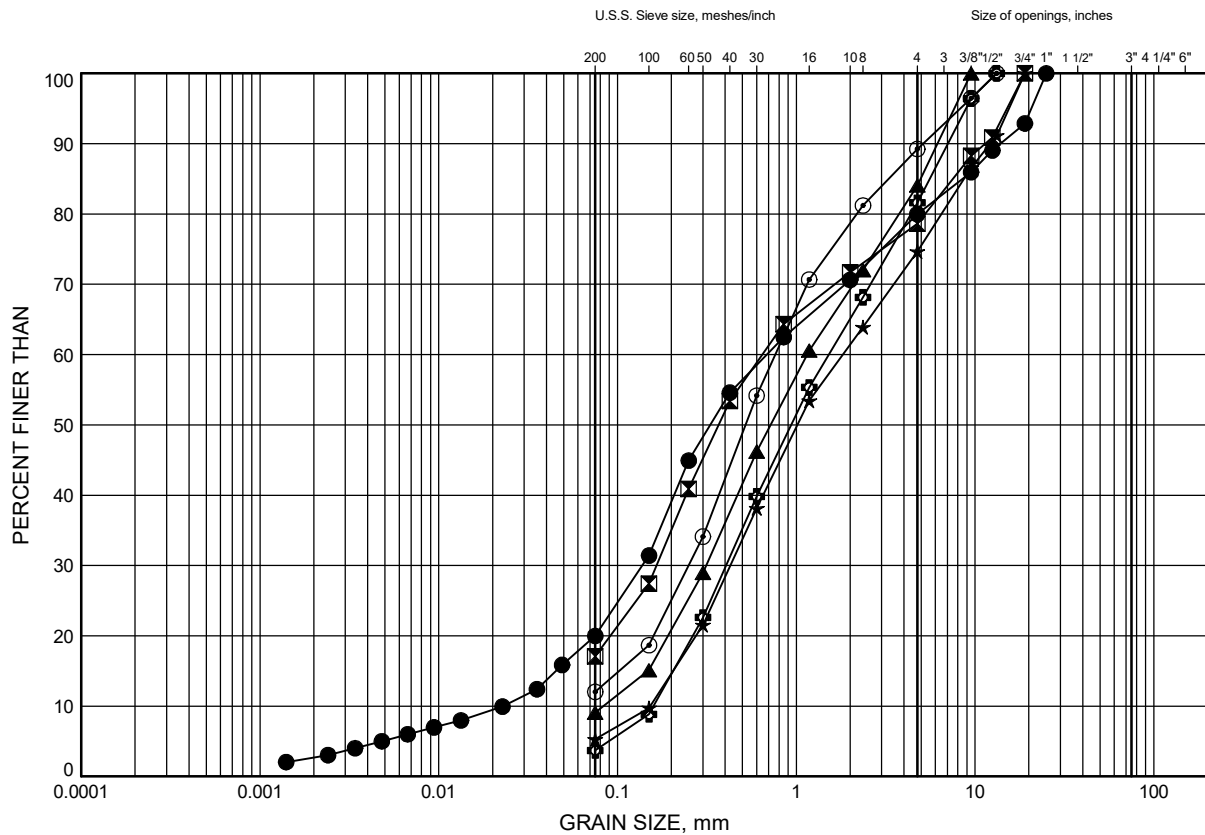
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Chkd. KS

Hwy 118 Soil Nailing

GRAIN SIZE DISTRIBUTION

FIGURE B3

SAND, Gravelly to Some Gravel



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-02	4.1	321.4
⊠	15-03	4.9	320.6
▲	15-04	5.2	312.2
★	15-04	7.0	310.4
⊙	15-05	0.9	324.1
⊕	15-05	2.6	322.4

Date September 2017
W.P. 5339-11-00



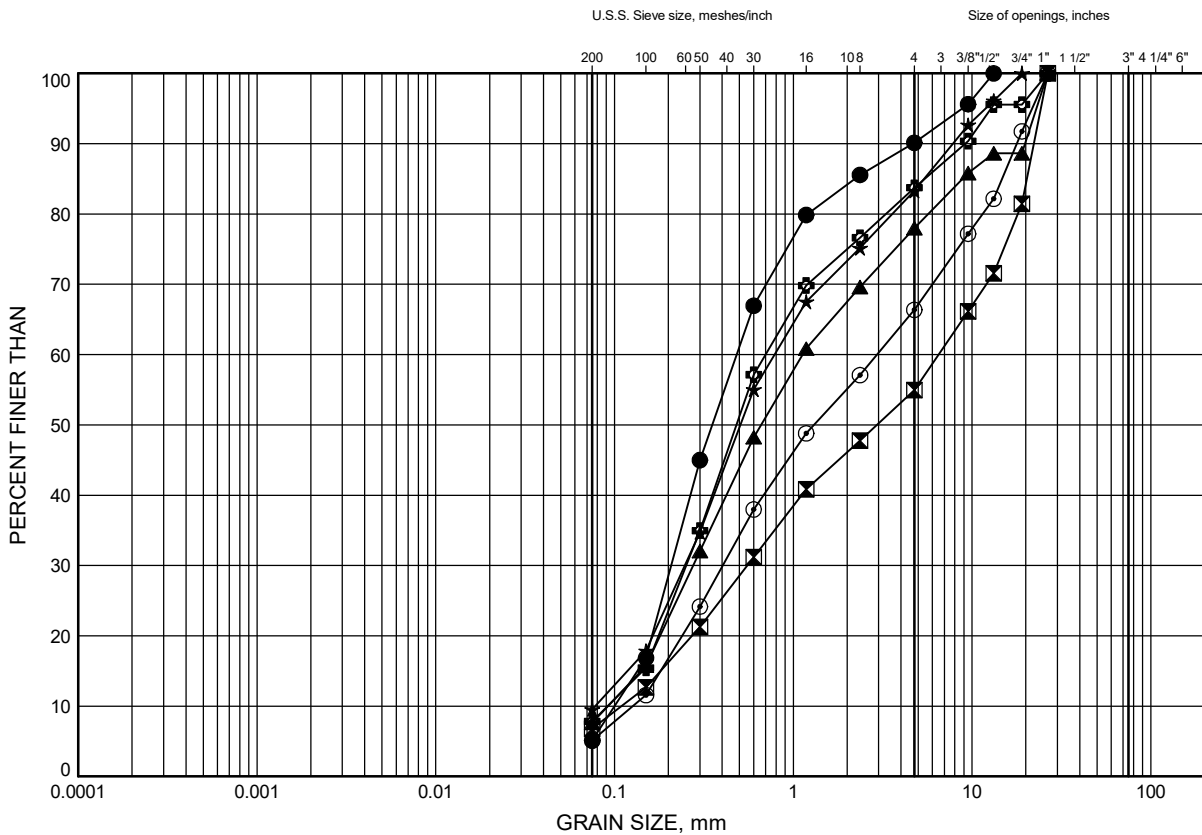
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Hwy 118 Soil Nailing

GRAIN SIZE DISTRIBUTION

FIGURE B4

SAND, Gravelly to Some Gravel



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-06	1.5	323.8
⊠	15-06	5.6	319.7
▲	15-08	2.6	321.7
★	15-08	4.9	319.4
⊙	15-09	6.4	317.9
⊕	15-10	2.0	315.7

Date September 2017
W.P. 5339-11-00

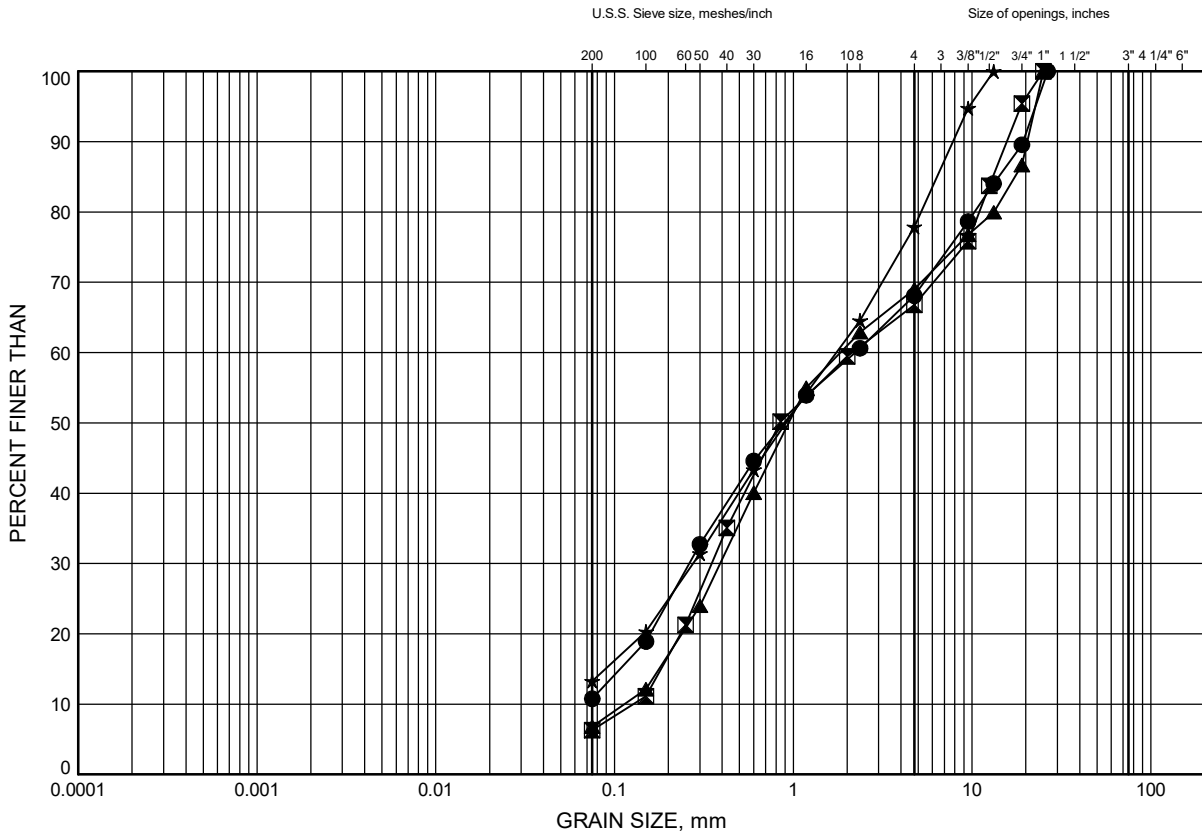


Prep'd MFA
Chkd. KS

Hwy 118 Soil Nailing GRAIN SIZE DISTRIBUTION

FIGURE B5

Gravelly SAND



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-11	5.6	318.7
⊠	15-13	2.4	315.3
▲	15-13	4.0	313.7
★	15-18	4.3	313.4

Date September 2017
W.P. 5339-11-00

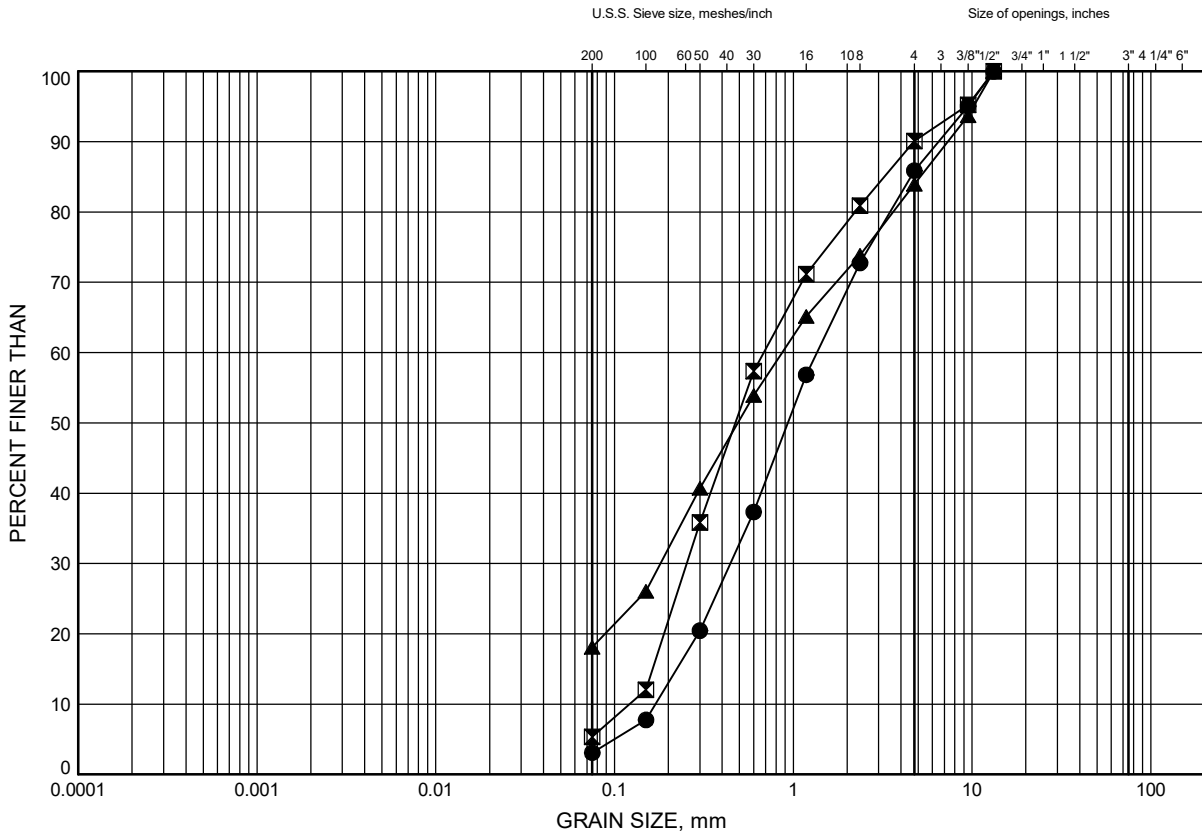


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Chkd. KS

Hwy 118 Soil Nailing GRAIN SIZE DISTRIBUTION

FIGURE B6

SAND, Some Gravel



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-06	3.4	321.9
⊠	15-07	1.4	316.3
▲	15-12	4.9	318.7

Date September 2017
W.P. 5339-11-00



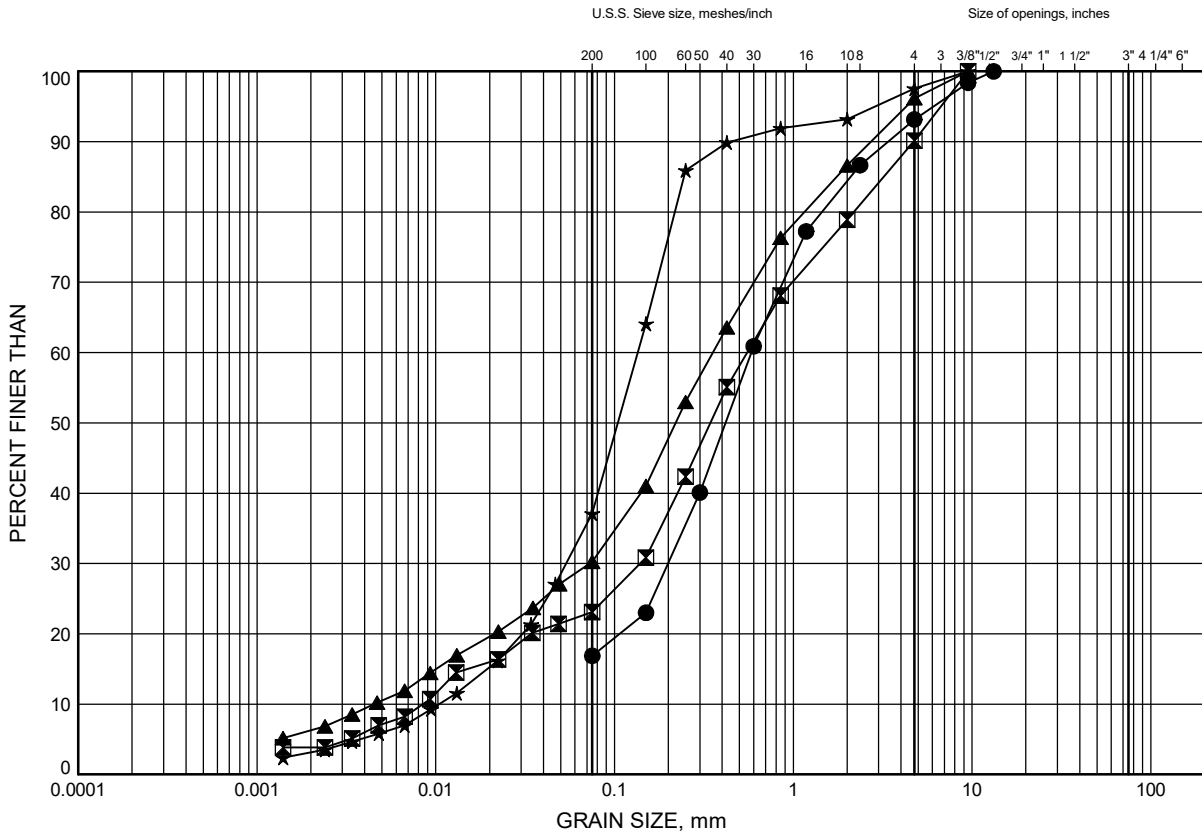
Prep'd MFA
Chkd. KS

Hwy 118 Soil Nailing

GRAIN SIZE DISTRIBUTION

FIGURE B7

SAND, Silty to Some Silt



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-02	2.6	322.9
⊠	15-03	1.5	324.0
▲	15-07	3.0	314.7
★	15-16	4.1	318.8

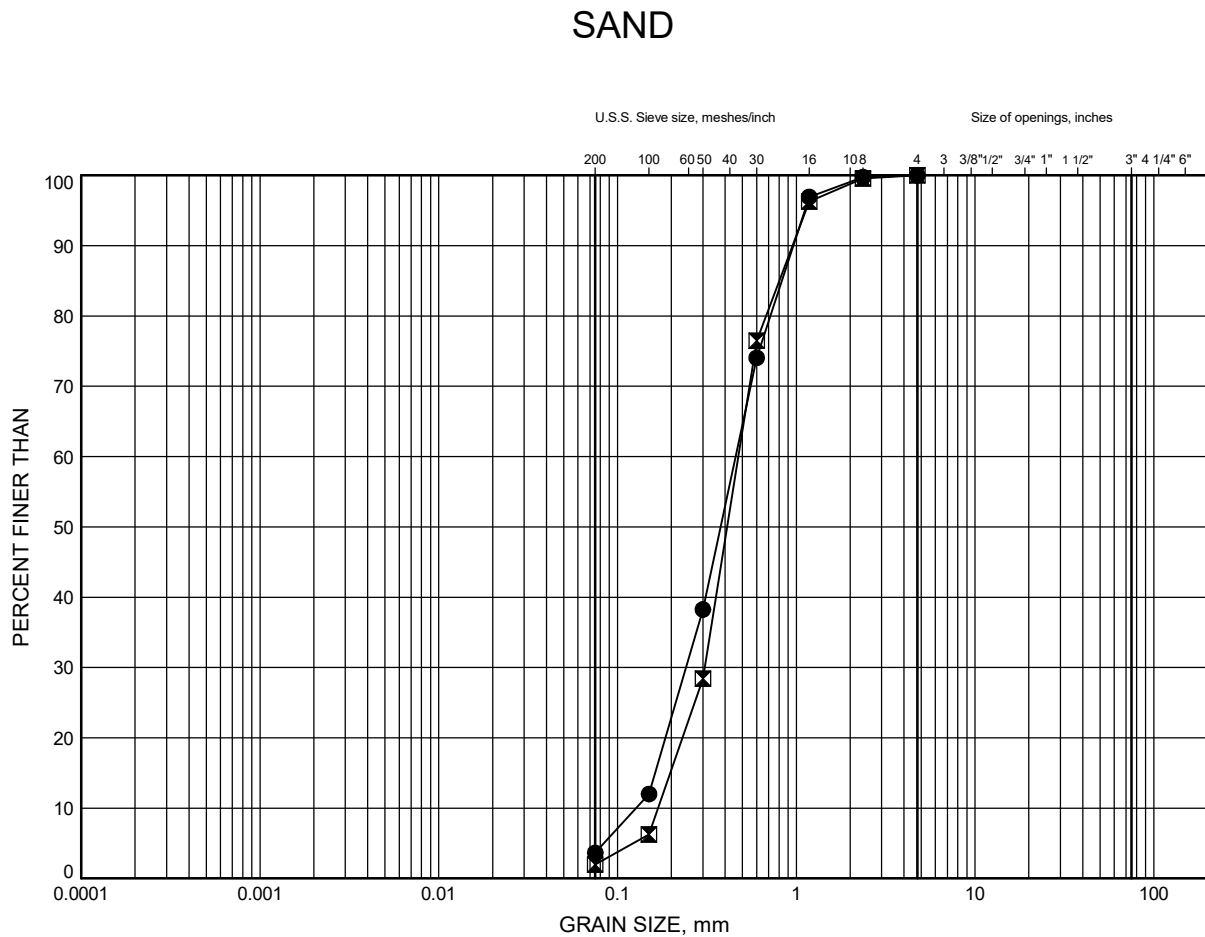
Date September 2017
W.P. 5339-11-00



Prep'd MFA
Chkd. KS

Hwy 118 Soil Nailing GRAIN SIZE DISTRIBUTION

FIGURE B8



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-14	3.4	320.1
⊠	15-14	4.9	318.6

Date September 2017
W.P. 5339-11-00

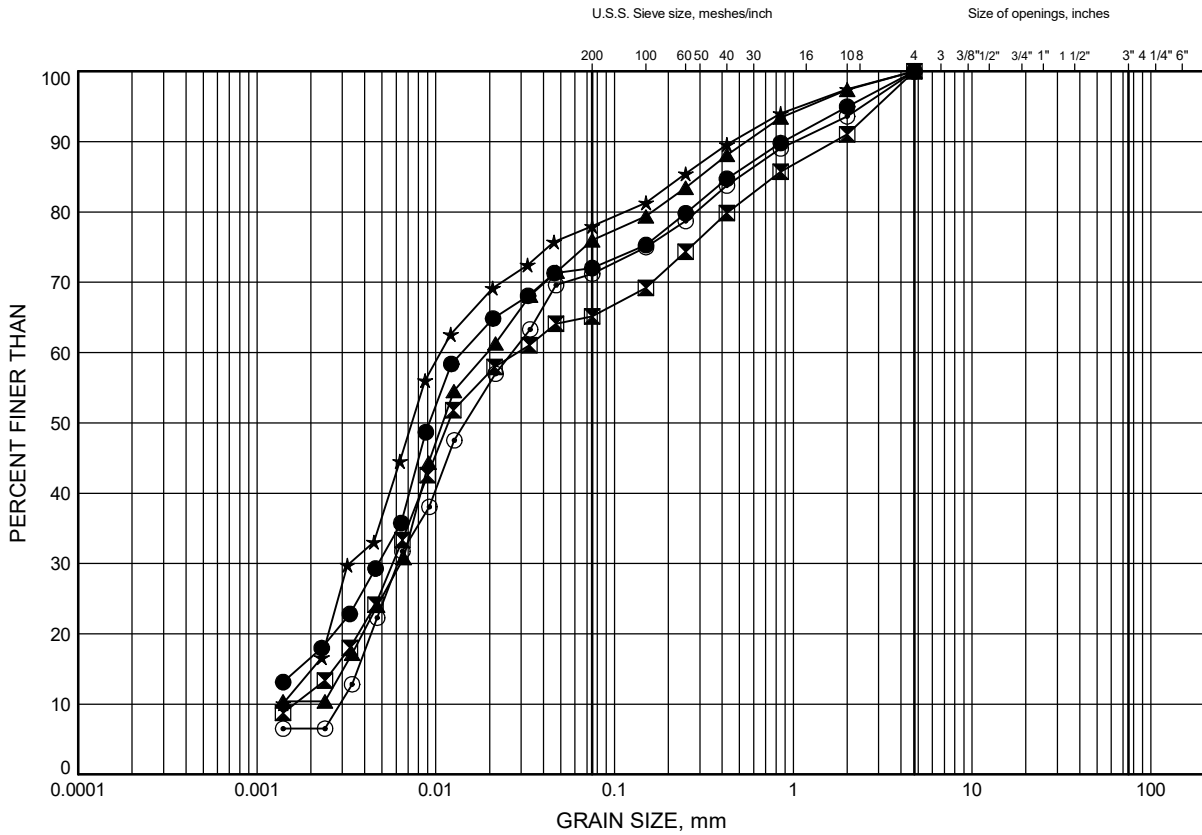


Prep'd MFA
Chkd. KS

Hwy 118 Soil Nailing GRAIN SIZE DISTRIBUTION

FIGURE B9

Sandy SILT



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-01	0.9	324.8
⊠	15-02	0.9	324.6
▲	15-03	2.7	322.8
★	15-09	1.8	322.5
⊙	15-11	3.4	320.9

Date September 2017

W.P. 5339-11-00



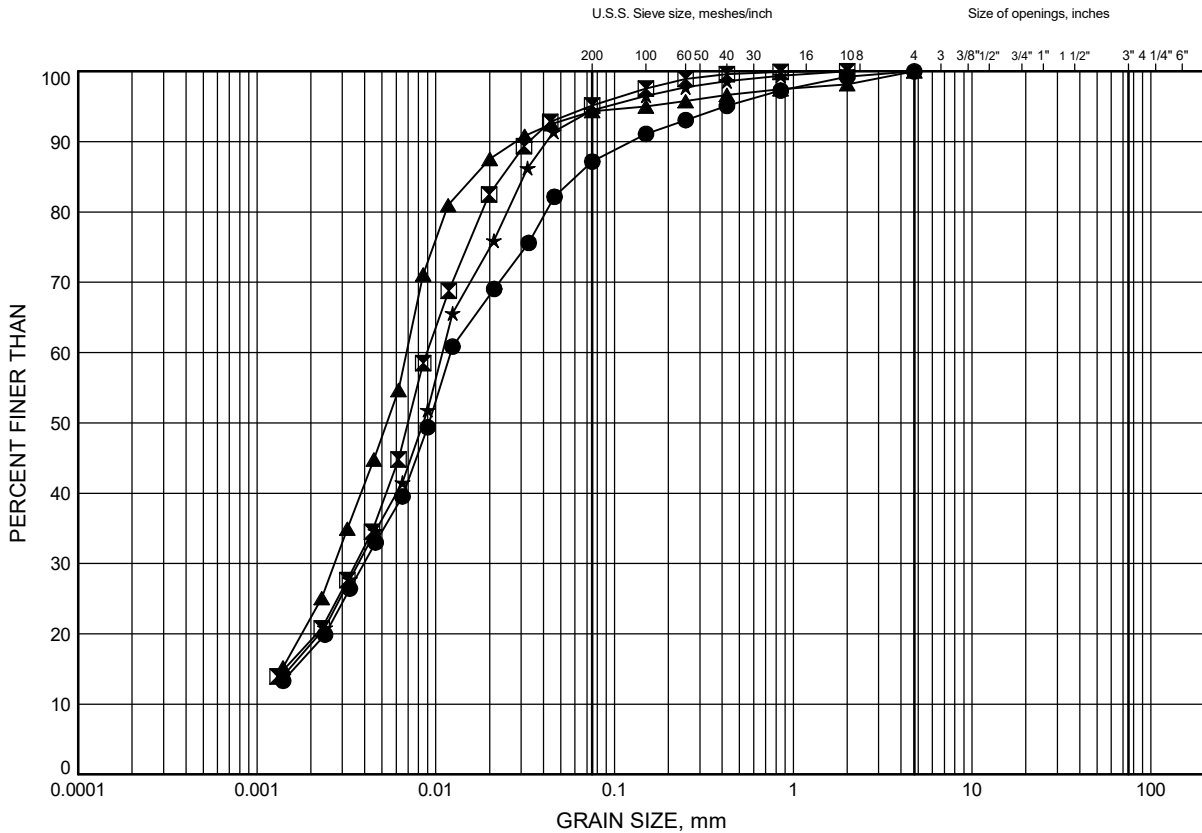
Prep'd MFA

Chkd. KS

Hwy 118 Soil Nailing GRAIN SIZE DISTRIBUTION

FIGURE B10

SILT, Some Clay



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-04	0.9	316.5
⊠	15-04	4.0	313.4
▲	15-08	1.1	323.2
★	15-12	1.8	321.8

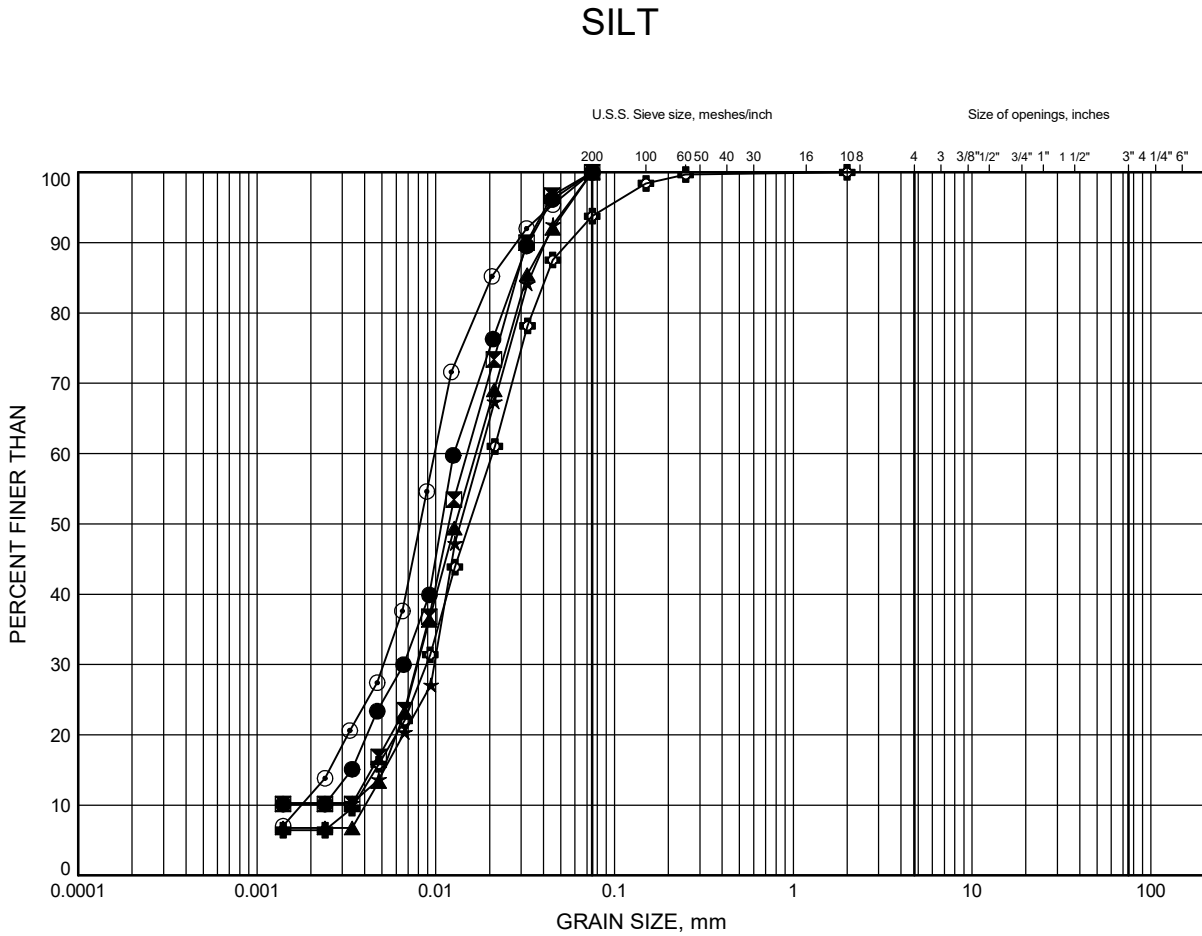
Date September 2017
W.P. 5339-11-00



Prep'd MFA
Chkd. KS

Hwy 118 Soil Nailing GRAIN SIZE DISTRIBUTION

FIGURE B11



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-09	3.2	321.1
⊠	15-12	2.6	321.0
▲	15-12	4.1	319.5
★	15-14	1.5	322.0
⊙	15-17	4.9	317.6
⊕	15-18	1.4	316.3

Date September 2017

W.P. 5339-11-00



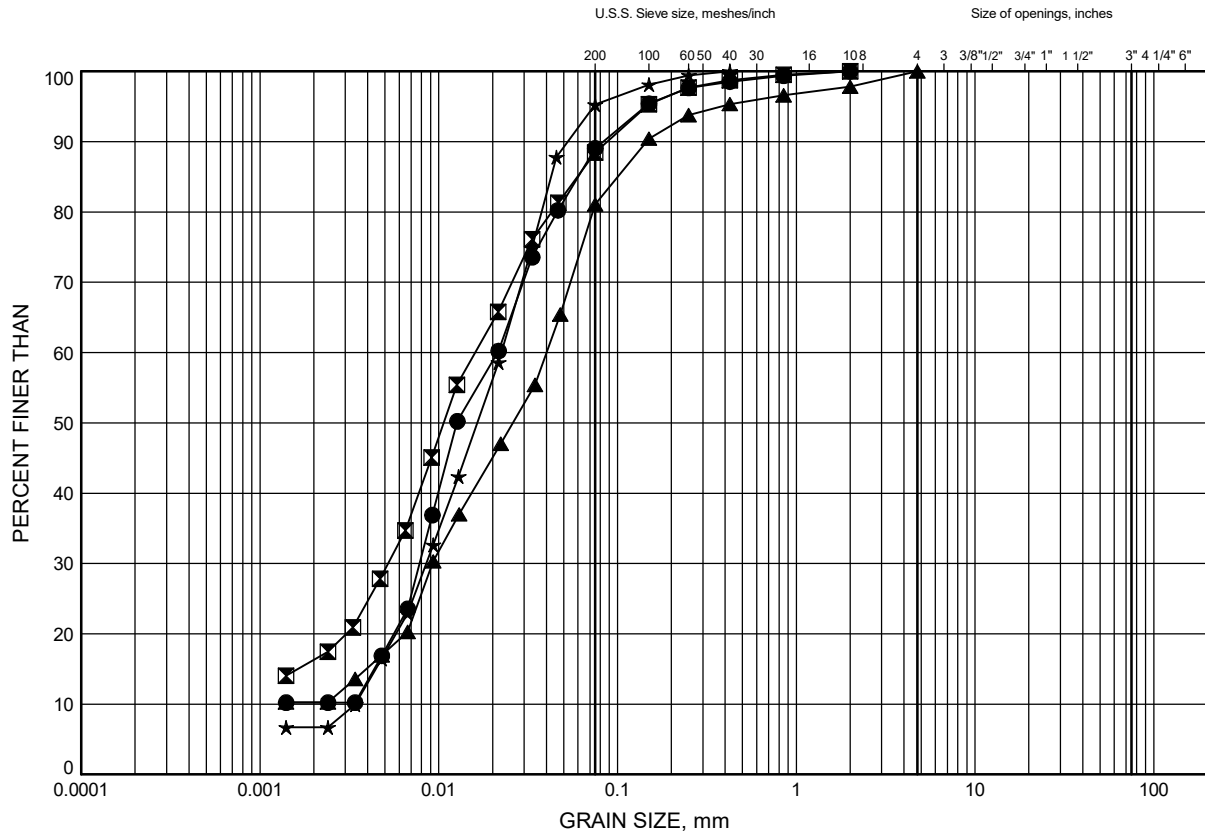
Prep'd MFA

Chkd. KS

Hwy 118 Soil Nailing GRAIN SIZE DISTRIBUTION

FIGURE B12

SILT, Some Sand



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-16	1.8	321.1
⊠	15-17	0.9	321.6
▲	15-17	2.6	319.9
★	15-18	3.2	314.5

Date September 2017

W.P. 5339-11-00



Prep'd MFA

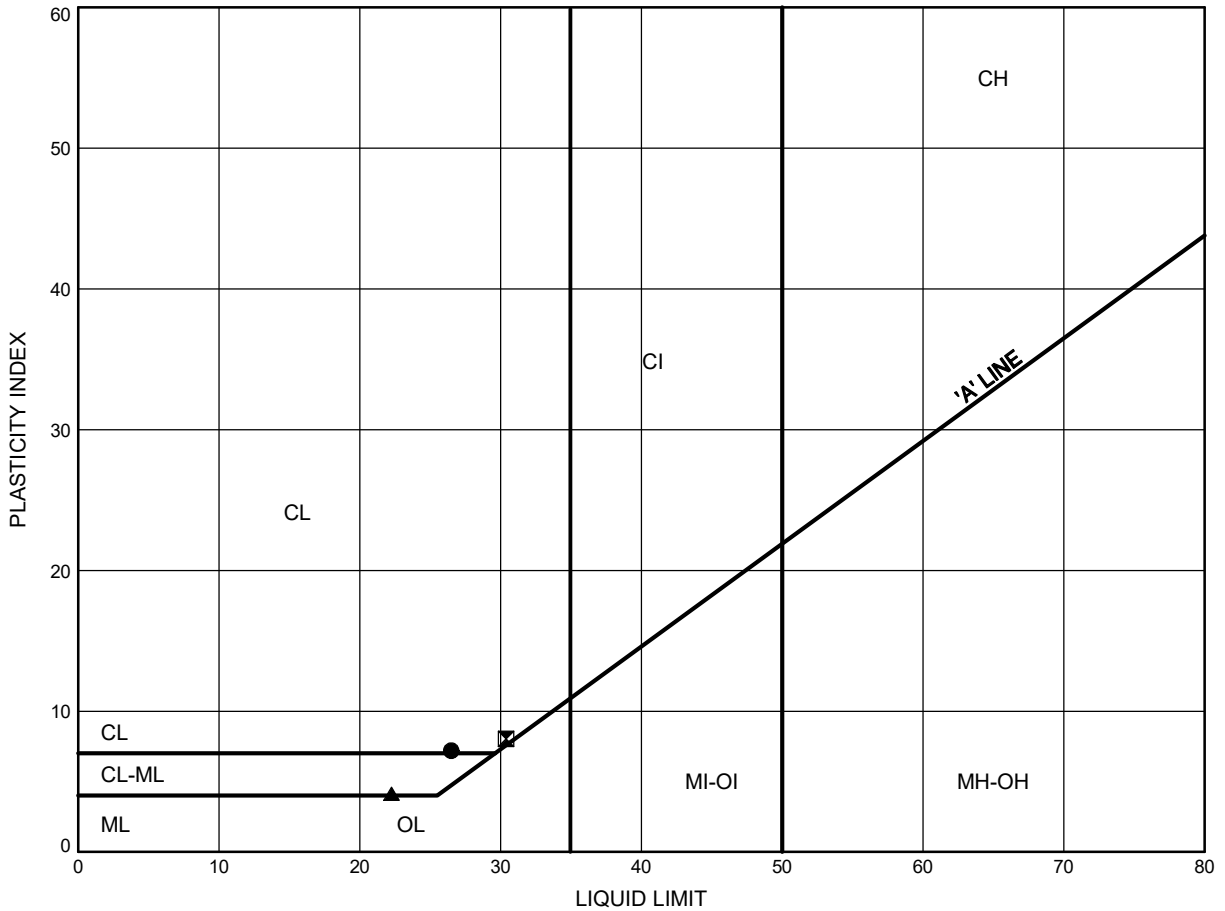
Chkd. KS

Hwy 118 Soil Nailing

ATTERBERG LIMITS TEST RESULTS

FIGURE B13

SILT, Some Clay



LEGEND

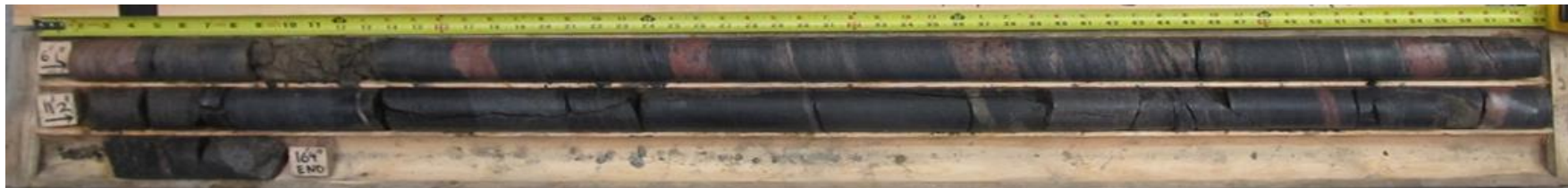
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-04	2.7	314.7
⊠	15-12	1.8	321.8
▲	15-17	1.8	320.7

Date September 2017
W.P. 5339-11-00



Prep'd MFA
Chkd. KS

BOREHOLE: 15-01
CORE RUN #1: 6' 1" – 11' 2"
CORE RUN #2: 11' 2" – 16' 4"



BOREHOLE: 15-02
CORE RUN #1: 16' 2" – 21' 4"
CORE RUN #2: 21' 4" – 26' 4"



BOREHOLE: **15-03**
CORE RUN #1: 20' 7" – 25' 8"
CORE RUN #2: 25' 8" – 29'
CORE RUN #3: 29' – 30' 11"



HIGHWAY 118 SLOPE STABILIZATION
0.5 km NORTH OF HALIBURTON COUNTY ROAD 21
HALIBURTON, ON

BOREHOLE: **15-05**
CORE RUN #1: 12' 2" – 15'
CORE RUN #2: 15' – 18' 6"
CORE RUN #3: 18' 6" – 23' 7"



BOREHOLE: **15-06**
CORE RUN #1: 21' 6" – 26' 6"
CORE RUN #2: 26' 6" – 31' 8"



BOREHOLE: **15-08**
CORE RUN #1: 17' – 18' 6"
CORE RUN #2: 18' 6" – 23'
CORE RUN #3: 23' – 25'
CORE RUN #4: 25' – 28' 9"
CORE RUN #5: 28' 9" – 31' 9"



BOREHOLE: **15-09**
CORE RUN #1: 23' 1" – 27' 7"
CORE RUN #2: 27' 7" – 31' 1"
CORE RUN #3: 31' 1" – 35' 7"



BOREHOLE: 15-11
CORE RUN #1: 24' 10" – 29' 10"
CORE RUN #2: 29' 10" – 35'



BOREHOLE: 15-12
CORE RUN #1: 18' 5" – 23' 5"
CORE RUN #2: 23' 5" – 28' 7"



HIGHWAY 118 SLOPE STABILIZATION
0.5 km NORTH OF HALIBURTON COUNTY ROAD 21
HALIBURTON, ON

BOREHOLE: **15-14**
CORE RUN #1: 18' – 23' 1"
CORE RUN #2: 23' 1" – 28' 1"



BOREHOLE: **15-15**
CORE RUN #1: 10' 11" – 13' 8"
CORE RUN #2: 13' 8" – 17'
CORE RUN #3: 17' – 18' 6"
CORE RUN #4: 18' 6" – 23' 5"



BOREHOLE: **15-16**
CORE RUN #1: 13' 10" – 18'
CORE RUN #2: 18' – 23' 1"



BOREHOLE: **15-17**
CORE RUN #1: 18' – 23' 2"
CORE RUN #2: 23' 2" – 28' 3"



**THURBER** ENGINEERING LTD.**POINT LOAD TEST SHEET**

Job No : 19-6887-0

Client : LVM-Merlex Division of EnGlobe Corp.

Project Name : Hwy 118 Soil Nailing

Date Drilled 02-Nov-15

Core Size : NQ BH No : BH 15-01

Date Tested 06-Nov-15

Tester : BT

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	I _{s(50)} (MPa)	Rock Type	Notes
1	1	1.9	D	9.5	47.2	84.1	3.9	Granitic Gneiss	Strong
2	1	1.9	A	19.7	47.2	48.5	6.6	Granitic Gneiss	Very Strong
3	1	1.9	D	12.9	47.3	95.7	5.3	Granitic Gneiss	Very Strong
4	1	1.8	A	22.0	47.3	48.1	7.4	Granitic Gneiss	Very Strong
5	1	2.6	D	11.0	47.3	117.7	4.6	Granitic Gneiss	Strong
6	1	2.5	A	22.8	47.3	43.7	8.3	Granitic Gneiss	Very Strong
7	2	4.6	D	7.9	47.3	106.9	3.3	Granitic Gneiss	Strong
8	2	4.6	A	24.5	47.3	51.5	7.9	Granitic Gneiss	Very Strong
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* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1

Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have $0.7 \times D$ on either side of test point.

**THURBER ENGINEERING LTD.****POINT LOAD TEST SHEET****Job No :** 19-6887-0**Client :** LVM-Merlex Division of EnGlobe Corp.**Project Name :** Hwy 118 Soil Nailing**Date Drilled** 02-Nov-15**Core Size :** NQ **BH No :** BH 15-02**Date Tested** 06-Nov-15**Tester :** BT

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	I _{s(50)} (MPa)	Rock Type	Notes
1	1	5.3	D	5.6	47.1	86.5	2.3	Granitic Gneiss	Medium Strong
2	1	5.3	A	12.6	47.1	46.6	4.4	Granitic Gneiss	Strong
3	1	6.0	D	11.4	47.2	80.0	4.7	Granitic Gneiss	Strong
4	1	6.0	A	23.8	47.2	51.2	7.7	Granitic Gneiss	Very Strong
5	2	6.9	D	12.5	47.3	90.2	5.2	Granitic Gneiss	Very Strong
6	2	6.9	A	25.0	47.3	44.3	9.0	Granitic Gneiss	Very Strong
7	2	7.7	D	13.1	47.3	94.0	5.4	Granitic Gneiss	Very Strong
8	2	7.7	A	22.6	47.3	47.0	7.8	Granitic Gneiss	Very Strong
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* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1

Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have $0.7 \times D$ on either side of test point.

**THURBER** ENGINEERING LTD.**POINT LOAD TEST SHEET**

Job No : 19-6887-0

Client : LVM-Merlex Division of EnGlobe Corp.

Project Name : Hwy 118 Soil Nailing

Date Drilled 03-Nov-15

Core Size : NQ BH No : BH 15-03

Date Tested 05-Nov-15

Tester : BT

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	I _{s(50)} (MPa)	Rock Type	Notes
1	1	6.3	D	8.8	47.0	86.3	3.7	Granitic Gneiss	Strong
2	1	6.4	A	9.4	47.0	45.7	3.3	Granitic Gneiss	Strong
3	1	6.9	D	8.8	47.3	84.4	3.6	Granitic Gneiss	Strong
4	1	6.9	A	23.0	47.3	49.8	7.6	Granitic Gneiss	Very Strong
5	1	7.5	D	7.0	47.3	87.1	2.9	Granitic Gneiss	Strong
6	1	7.6	A	21.1	47.3	45.7	7.4	Granitic Gneiss	Very Strong
7	2	8.4	D	8.7	47.3	89.1	3.6	Granitic Gneiss	Strong
8	2	8.5	A	16.4	47.3	43.9	6.0	Granitic Gneiss	Very Strong
9	3	9.2	D	11.1	47.3	82.0	4.6	Granitic Gneiss	Strong
10	3	9.2	A	20.5	47.3	43.3	7.5	Granitic Gneiss	Very Strong
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* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1

Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have $0.7 \times D$ on either side of test point.

**THURBER ENGINEERING LTD.****POINT LOAD TEST SHEET****Job No :** 19-6887-0**Client :** LVM-Merlex Division of EnGlobe Corp.**Project Name :** Hwy 118 Soil Nailing**Date Drilled** 30-Oct-15**Core Size :** NQ **BH No :** BH 15-05**Date Tested** 02-Nov-15**Tester :** RMT/WHW

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	I _{s(50)} (MPa)	Rock Type	Notes
1	1	3.9	A	19.0	47.4	49.3	6.3	Granitic Gneiss	Very Strong
2	1	3.9	D	4.8	47.3	87.9	2.0	Granitic Gneiss	Medium Strong
3	2	4.8	A	8.6	47.3	48.0	2.9	Granitic Gneiss	Strong
4	2	4.8	D	11.1	47.4	118.5	4.6	Granitic Gneiss	Strong
5	3	5.7	A	20.7	47.4	39.7	8.1	Granitic Gneiss	Very Strong
6	3	5.7	D	10.9	47.4	105.7	4.5	Granitic Gneiss	Strong
7	3	6.2	A	18.4	47.3	44.7	6.6	Granitic Gneiss	Very Strong
8	3	6.3	D	8.3	47.4	92.9	3.4	Granitic Gneiss	Strong
9	3	6.9	A	21.2	47.3	48.4	7.1	Granitic Gneiss	Very Strong
10	3	6.9	D	9.1	47.4	99.4	3.7	Granitic Gneiss	Strong
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* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1

Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have $0.7 \times D$ on either side of test point.



THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

Job No : 19-6887-0

Client : LVM-Merlex Division of EnGlobe Corp.

Project Name : Hwy 118 Soil Nailing

Date Drilled 04-Nov-15

Core Size : NQ BH No : BH 15-06

Date Tested 06-Nov-15

Tester : BT

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	I _{s(50)} (MPa)	Rock Type	Notes
1	1	6.9	D	9.0	47.3	109.6	3.7	Granitic Gneiss	Strong
2	1	6.9	A	21.3	47.3	50.8	6.9	Granitic Gneiss	Very Strong
3	1	7.5	D	8.4	47.3	114.3	3.5	Granitic Gneiss	Strong
4	1	7.5	A	8.6	47.3	51.5	2.8	Granitic Gneiss	Strong
5	2	8.1	D	9.4	47.3	95.1	3.9	Granitic Gneiss	Strong
6	2	8.1	A	24.1	47.3	43.9	8.8	Granitic Gneiss	Very Strong
7	2	8.8	D	10.8	47.3	91.9	4.4	Granitic Gneiss	Strong
8	2	8.8	A	19.3	47.3	53.0	6.1	Granitic Gneiss	Very Strong
9	2	9.6	D	7.1	47.2	79.2	3.0	Granitic Gneiss	Strong
10	2	9.6	A	21.3	47.3	45.3	7.6	Granitic Gneiss	Very Strong
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* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1

Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have $0.7 \times D$ on either side of test point.

**THURBER ENGINEERING LTD.****POINT LOAD TEST SHEET****Job No :** 19-6887-0**Client :** LVM-Merlex Division of EnGlobe Corp.**Project Name :** Hwy 118 Soil Nailing**Date Drilled** 29-Oct-15**Core Size :** NQ-HQ **BH No :** BH 15-08**Date Tested** 02-Nov-15**Tester :** RMT/WHW

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	I _{s(50)} (MPa)	Rock Type	Notes
1	3	7.1	A	19.1	47.5	57.0	5.6	Granitic Gneiss	Very Strong
2	4	8.0	A	33.3	62.9	54.9	8.1	Granitic Gneiss	Very Strong
3	4	8.1	A	35.0	62.9	52.4	8.9	Granitic Gneiss	Very Strong
4	5	8.9	A	35.0	62.9	61.0	7.9	Granitic Gneiss	Very Strong
5	5	9.1	A	29.3	62.8	46.3	8.2	Granitic Gneiss	Very Strong
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* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1

Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have $0.7 \times D$ on either side of test point.

**THURBER ENGINEERING LTD.****POINT LOAD TEST SHEET****Job No :** 19-6887-0**Client :** LVM-Merlex Division of EnGlobe Corp.**Project Name :** Hwy 118 Soil Nailing**Date Drilled** 03-Nov-15**Core Size :** NQ **BH No :** BH 15-09**Date Tested** 05-Nov-15**Tester :** BT

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	I _{S(50)} (MPa)	Rock Type	Notes
1	1	7.2	D	8.4	47.1	115.0	3.5	Granitic Gneiss	Strong
2	1	7.2	A	20.7	47.1	53.4	6.5	Granitic Gneiss	Very Strong
3	1	7.8	D	15.7	47.3	106.5	6.5	Granitic Gneiss	Very Strong
4	1	7.8	A	22.4	47.3	51.0	7.2	Granitic Gneiss	Very Strong
5	2	8.7	D	13.6	47.3	115.2	5.6	Granitic Gneiss	Very Strong
6	2	8.8	A	22.8	47.3	41.1	8.7	Granitic Gneiss	Very Strong
7	2	9.3	D	6.2	47.3	89.0	2.6	Granitic Gneiss	Strong
8	2	9.4	A	20.6	47.3	44.5	7.4	Granitic Gneiss	Very Strong
9	3	10.0	D	9.5	47.4	89.4	3.9	Granitic Gneiss	Strong
10	3	10.0	A	21.6	47.4	43.0	8.0	Granitic Gneiss	Very Strong
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* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1

Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have $0.7 \times D$ on either side of test point.



THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

Job No : 19-6887-0 Client : LVM-Merlex Division of EnGlobe Corp.
 Date Drilled : 27-Oct-15
 Project Name : Hwy 118 Soil Nailing Date Tested : 02-Nov-15
 Core Size : NQ BH No : BH 15-11 Tester : RMT/WHW

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	I _{s(50)} (MPa)	Rock Type	Notes
1	1	7.8	A	13.6	47.5	47.6	4.6	Granitic Gneiss	Strong
2	1	7.8	D	8.8	47.5	80.1	3.6	Granitic Gneiss	Strong
3	1	8.6	A	15.8	47.6	43.7	5.7	Granitic Gneiss	Very Strong
4	1	8.7	D	9.2	47.7	60.9	3.7	Granitic Gneiss	Strong
5	2	9.6	A	12.5	47.6	41.4	4.7	Granitic Gneiss	Strong
6	2	9.7	D	8.3	47.6	65.8	3.4	Granitic Gneiss	Strong
7	2	10.1	D	9.2	47.5	91.9	3.8	Granitic Gneiss	Strong
8	2	10.2	A	20.0	47.5	48.7	6.7	Granitic Gneiss	Very Strong
9	2	10.5	A	22.2	47.6	45.5	7.8	Granitic Gneiss	Very Strong
10	2	10.6	D	7.2	47.5	77.8	2.9	Granitic Gneiss	Strong
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* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1

Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have $0.7 \times D$ on either side of test point.

**THURBER** ENGINEERING LTD.**POINT LOAD TEST SHEET**

Job No : 19-6887-0

Client : LVM-Merlex Division of EnGlobe Corp.

Project Name : Hwy 118 Soil Nailing

Date Drilled 04-Nov-15

Core Size : NQ BH No : BH 15-12

Date Tested 06-Nov-15

Tester : BT

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	I _{s(50)} (MPa)	Rock Type	Notes
1	1	5.9	D	9.8	47.3	75.1	4.1	Granitic Gneiss	Strong
2	1	5.8	A	19.0	47.3	44.7	6.8	Granitic Gneiss	Very Strong
3	1	6.4	D	10.5	47.3	117.8	4.4	Granitic Gneiss	Strong
4	1	6.4	A	15.3	47.3	46.3	5.3	Granitic Gneiss	Very Strong
5	2	7.2	D	8.2	47.3	61.5	3.4	Granitic Gneiss	Strong
6	2	7.2	A	18.6	47.3	41.8	7.0	Granitic Gneiss	Very Strong
7	2	7.8	D	9.0	47.4	80.8	3.7	Granitic Gneiss	Strong
8	2	7.8	A	16.9	47.4	47.1	5.8	Granitic Gneiss	Very Strong
9	2	8.7	D	10.0	47.3	103.4	4.1	Granitic Gneiss	Strong
10	2	8.6	A	18.3	47.3	50.1	6.0	Granitic Gneiss	Very Strong
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Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have $0.7 \times D$ on either side of test point.

**THURBER ENGINEERING LTD.****POINT LOAD TEST SHEET****Job No :** 19-6887-0**Client :** LVM-Merlex Division of EnGlobe Corp.**Project Name :** Hwy 118 Soil Nailing**Date Drilled** 27-Oct-15**Core Size :** NQ **BH No :** BH 15-14**Date Tested** 02-Nov-15**Tester :** RMT/WHW

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	I _{S(50)} (MPa)	Rock Type	Notes
1	1	5.8	A	13.5	47.4	40.3	5.2	Granitic Gneiss	Very Strong
2	1	5.9	D	11.6	47.4	103.5	4.8	Granitic Gneiss	Strong
3	1	6.7	D	9.3	47.4	70.8	3.8	Granitic Gneiss	Strong
4	1	6.8	A	2.5	47.4	32.1	1.2	Granitic Gneiss	Weak
5	2	7.2	D	1.9	47.4	69.2	0.8	Granitic Gneiss	Weak
6	2	7.2	A	15.1	47.4	52.2	4.8	Granitic Gneiss	Strong
7	2	8.1	D	10.3	47.4	86.1	4.3	Granitic Gneiss	Strong
8	2	8.2	A	19.3	47.4	52.6	6.1	Granitic Gneiss	Very Strong
9	2	8.4	D	5.9	47.4	95.6	2.4	Granitic Gneiss	Medium Strong
10	2	8.5	A	17.0	47.4	47.3	5.8	Granitic Gneiss	Very Strong
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* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1

Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have $0.7 \times D$ on either side of test point.

**THURBER** ENGINEERING LTD.**POINT LOAD TEST SHEET**

Job No : 19-6887-0

Client : LVM-Merlex Division of EnGlobe Corp.

Project Name : Hwy 118 Soil Nailing

Date Drilled 27-Oct-15

Core Size : NQ BH No : BH 15-15

Date Tested 02-Nov-15

Tester : RMT/WHW

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	Rock Type	Notes
1	1	3.4	D	10.2	47.5	54.6	4.2	Granitic Gneiss	Strong
2	1	3.5	A	9.4	47.6	32.5	4.3	Granitic Gneiss	Strong
3	3	5.3	D	10.8	47.5	57.9	4.4	Granitic Gneiss	Strong
4	3	5.3	A	23.1	47.6	39.1	9.1	Granitic Gneiss	Very Strong
5	4	6.5	A	22.2	47.8	51.1	7.1	Granitic Gneiss	Very Strong
6	4	6.5	D	10.5	47.5	76.6	4.3	Granitic Gneiss	Strong
7	4	7.0	A	19.3	47.4	63.6	5.3	Granitic Gneiss	Very Strong
8	4	7.1	D	2.8	47.5	54.9	1.1	Granitic Gneiss	Weak
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33									

* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1

Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have $0.7 \times D$ on either side of test point.

**THURBER ENGINEERING LTD.****POINT LOAD TEST SHEET****Job No :** 19-6887-0**Client :** LVM-Merlex Division of EnGlobe Corp.**Project Name :** Hwy 118 Soil Nailing**Date Drilled** 26-Oct-15**Core Size :** NQ **BH No :** BH 15-16**Date Tested** 02-Nov-15**Tester :** RMT/WHW

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	I _{S(50)} (MPa)	Rock Type	Notes
1	1	5.4	D	4.0	47.6	60.4	1.6	Granitic Gneiss	Medium Strong
2	1	5.5	A	10.8	47.6	48.2	3.6	Granitic Gneiss	Strong
3	2	5.7	D	14.7	47.6	68.9	6.0	Granitic Gneiss	Very Strong
4	2	5.8	A	23.3	47.6	47.0	8.0	Granitic Gneiss	Very Strong
5	2	6.4	D	11.6	47.6	56.9	4.7	Granitic Gneiss	Strong
6	2	6.5	A	21.2	47.6	51.0	6.8	Granitic Gneiss	Very Strong
7	2	6.7	D	17.8	47.6	71.6	7.3	Granitic Gneiss	Very Strong
8	2	6.8	A	23.7	47.6	48.8	7.9	Granitic Gneiss	Very Strong
9	2	6.9	D	11.1	47.6	44.7	4.5	Granitic Gneiss	Strong
10	2	7.0	A	12.6	47.6	39.7	4.9	Granitic Gneiss	Strong
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* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1

Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have $0.7 \times D$ on either side of test point.

**THURBER** ENGINEERING LTD.**POINT LOAD TEST SHEET**

Job No : 19-6887-0

Client : LVM-Merlex Division of EnGlobe Corp.

Project Name : Hwy 118 Soil Nailing

Date Drilled 04-Nov-15

Core Size : NQ BH No : BH 15-17

Date Tested 06-Nov-15

Tester : BT

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	I _{s(50)} (MPa)	Rock Type	Notes
1	1	5.5	D	8.4	47.3	103.8	3.5	Granitic Gneiss	Strong
2	1	5.5	A	20.8	47.3	47.4	7.1	Granitic Gneiss	Very Strong
3	1	6.1	D	6.8	47.4	93.0	2.8	Granitic Gneiss	Strong
4	1	6.1	A	22.8	47.4	47.0	7.8	Granitic Gneiss	Very Strong
5	1	6.8	D	14.4	47.3	96.8	6.0	Granitic Gneiss	Very Strong
6	1	6.7	A	18.7	47.3	47.2	6.4	Granitic Gneiss	Very Strong
7	2	7.5	D	11.9	47.4	103.9	4.9	Granitic Gneiss	Strong
8	2	7.5	A	25.3	47.4	51.3	8.1	Granitic Gneiss	Very Strong
9	2	8.1	D	11.3	47.3	74.5	4.7	Granitic Gneiss	Strong
10	2	8.1	A	15.0	47.3	40.3	5.8	Granitic Gneiss	Very Strong
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* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1

Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have $0.7 \times D$ on either side of test point.



Appendix C

Selected Site Photographs



**Photo 1: Area 1 – Highway 118 Looking North
Significant Tension Cracks traversing entire roadway (April 2014)
(Courtesy of AECOM)**



Photo 2: Area 1 – Highway 118 Looking North



Photo 3: Area 1 – Looking East – Transverse Cracks (Rock Cut in Background)



Photo 4: Area 1 – Highway 118 Looking South – Longitudinal Cracks on Shoulder



Photo 5: Area 2 – Looking South – Longitudinal Crack and Sagging Guardrail



Photo 6: Area 2 – Highway 118 Looking North – Steep West Slope (Lakeside)



Photo 7: Area 2/3 – Highway 118 Looking North - Tilted Hydro Pole on Slope



Photo 8: Area 3 – Looking North – West Slope



Photo 9: Area 3 – Looking South – West Slope



Appendix D

Borehole Locations and Soil Strata Drawings

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

CONT No 5014-E-0004
WP No 5339-11-00



HIGHWAY 118
SLOPE REHABILITATION
BOREHOLE LOCATIONS PLAN

SHEET



KEYPLAN

LEGEND

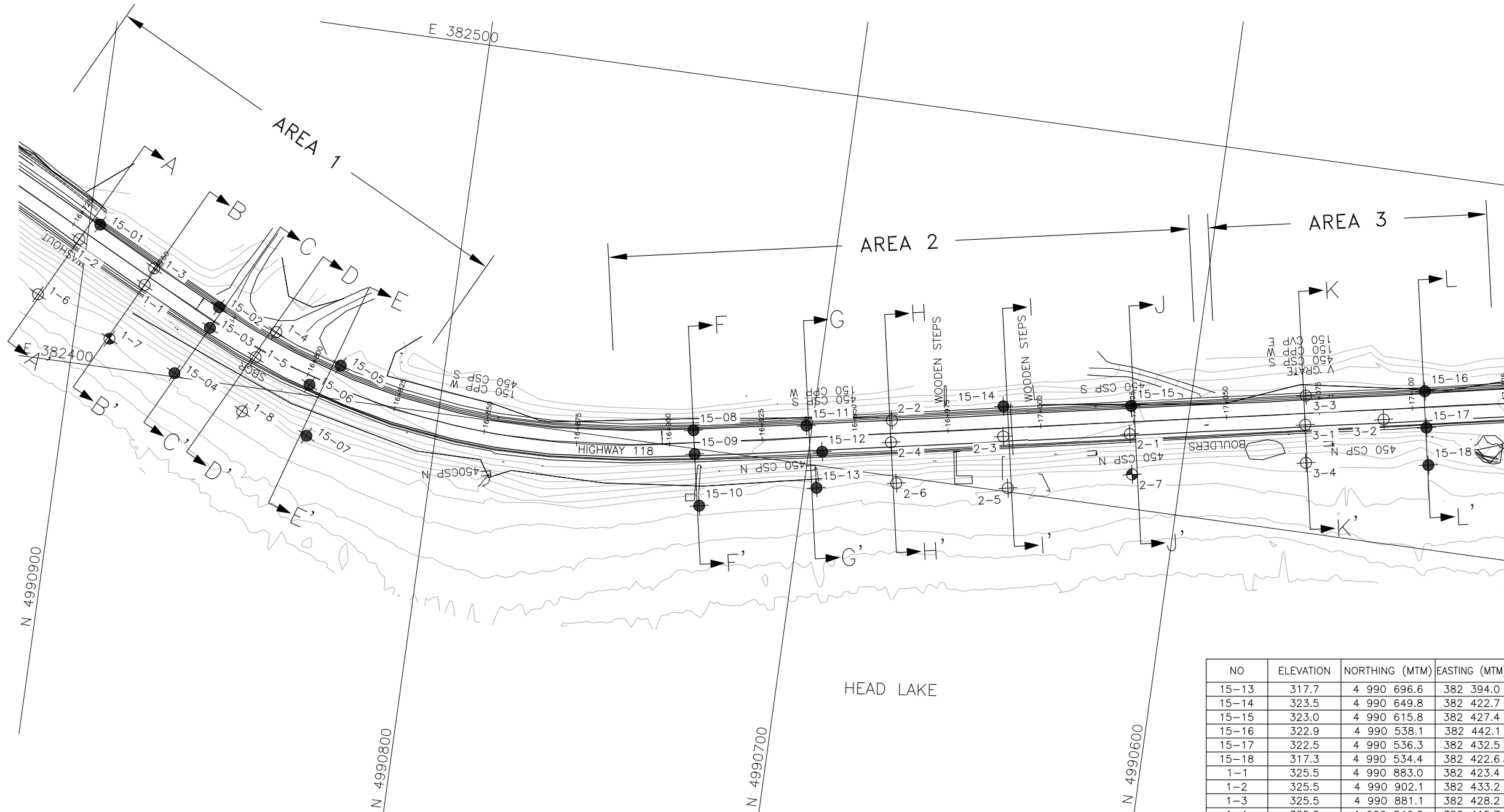
- Borehole by Thurber
- Borehole by Others
- DCPT by Others
- Blows /0.3m (Std Pen Test, 475J/blow)
- Blows /0.3m (60' Cone, 475J/blow)
- Water Level During Drilling
- Water Level In
- Piezometer
- 90% Rock Quality Designation (RQD)
- Auger Refusal

NO	ELEVATION	NORTHING (MTM)	EASTING (MTM)
15-01	325.7	4 990 897.1	382 437.9
15-02	325.5	4 990 862.4	382 420.2
15-03	325.5	4 990 864.0	382 414.4
15-04	317.7	4 990 871.8	382 401.0
15-05	325.0	4 990 827.8	382 409.1
15-06	325.3	4 990 835.4	382 402.9
15-07	317.7	4 990 834.4	382 389.2
15-08	324.3	4 990 731.5	382 404.9
15-09	324.3	4 990 730.3	382 398.6
15-10	317.7	4 990 727.2	382 385.0
15-11	324.3	4 990 701.6	382 410.2
15-12	323.6	4 990 696.4	382 403.9

NOTES

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 31E-369



HEAD LAKE



PLAN

NO	ELEVATION	NORTHING (MTM)	EASTING (MTM)
15-13	317.7	4 990 696.6	382 394.0
15-14	323.5	4 990 649.8	382 422.7
15-15	323.0	4 990 615.8	382 427.4
15-16	322.9	4 990 538.1	382 442.1
15-17	322.5	4 990 536.3	382 432.5
15-18	317.3	4 990 534.4	382 422.6
1-1	325.5	4 990 883.0	382 423.4
1-2	325.5	4 990 902.1	382 433.2
1-3	325.5	4 990 881.1	382 428.2
1-4	325.2	4 990 846.2	382 415.7
1-5	325.3	4 990 850.8	382 408.2
1-6	317.6	4 990 911.1	382 417.0
1-7	317.7	4 990 890.4	382 407.8
1-8	317.7	4 990 852.4	382 393.3
2-1	322.9	4 990 615.1	382 419.9
2-2	323.6	4 990 679.0	382 414.8
2-3	323.3	4 990 648.7	382 414.6
2-4	323.5	4 990 678.4	382 408.9
2-5	317.7	4 990 645.6	382 401.0
2-6	317.7	4 990 675.5	382 398.2
2-7	317.7	4 990 613.0	382 409.2
3-1	322.6	4 990 568.7	382 428.8
3-2	322.7	4 990 548.0	382 433.1
3-3	322.8	4 990 569.6	382 436.6
3-4	318.3	4 990 567.1	382 418.7



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	ME	CHK KS	CODE
DRAWN	MFA	CHK ME	SITE
			LOAD
			STRUCT
			FIGURE D1
			DATE DEC 2017

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



CONT No 5014-E-0004
WP No 5339-11-00

HIGHWAY 118
SLOPE REHABILITATION
SECTIONS - AREA 1
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET



KEYPLAN

LEGEND

- Borehole by Thurber
- Borehole by Others
- DCPT by Others
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60' Cone, 475J/blow)
- Water Level During Drilling
- Water Level In
- Piezometer
- 90% Rock Quality Designation (RQD)
- Auger Refusal

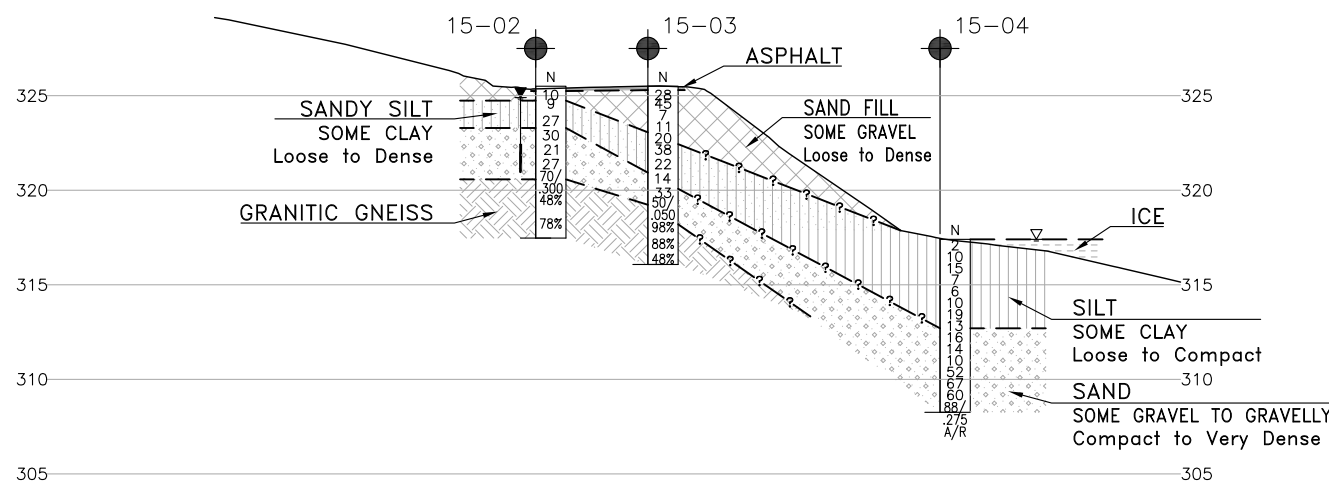
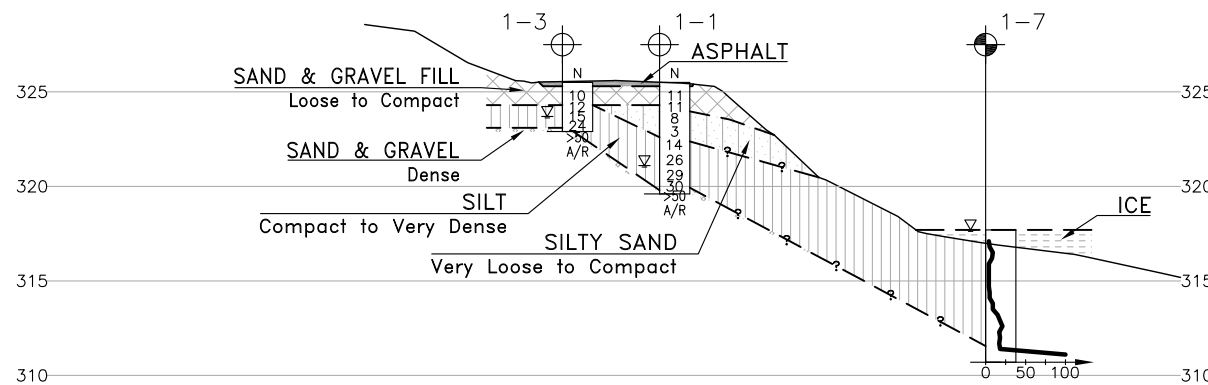
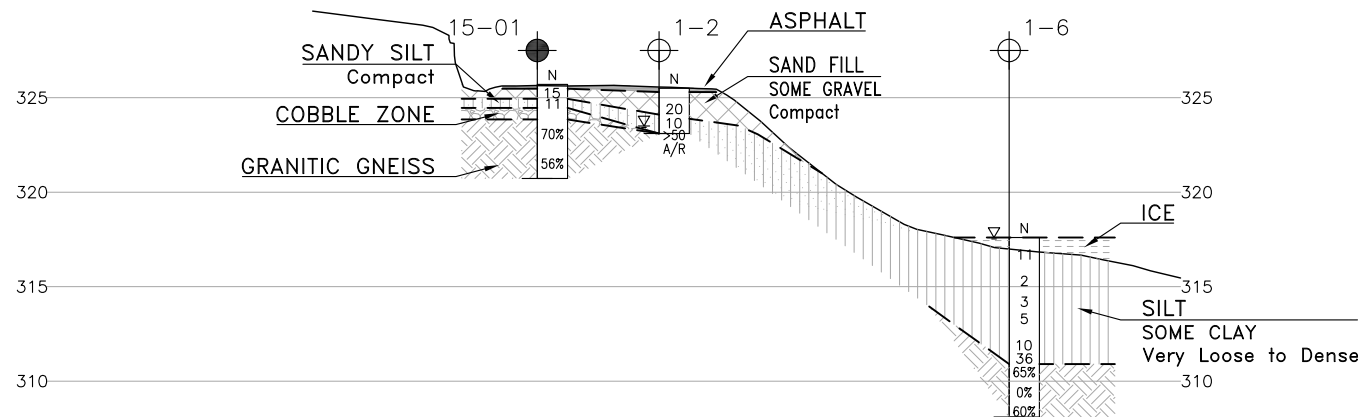
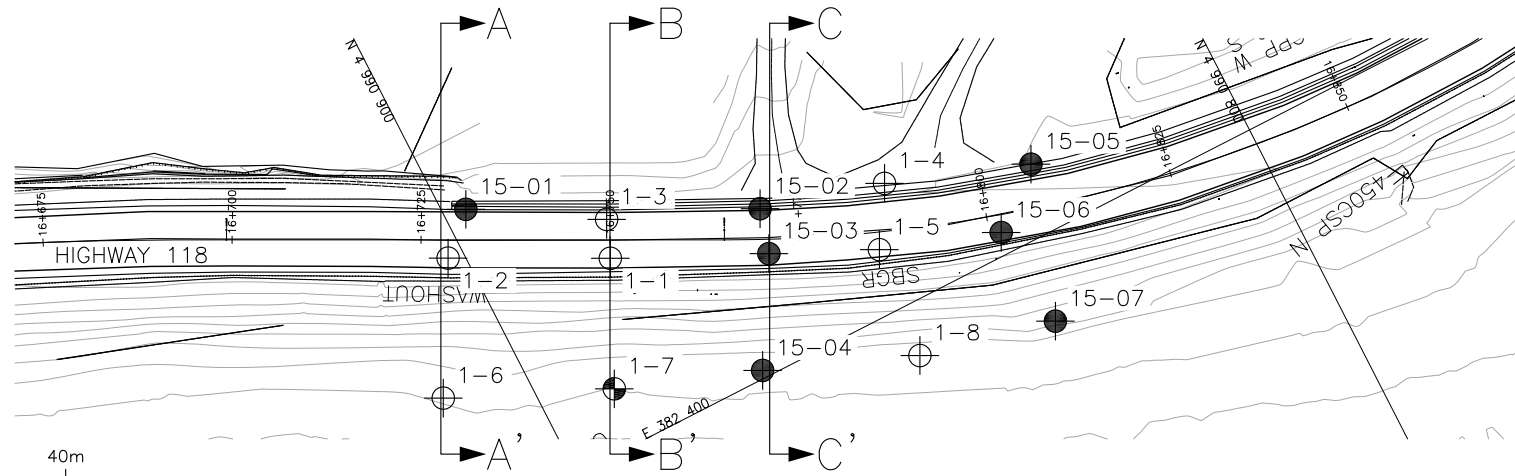
NO	ELEVATION	NORTHING (MTM)	EASTING (MTM)
15-01	325.7	4 990 897.1	382 437.9
15-02	325.5	4 990 862.4	382 420.2
15-03	325.5	4 990 864.0	382 414.4
15-04	317.7	4 990 871.8	382 401.0
15-05	325.0	4 990 827.8	382 409.1
15-06	325.3	4 990 835.4	382 402.9
15-07	317.7	4 990 834.4	382 389.2
1-1	325.5	4 990 883.0	382 423.4
1-2	325.5	4 990 902.1	382 433.2
1-3	325.5	4 990 881.1	382 428.2
1-4	325.2	4 990 846.2	382 415.7
1-5	325.3	4 990 850.8	382 408.2

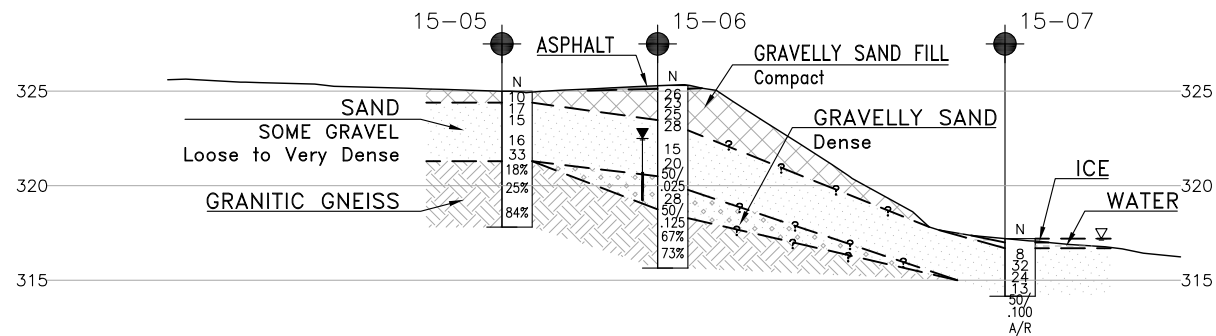
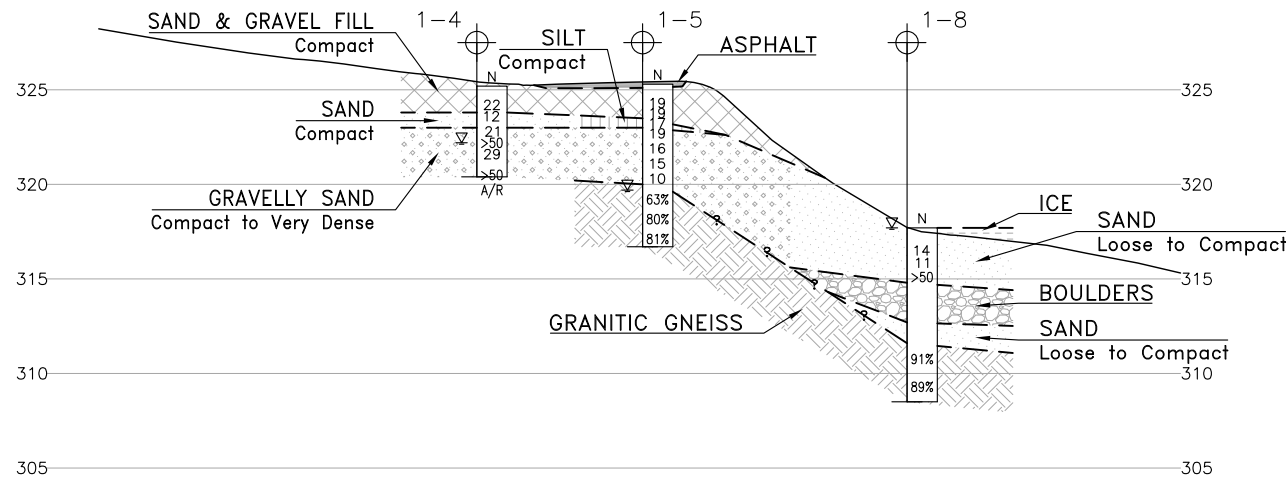
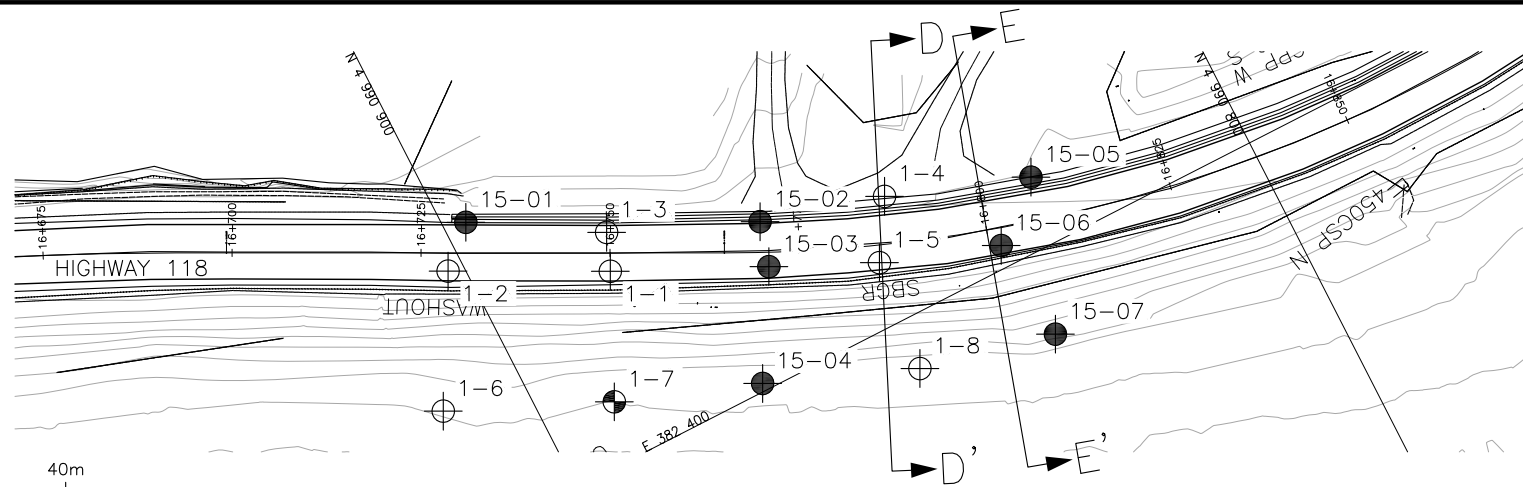
-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 31E-369

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	ME	CHK KS	CODE LOAD DATE DEC 2017
DRAWN	MFA	CHK ME	SITE STRUCTURE FIGURE D2





NO	ELEVATION	NORTHING (MTM)	EASTING (MTM)
1-6	317.6	4 990 911.1	382 417.0
1-7	317.7	4 990 890.4	382 407.8
1-8	317.7	4 990 852.4	382 393.3

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



CONT No 5014-E-0004
WP No 5339-11-00

HIGHWAY 118
SLOPE REHABILITATION
SECTIONS - AREA 1
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

	Borehole by Thurber
	Borehole by Others
	DCPT by Others
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60' Cone, 475J/blow)
	Water Level During Drilling
	Water Level In Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING (MTM)	EASTING (MTM)
15-01	325.7	4 990 897.1	382 437.9
15-02	325.5	4 990 862.4	382 420.2
15-03	325.5	4 990 864.0	382 414.4
15-04	317.7	4 990 871.8	382 401.0
15-05	325.0	4 990 827.8	382 409.1
15-06	325.3	4 990 835.4	382 402.9
15-07	317.7	4 990 834.4	382 389.2
1-1	325.5	4 990 883.0	382 423.4
1-2	325.5	4 990 902.1	382 433.2
1-3	325.5	4 990 881.1	382 428.2
1-4	325.2	4 990 846.2	382 415.7
1-5	325.3	4 990 850.8	382 408.2

-NOTES-

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GEOCRES No. 31E-369

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	ME	CHK KS	CODE
DRAWN	MFA	CHK ME	SITE
			LOAD
			STRUCT
			FIGURE D3
			DATE DEC 2017

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



CONT No 5014-E-0004
WP No 5339-11-00

HIGHWAY 118
SLOPE REHABILITATION
SECTIONS - AREA 2
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET



KEYPLAN

LEGEND

- Borehole by Thurber
- Borehole by Others
- DCPT by Others
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60' Cone, 475J/blow)
- Water Level During Drilling
- Water Level In
- Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

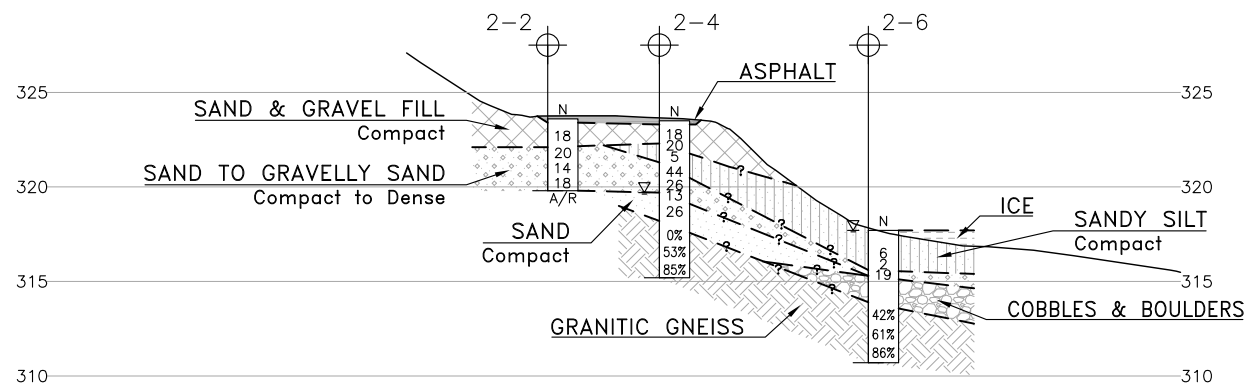
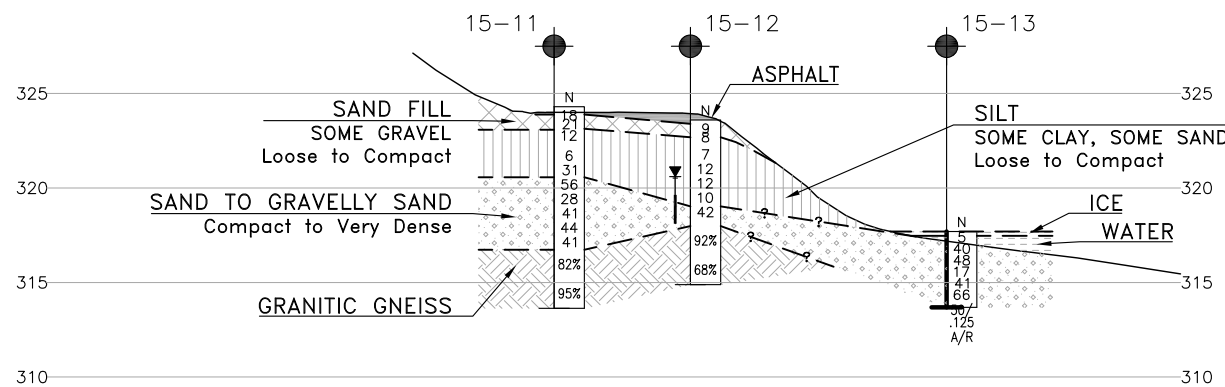
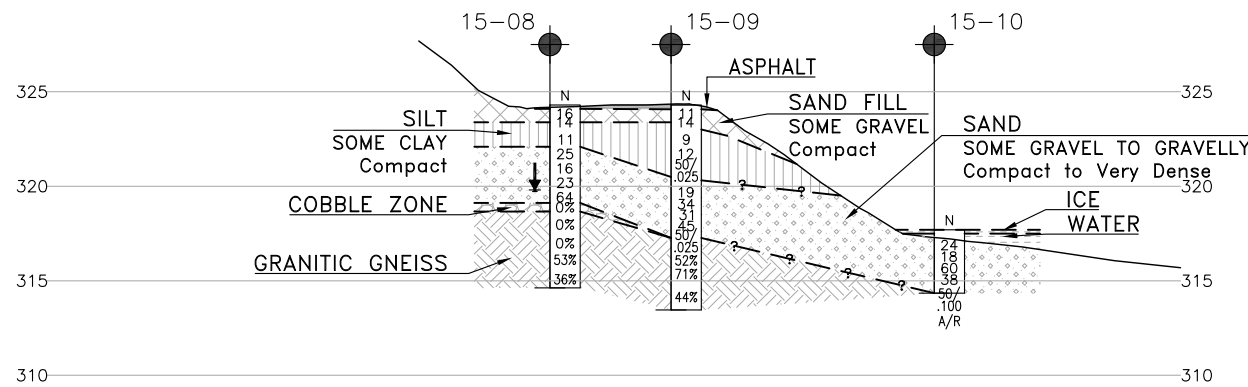
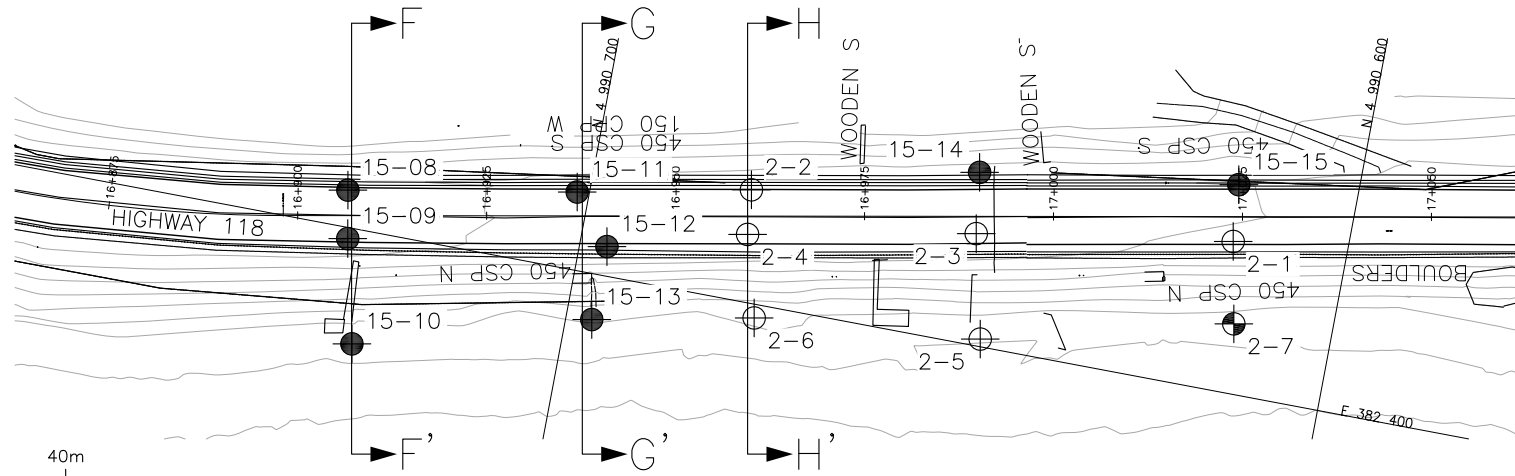
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15-08	324.3	4 990 731.5	382 404.9
15-09	324.3	4 990 730.3	382 398.6
15-10	317.7	4 990 727.2	382 385.0
15-11	324.3	4 990 701.6	382 410.2
15-12	323.6	4 990 696.4	382 403.9
15-13	317.7	4 990 696.6	382 394.0
15-14	323.5	4 990 649.8	382 422.7
15-15	323.0	4 990 615.8	382 427.4
2-1	322.9	4 990 615.1	382 419.9
2-2	323.6	4 990 679.0	382 414.8
2-3	323.3	4 990 648.7	382 414.6
2-4	323.5	4 990 678.4	382 408.9

-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 31E-369

REVISIONS	DATE	BY	DESCRIPTION
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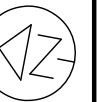


METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



CONT No 5014-E-0004
WP No 5339-11-00

HIGHWAY 118
SLOPE REHABILITATION
SECTIONS - AREA 2
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET



KEYPLAN

LEGEND

- Borehole by Thurber
- Borehole by Others
- DCPT by Others
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60' Cone, 475J/blow)
- Water Level During Drilling
- Water Level In Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

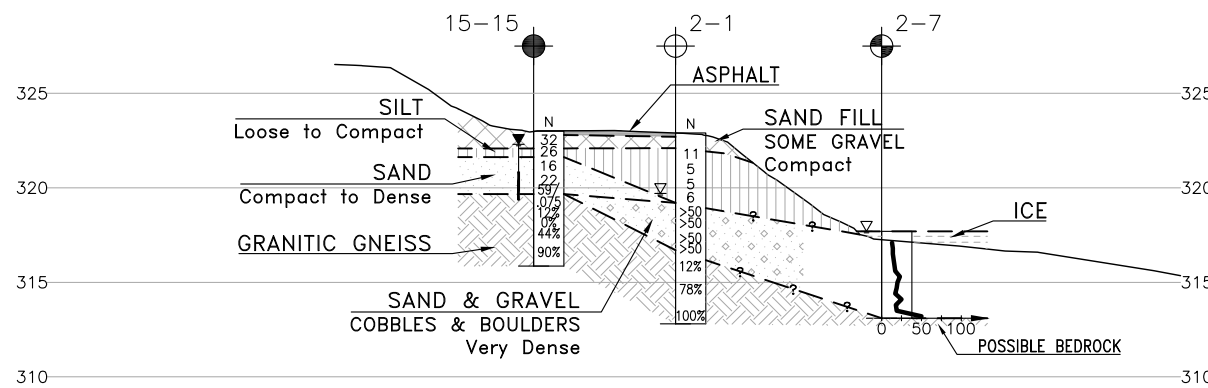
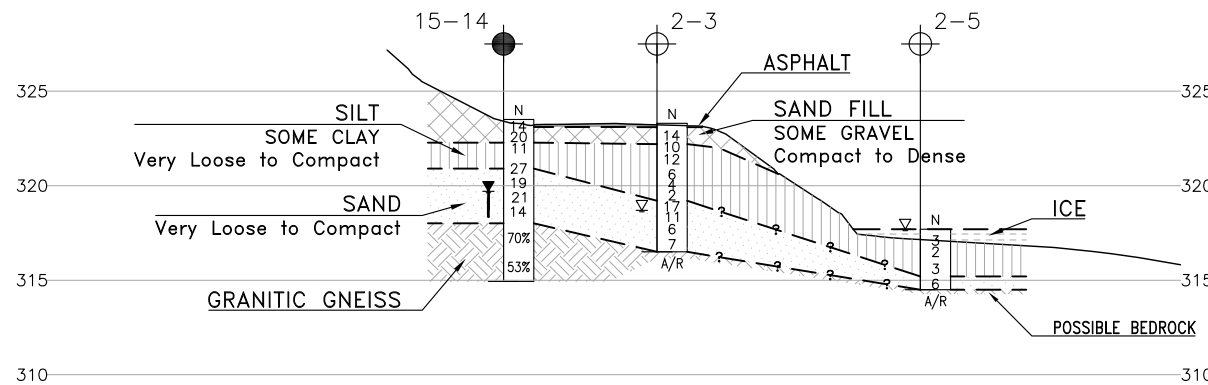
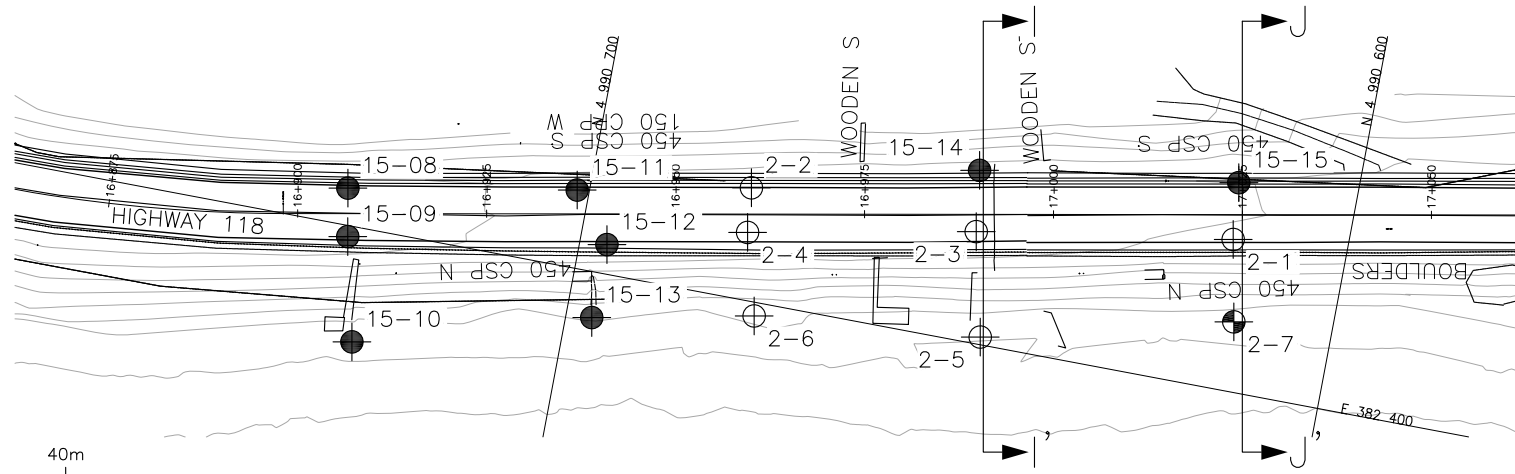
NO	ELEVATION	NORTHING (MTM)	EASTING (MTM)
15-08	324.3	4 990 731.5	382 404.9
15-09	324.3	4 990 730.3	382 398.6
15-10	317.7	4 990 727.2	382 385.0
15-11	324.3	4 990 701.6	382 410.2
15-12	323.6	4 990 696.4	382 403.9
15-13	317.7	4 990 696.6	382 394.0
15-14	323.5	4 990 649.8	382 422.7
15-15	323.0	4 990 615.8	382 427.4
2-1	322.9	4 990 615.1	382 419.9
2-2	323.6	4 990 679.0	382 414.8
2-3	323.3	4 990 648.7	382 414.6
2-4	323.5	4 990 678.4	382 408.9

-NOTES-

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- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 31E-369

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	ME	CHK KS	CODE LOAD DATE DEC 2017
DRAWN	MFA	CHK ME	SITE STRUCTURE FIGURE D5

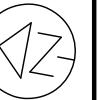


METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



CONT No 5014-E-0004
WP No 5339-11-00

HIGHWAY 118
SLOPE REHABILITATION
SECTIONS - AREA 3
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET



KEYPLAN

LEGEND

- Borehole by Thurber
- Borehole by Others
- DCPT by Others
- Blows /0.3m (Std Pen Test, 475J/blow)
- Blows /0.3m (60' Cone, 475J/blow)
- Water Level During Drilling
- Water Level In
- Piezometer
- Rock Quality Designation (RQD)
- Auger Refusal

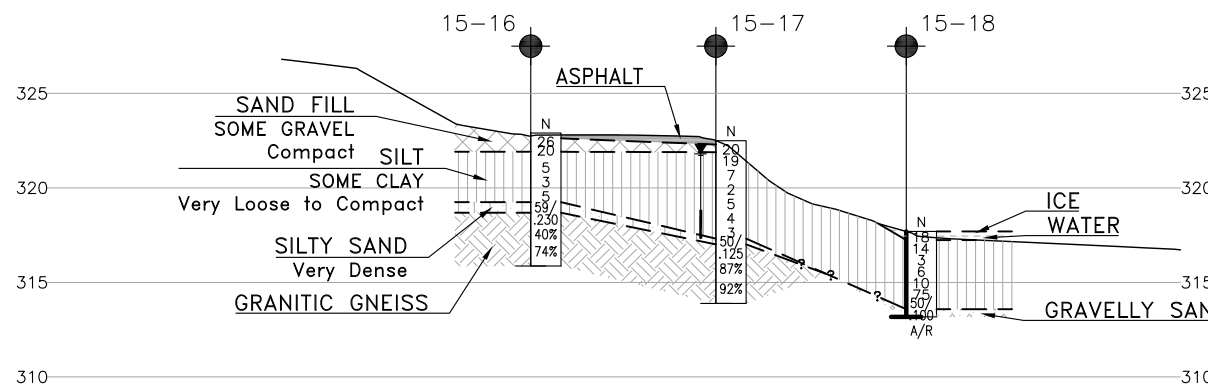
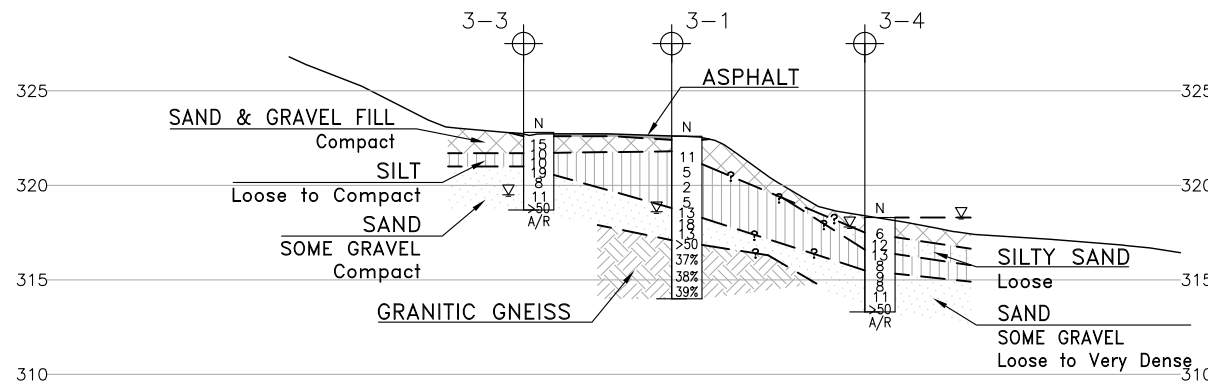
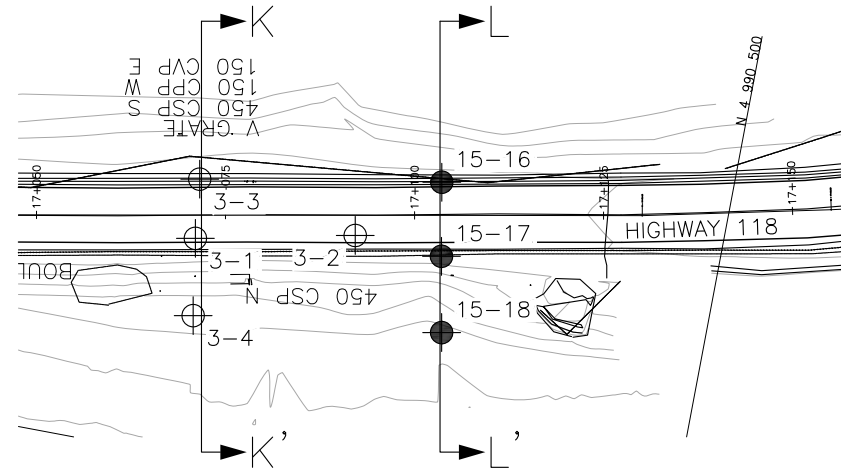
NO	ELEVATION	NORTHING (MTM)	EASTING (MTM)
15-16	322.9	4 990 538.1	382 442.1
15-17	322.5	4 990 536.3	382 432.5
15-18	317.3	4 990 534.4	382 422.6
3-1	322.6	4 990 568.7	382 428.8
3-2	322.7	4 990 548.0	382 433.1
3-3	322.8	4 990 569.6	382 436.6
3-4	318.3	4 990 567.1	382 418.7

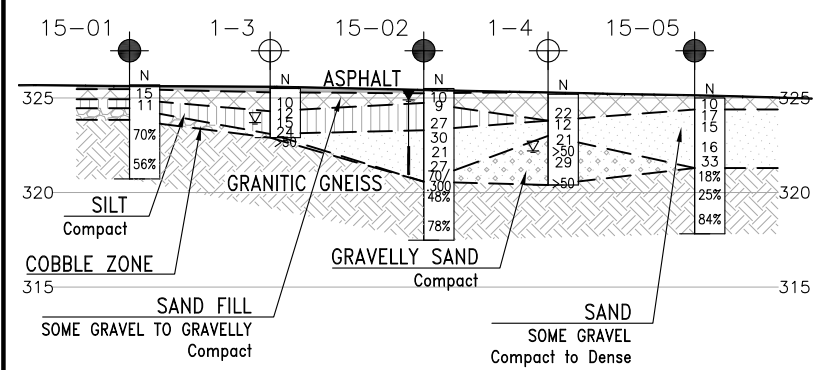
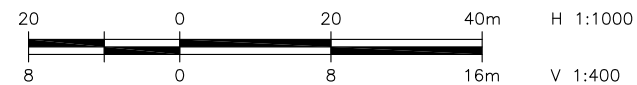
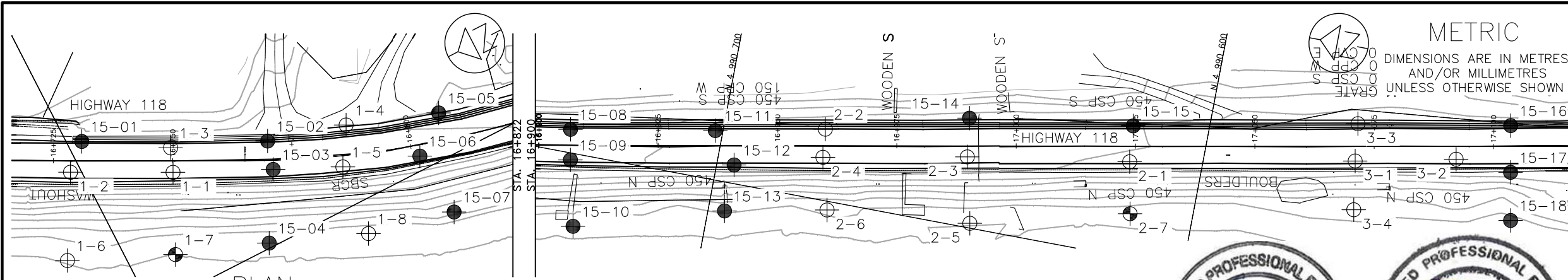
NOTES

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

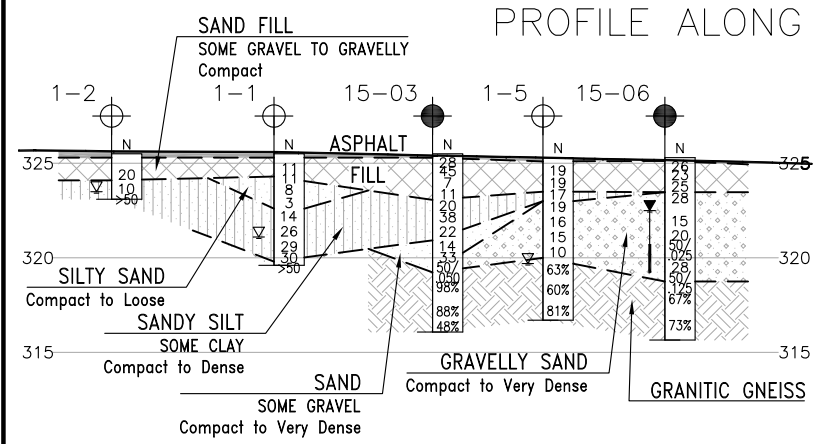
GEOCRES No. 31E-369

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	ME	CHK KS	CODE
DRAWN	MFA	CHK ME	SITE
			LOAD
			STRUCT
			FIGURE D6
			DATE DEC 2017

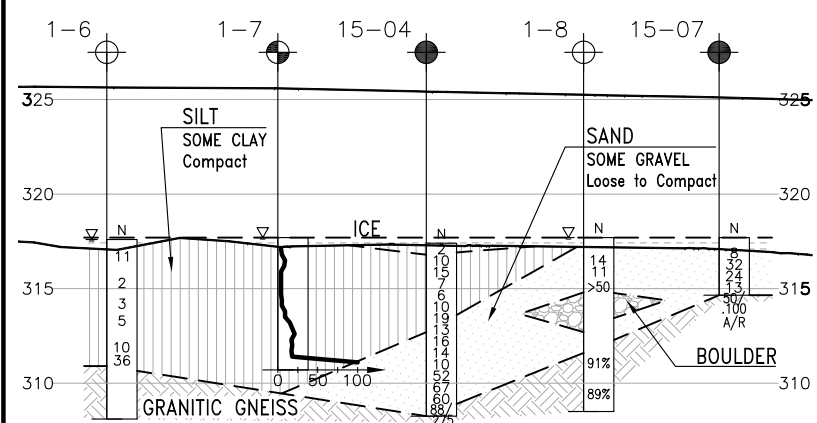




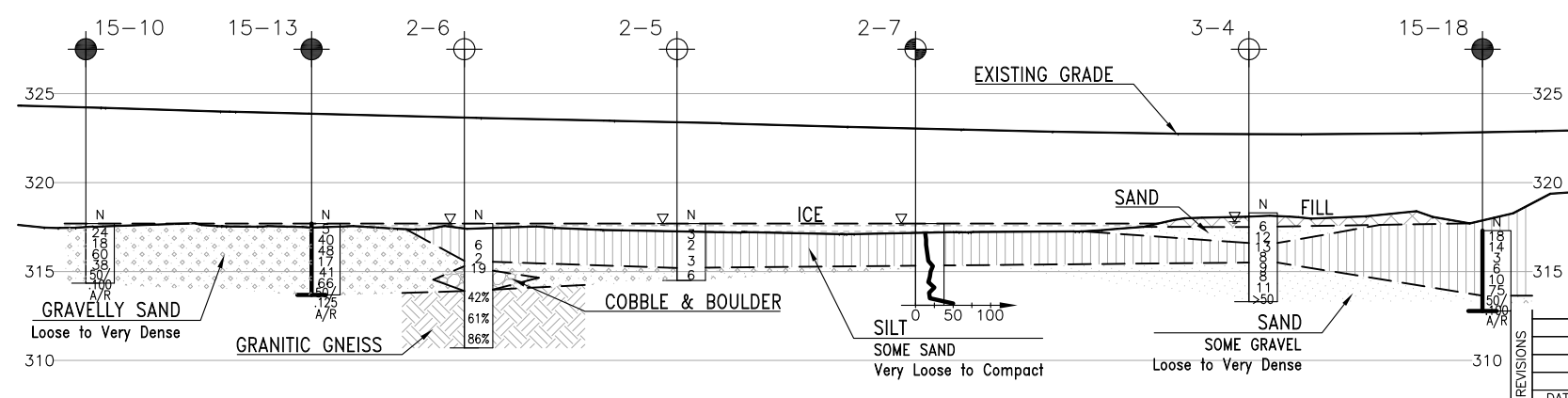
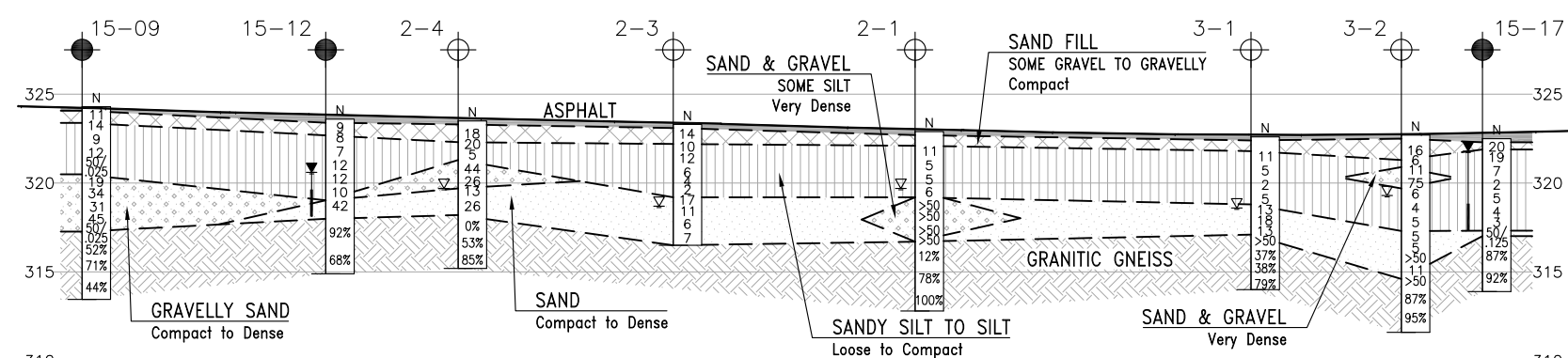
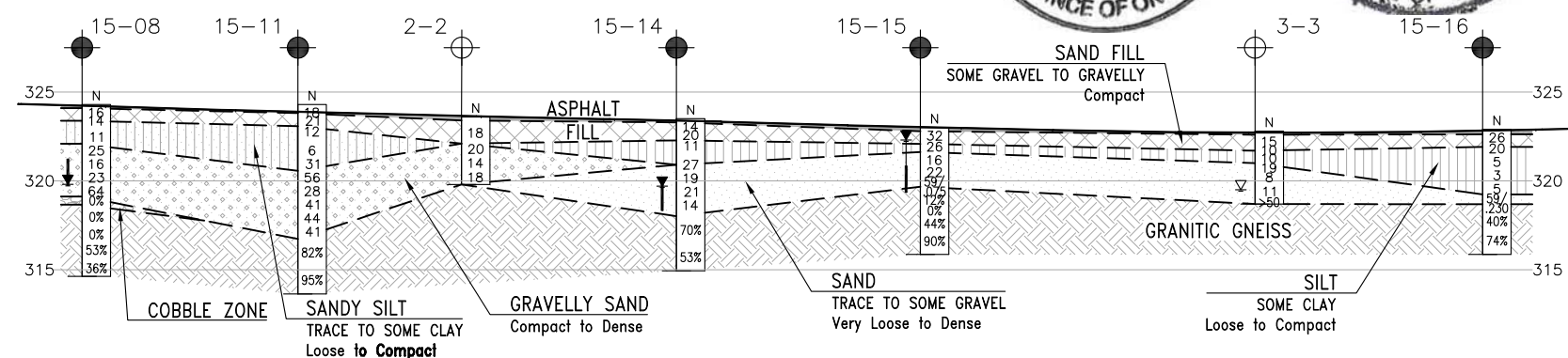
PROFILE ALONG EAST SHOULDER



PROFILE ALONG WEST SHOULDER



PROFILE ALONG TOE OF SLOPE



CONT No 5014-E-0004
WP No 5339-11-00

HIGHWAY 118
SLOPE REHABILITATION
PROFILES
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



LEGEND

●	Borehole by Thurber
⊕	Borehole by Others
⊙	DCPT by Others
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
▽	Water Level During Drilling
┆	Water Level In
┆	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING (MTM)	EASTING (MTM)
15-01	325.7	4 990 897.1	382 437.9
15-02	325.5	4 990 862.4	382 420.2
15-03	325.5	4 990 864.0	382 414.4
15-04	317.7	4 990 871.8	382 401.0
15-05	325.0	4 990 827.8	382 409.1
15-06	325.3	4 990 835.4	382 402.9
15-07	317.7	4 990 834.4	382 389.2
15-08	324.3	4 990 731.5	382 404.9
15-09	324.3	4 990 730.3	382 398.6
15-10	317.7	4 990 727.2	382 385.0
15-11	324.3	4 990 701.6	382 410.2
15-12	323.6	4 990 696.4	382 403.9

NOTES

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEORES No. 31E-369

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	ME	CHK KS	CODE
DRAWN	MFA	CHK ME	SITE
			LOAD
			STRUCT
			FIGURE D7
			DATE DEC 2017



Appendix E

**Factual Data from Previous Investigation
exp. Report, Geocres No. 31E-326**

EXPLANATION OF TERMS USED IN REPORT

N-VALUE: THE STANDARD PENETRATION TEST (SPT) N-VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N-VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N-VALUE IS DENOTED THUS \bar{N} .

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

C_u (kPa)	0 – 12	12 – 25	25 – 50	50 – 100	100 – 200	>200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 – 5	5 – 10	10 – 30	30 – 50	>50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND/OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY IS:

RQD (%)	0 – 25	25 – 50	50 – 75	75 – 90	90 – 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINT AND BEDDING:

SPACING	50mm	50 – 300mm	0.3m – 1m	1m – 3m	>3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	FS	FOIL SAMPLE

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
c_c	1	COMPRESSION INDEX
c_s	1	SWELLING INDEX
c_a	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_i	1	SENSITIVITY = c_u / τ_r

PHYSICAL PROPERTIES OF SOIL

P_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{\text{max}} - e}{e_{\text{max}} - e_{\text{min}}}$
P_w	kg/m^3	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m^3	UNIT WEIGHT OF WATER	s_r	%	DEGREE OF SATURATION	D_n	mm	N PERCENT – DIAMETER
P	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ'	kN/m^3	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
P_d	kg/m^3	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $(w_L - w_p)$	v	m/s	DISCHARGE VELOCITY
P_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $(w - w_p) / I_p$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $(w_L - w) / I_p$	k	m/s	HYDRAULIC CONDUCTIVITY
P'	kg/m^3	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m^2	SEEPAGE FORCE
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

Brampton, Ontario

RECORD OF BOREHOLE No 1-1

1 OF 1

METRIC

W.P. ADM-00210117-A0 LOCATION Highway 118, Haliburton ON, MTM 17T 4990883.0, 382423.4; Area 1 Sta. 16+750 ORIGINATED BY EF
 DIST Huntsville 52 HWY 118 BOREHOLE TYPE CME-850 Track, Continuous hollow stem augering COMPILED BY TSA
 DATUM GBM 778012 Elev. 322.366 m DATE 1.24.13 - 1.24.13 CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV/ DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)			GR	SA	SI	CL
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE															
325.5	Ground Surface							20	40	60	80	100											
0.0325.3	150 mm Asphalt Pavement																						
0.2	FILL: GRAVELLY SAND (SW) occasional cobble, frozen, brown, loose to compact		1	AS			325							○									
			2	AS										○									
			3A	SS	11									○					27 63 (10)				
324.3																							
1.2	SILTY SAND (SM) trace gravel, grey to brown, moist, compact to loose - becoming more sand		3B	SS	11		324								○								
			4	SS	8									○									
	- becoming very loose		5	SS	3		323								○				8 63 (29)				
322.6																							
2.9	SILT (ML) some sand, moist, brown with oxidation, compact to dense - cobble or boulder at 3.96-4.27 m - becoming wet		6	SS	14		322								○				0 16 (84)				
			7	SS	26												○						
								321									○						
				8	SS	29												○					
			9A	SS	30		320																
319.7																							
5.8319.6	SAND AND GRAVEL (SW) , brown, wet, dense		9B	SS	>50										○								
5.9	Split-Spoon and Auger Refusal on Possible Bedrock END OF BOREHOLE																						
	NOTES: 1. This drawing is to be read with the subject report and project numbers as presented above. 2. Interpretation assistance by exp is required before use by others. 3. Groundwater level was measured in open borehole.																						

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MTO_EXP RECORD OF BOREHOLE HWY118_SLOPE INSTABILITY.GPJ ONTARIO MOT.GDT 4/9/13

Brampton, Ontario

RECORD OF BOREHOLE No 1-2

1 OF 1

METRIC

W.P. ADM-00210117-A0 LOCATION Highway 118, Haliburton ON, MTM 17T 4990902.1, 382433.2; Area 1 Sta. 16+729 ORIGINATED BY EF
 DIST Huntsville 52 HWY 118 BOREHOLE TYPE CME-850 Track, Continuous hollow stem augering COMPILED BY TSA
 DATUM GBM 778012 Elev. 322.366 m DATE 1.24.13 - 1.24.13 CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV/ DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
325.5	Ground Surface							20	40	60	80	100								
0.0 325.3	200 mm Asphalt Pavement																			
0.2	FILL: SAND AND GRAVEL (SW) occasional cobble, frozen, brown, loose to compact		1	AS			325							○						
324.2		2	SS	20											○					
1.4	SANDY SILT (ML) trace gravel, trace peat, and trace organics, moist, grey and brown, loose							324											○	2 33 (65)
	- becoming wet, brown, dense		3	SS	10															
323.1			4	SS	>50											○				
2.4	Split-Spoon and Auger Refusal on Possible Bedrock END OF BOREHOLE																			
NOTES: 1. This drawing is to be read with the subject report and project numbers as presented above. 2. Interpretation assistance by exp is required before use by others. 3. Groundwater level was measured in open borehole.																				

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MTO_EXP RECORD OF BOREHOLE HWY118_SLOPE INSTABILITY.GPJ ONTARIO MOT.GDT 4/9/13

Brampton, Ontario

RECORD OF BOREHOLE No 1-3

1 OF 1

METRIC

W.P. ADM-00210117-A0 LOCATION Highway 118, Haliburton ON, MTM 17T 4990881.1, 382428.2; Area 1 Sta. 16+750 ORIGINATED BY EF
 DIST Huntsville 52 HWY 118 BOREHOLE TYPE CME-850 Track, Continuous hollow stem augering COMPILED BY TSA
 DATUM GBM 778012 Elev. 322.366 m DATE 1.24.13 - 1.24.13 CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL										
ELEV/ DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa																			
								○ UNCONFINED	+	FIELD VANE																	
325.5	Ground Surface						● QUICK TRIAXIAL	×	LAB VANE	WATER CONTENT (%)																	
0.0	200 mm Asphalt Pavement						20	40	60	80	100	10	20	30													
0.2	FILL: SAND AND GRAVEL (SW) crushed, frozen, brown, loose		1	AS		▽																					
325.3			2A	SS	10																						
324.3	2B	SS	12																								
1.2	SILT (ML) trace sand, trace organics, moist, greyish brown with oxidation, compact -becoming wet		3	SS	15																						
323.1			4A	SS	24																						
2.4	SAND AND GRAVEL (SW) trace silt, greyish brown, wet, very dense		4B	SS	>50	323																					
2.6	Split-Spoon and Auger Refusal on Possible Bedrock END OF BOREHOLE																										
NOTES: 1. This drawing is to be read with the subject report and project numbers as presented above. 2. Interpretation assistance by exp is required before use by others. 3. Groundwater level was measured in open borehole.																											

MTO_EXP RECORD OF BOREHOLE HWY118_SLOPE INSTABILITY.GPJ ONTARIO MOT.GDT 4/9/13

Brampton, Ontario

RECORD OF BOREHOLE No 1-4

1 OF 1

METRIC

W.P. ADM-00210117-A0 LOCATION Highway 118, Haliburton ON, MTM 17T 4990846.2, 382415.7; Area 1 Sta. 16+787 ORIGINATED BY EF
 DIST Huntsville 52 HWY 118 BOREHOLE TYPE CME-850 Track, Continuous hollow stem augering COMPILED BY TSA
 DATUM GBM 778012 Elev. 322.366 m DATE 1.24.13 - 1.24.13 CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV/ DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
325.2	Ground Surface					20 40 60 80 100											
0.0	FILL: SAND (SW) to SAND AND GRAVEL (SW) occasional cobble, frozen, brown, loose to compact		1	AS			325										
			2	AS													
323.8			3	SS	22		324										
1.4	SAND (SW-SM) fine grain, trace gravel, trace silt, damp, brown , compact		4	SS	12											6 88 (6)	
323.0							323										
2.2	SAND AND GRAVEL (SW) trace to some silt, damp, brown, compact - becoming very dense, wet - Split-spoon Refusal at 3.20 m (possibly cobble or boulder) past by auger to 3.66 m - becoming more silt, wet, greyish brown, very dense		5	SS	21											25 70 (5)	
			6	SS	>50		322										
			7	SS	29		321									30 55 (15)	
320.3			8	SS	>50												
4.8	Split-Spoon and Auger Refusal on Possible Bedrock END OF BOREHOLE NOTES: 1. This drawing is to be read with the subject report and project numbers as presented above. 2. Interpretation assistance by exp is required before use by others. 3. Groundwater level was measured in open borehole.																

MTO_EXP RECORD OF BOREHOLE HWY118_SLOPE INSTABILITY.GPJ ONTARIO MOT.GDT 4/9/13





Brampton, Ontario

RECORD OF BOREHOLE No 1-5

1 OF 1

METRIC

W.P. ADM-00210117-A0 LOCATION Highway 118, Haliburton ON, MTM 17T 4990850.8, 382408.2; Area 1 Sta. 16+786 ORIGINATED BY EF
 DIST Huntsville 52 HWY 118 BOREHOLE TYPE CME-850 Track, Continuous hollow stem augering COMPILED BY TSA
 DATUM GBM 778012 Elev. 322.366 m DATE 1.25.13 - 1.25.13 CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV/ DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
325.3	Ground Surface						20	40	60	80	100						
0.0325.2	150 mm Asphalt Pavement																
0.2	FILL: SAND (SW) TO SAND AND GRAVEL (SW) trace silt, frozen, brown, compact		1	AS													
			2	SS	19												
323.5			3A	SS	19												
1.8	SILT (ML) trace sand, moist, greyish brown, compact		3B	SS	17												
323.0																	
2.3	SAND AND GRAVEL (SW) damp, brown, compact -becoming more sand fine grain, loose		4	SS	19												
			5	SS	16												
			6	SS	15												
			7	SS	10												
320.0																	
5.3	Split-Spoon and Auger Refusal NQ Coring BEDROCK Granitic layering (Gneiss), light grey/pink Length (m) RQD (%) Run 1 0.45 63 Run 2 1.52 60 Run 3 0.95 81		8	NQ													
			9	NQ													
			10	NQ													
316.7																	
8.6	END OF BOREHOLE																
	NOTES: 1. This drawing is to be read with the subject report and project numbers as presented above. 2. Interpretation assistance by exp is required before use by others. 3. 2" I.D. Standpipe piezometer was installed on 25/01/2013. Groundwater level measured at 5.59 m on 06/02/2013. The piezometer was decommissioned because of safety issue.																

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MTO_EXP RECORD OF BOREHOLE HWY118_SLOPE INSTABILITY.GPJ ONTARIO MOT.GDT 4/9/13

Brampton, Ontario

RECORD OF BOREHOLE No 1-6

1 OF 1

METRIC

W.P. ADM-00210117-A0 LOCATION Highway 118, Haliburton ON, MTM 17T 4990911.1, 382417.0; Area 1 Sta. 16+728 ORIGINATED BY EF
 DIST Huntsville 52 HWY 118 BOREHOLE TYPE CME-850 Track, Continuous hollow stem augering COMPILED BY TSA
 DATUM GBM 778012 Elev. 322.366 m DATE 2.5.13 - 2.5.13 CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV/ DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
317.6	Top of Ice>					20	40	60	80	100							
0.0	610 mm thick ice	△		ICE													
317.0		△															
0.6	SILT (CL-ML) some clay, trace sand, some organics, moist, grey, compact		1	SS	11												
			2	VANE					+								
	- becoming wet, very loose		3	SS	2											0 5 77 18	
			4	VANE					+								
			5	SS	3												
			6	VANE													
	- becoming loose		7	SS	5											2 1 91 6	
			8	VANE													
	- becoming some sand, loose to compact		9	SS	10												
311.0			10	SS	36												
6.7	Split-Spoon and Auger Refusal NQ Coring BEDROCK Granitic layering (Gneiss), light grey/pink		11	NQ													
	Length (m) RQD (%)																
	Run 1 1.37 65																
	Run 2 0.34 0																
	Run 3 1.09 60																
			12	NQ													
			13	NQ													
308.2																	
9.5	END OF BOREHOLE																
	NOTES: 1. This drawing is to be read with the subject report and project numbers as presented above. 2. Interpretation assistance by exp is required before use by others.																

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MTO_EXP RECORD OF BOREHOLE HWY118_SLOPE INSTABILITY.GPJ ONTARIO MOT.GDT 4/9/13


Brampton, Ontario

RECORD OF BOREHOLE No 1-7

1 OF 1

METRIC

W.P. ADM-00210117-A0 LOCATION Highway 118, Haliburton ON, MTM 17T 4990890.4, 382407.8; Area 1 Sta. 16+751 ORIGINATED BY EF
 DIST Huntsville 52 HWY 118 BOREHOLE TYPE CME-850 Track, Continuous hollow stem augering COMPILED BY TSA
 DATUM GBM 778012 Elev. 322.366 m DATE 2.5.13 - 2.5.13 CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT  20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV/ DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
317.7	Top of Ice>										
0.0	300 mm thick Ice	△									
317.4											
0.3	No Samples Cone Test was done in every 0.3 m										
317											
316											
315											
314											
313											
312											
311											
310.7											
7.0	Cone Refusal on Possible Bedrock END OF BOREHOLE										
	NOTES: 1. This drawing is to be read with the subject report and project numbers as presented above. 2. Interpretation assistance by exp is required before use by others.										

Brampton, Ontario

RECORD OF BOREHOLE No 1-8

1 OF 1

METRIC

W.P. ADM-00210117-A0 LOCATION Highway 118, Haliburton ON, MTM 17T 4990852.4, 382393.3; Area 1 Sta. 16+790 ORIGINATED BY EF
 DIST Huntsville 52 HWY 118 BOREHOLE TYPE CME-850 Track, Continuous hollow stem augering COMPILED BY TSA
 DATUM GBM 778012 Elev. 322.366 m DATE 2.6.13 - 2.6.13 CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV/ DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
317.7	Top of Ice>						20	40	60	80	100									
0.0	300 mm thick Ice	△																		
317.4																				
0.3	SAND (SW) fine grains, trace silt, trace gravel, trace organics, wet, brown, loose to compact		1	AS											○					
			2	SS	14											○				
			3	SS	11											○				
			4	SS	>50											○				
314.8																				
2.9	NQ Coring		5	NQ																
	Boulder																			
	Length (m) Run 1 0.11 Run 2 1.57 Run 3 0.43		6	NQ																
			7-A	NQ																
312.7																				
5.0	SAND (SW) same as above		7-B	NQ																
311.6																				
6.1	Split-Spoon and Auger Refusal NQ Coring BEDROCK Granitic layering (Gneiss), light grey/pink		8	NQ																
	Length (m) RQD (%) Run 1 1.52 91 Run 2 1.51 89																			
			9	NQ																
308.5																				
9.2																				

+³, ×³: Numbers refer to
Sensitivity

○ 3% STRAIN AT FAILURE

MTO_EXP RECORD OF BOREHOLE HWY118_SLOPE INSTABILITY.GPJ ONTARIO MOT.GDT 4/9/13

Brampton, Ontario

RECORD OF BOREHOLE No 2-1

1 OF 1

METRIC

W.P. ADM-00210117-A0 LOCATION Highway 118, Haliburton ON, MTM 17T 4990615.1, 382419.9; Area 2 Sta. 17+024 ORIGINATED BY EF
 DIST Huntsville 52 HWY 118 BOREHOLE TYPE CME-850 Track, Continuous hollow stem augering COMPILED BY TSA
 DATUM GBM 778012 Elev. 322.366 m DATE 1.18.13 - 1.18.13 CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV/ DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)		
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE								
322.9	Ground Surface							20	40	60	80	100							
0.0	200 mm Asphalt Pavement		1	AS															
0.2	FILL: SAND (SW) TO SAND AND GRAVEL (SW) occasional cobble, frozen, brown		2	AS															
322.1																			
0.8		SANDY SILT (ML) trace peat, trace rootlets, moist, brown, compact		3	SS	11													
				4	SS	5													
			5	SS	5														
			6	SS	6														
319.2	SAND AND GRAVEL (GW-GM) some silt, wet, brown, very dense																		
3.7			7	SS	>50														
		- Split-spoon Refusal at 4.11 m (possibly cobble or boulder) past by auger to 4.42 m		8	SS	>50													
		- Split-spoon refusal at 4.65 m and auger refusal at 4.72 m (possible cobble or boulder) ran HWT casing to 5.33 m		9	SS	>50													
	- Broken up bits at 6.15 m (possible bedrock) ran HWT casing to 6.48 m																		
316.7			10	SS	>50														
6.2	Split-Spoon and Auger Refusal NQ Coring BEDROCK Granitic layering (Gneiss), light grey/pink Length (m) RQD (%) Run 1 1.50 12 Run 2 1.52 78 Run 3 0.91 100		11	NQ															
			12	NQ															
			13	NQ															
312.8	END OF BOREHOLE																		
0.1	NOTES: 1. This drawing is to be read with the subject report and project numbers as presented above. 2. Interpretation assistance by exp is required before use by others. 3. Groundwater level was measured in open borehole.																		

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MTO_EXP RECORD OF BOREHOLE HWY118_SLOPE INSTABILITY.GPJ ONTARIO MOT.GDT 4/9/13

Brampton, Ontario

RECORD OF BOREHOLE No 2-2

1 OF 1

METRIC

W.P. ADM-00210117-A0 LOCATION Highway 118, Haliburton ON, MTM 17T 4990679.0, 382414.8; Area 2 Sta. 16+960 ORIGINATED BY EF
 DIST Huntsville 52 HWY 118 BOREHOLE TYPE CME-850 Track, Continuous hollow stem augering COMPILED BY TSA
 DATUM GBM 778012 Elev. 322.366 m DATE 1.27.13 - 1.27.13 CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV/ DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					w _p	w	w _L		GR	SA	SI	CL
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	WATER CONTENT (%)								
323.6	Ground Surface																			
0.0 323.4	200 mm Asphalt Pavement																			
0.2	FILL: SAND (SW) to SAND AND GRAVEL (SW) frozen, brown, compact		1	AS																
	- becoming damp		2	SS	18															
322.1																				
1.5	SAND AND GRAVEL (SW) trace silt, moist, brown, compact		3	SS	20															
			4	SS	14															
319.9																				
3.8	Split-Spoon and Auger Refusal on Possible Bedrock END OF BOREHOLE																			
	NOTES: 1. This drawing is to be read with the subject report and project numbers as presented above. 2. Interpretation assistance by exp is required before use by others. 3. No groundwater was observed.																			

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MTO_EXP RECORD OF BOREHOLE HWY118_SLOPE INSTABILITY.GPJ ONTARIO MOT.GDT 4/9/13

Brampton, Ontario

RECORD OF BOREHOLE No 2-3

1 OF 1

METRIC

W.P. ADM-00210117-A0 LOCATION Highway 118, Haliburton ON, MTM 17T 4990648.7, 382414.6; Area 2 Sta. 16+990 ORIGINATED BY EF
 DIST Huntsville 52 HWY 118 BOREHOLE TYPE CME-850 Track, Continuous hollow stem augering COMPILED BY TSA
 DATUM GBM 778012 Elev. 322.366 m DATE 1.27.13 - 1.27.13 CHECKED BY SM

SOIL PROFILE				SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV/ DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)							GR	SA	SI	CL		
						20			40	60	80	100	20									40	60
323.3	Ground Surface																						
0.0 323.1	200 mm Asphalt Pavement																						
0.2	FILL: SAND AND GRAVEL (SW) frozen, brown, compact		1	AS																			
	- becoming damp		2A	SS	14																		
322.2																							
1.1	SILT (ML) trace sand, greyish brown, moist, compact		2B	SS	10																		
			3	SS	12														0 12 (88)				
	- becoming trace clay, wet, loose		4	SS	6														0 2 87 11				
			5	SS	4														0 2 (98)				
	- becoming, very loose																						
319.2			6A	SS	2																		
4.1	SAND (SW) fine grain, trace silt, damp, brown, compact		6B	SS	17																		
			7	SS	11																		
	- becoming wet, loose		8	SS	6														0 94 (6)				
			9	SS	7																		
317																							
316.5																							
6.8	Split-Spoon and Auger Refusal on Possible Bedrock END OF BOREHOLE																						
	NOTES: 1. This drawing is to be read with the subject report and project numbers as presented above. 2. Interpretation assistance by exp is required before use by others. 3. Groundwater level was measured in open borehole.																						

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MTO_EXP RECORD OF BOREHOLE HWY118_SLOPE INSTABILITY.GPJ ONTARIO MOT.GDT 4/9/13



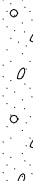


Brampton, Ontario

RECORD OF BOREHOLE No 2-4

1 OF 1

METRIC

W.P. ADM-00210117-A0 LOCATION Highway 118, Haliburton ON, MTM 17T 4990678.4, 382408.9; Area 2 Sta. 16+960 ORIGINATED BY EF
 DIST Huntsville 52 HWY 118 BOREHOLE TYPE CME-850 Track, Continuous hollow stem augering COMPILED BY TSA
 DATUM GBM 778012 Elev. 322.366 m DATE 1.30.13 - 1.30.13 CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV/ DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)		
								20 40 60 80 100									10 20 30		
323.5	Ground Surface																		
0.0	200 mm Asphalt Pavement																		
0.2	FILL: SAND AND GRAVEL (SW) frozen, brown, compact - becoming damp		1	AS															
			2	AS															
322.3			3A	SS	18														
1.2	SANDY SILT (ML) greyish brown, moist, compact - becoming loose		3B	SS	20														
			4	SS	5														
321.3																			
2.2	SAND AND GRAVEL (SW) damp, brown, dense to compact		5	SS	44														
			6	SS	26														
319.7																			
3.8	SAND (SW) trace gravel, trace silt, moist, brown, compact - becoming fine sand, greyish brown		7	SS	13														
			8	SS	26														
318.3																			
5.3	Split-Spoon and Auger Refusal NQ Coring BEDROCK Granitic layering (Gneiss), light grey/pink Length (m) RQD (%) Run 1 0.53 0 Run 2 1.58 53 Run 3 0.94 85		9	NQ															
			10	NQ															
			11	NQ															
315.2																			
8.3	END OF BOREHOLE																		
	NOTES: 1. This drawing is to be read with the subject report and project numbers as presented above. 2. Interpretation assistance by exp is required before use by others. 3. 2" I.D. Standpipe piezometer was installed on 30/01/2013. Groundwater level measured at 3.85 m on 06/02/2013. The piezometer was decommissioned because of safety issue.																		

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MTO_EXP RECORD OF BOREHOLE HWY118_SLOPE INSTABILITY.GPJ ONTARIO MOT.GDT 4/9/13

Brampton, Ontario

RECORD OF BOREHOLE No 2-5

1 OF 1

METRIC

W.P. ADM-00210117-A0 LOCATION Highway 118, Haliburton ON, MTM 17T 4990645.6, 382401.0; Area 2 Sta. 16+990 ORIGINATED BY EF
 DIST Huntsville 52 HWY 118 BOREHOLE TYPE CME-850 Track, Continuous hollow stem augering COMPILED BY TSA
 DATUM GBM 778012 Elev. 322.366 m DATE 2.4.13 - 2.4.13 CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT						PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV/ DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa													
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										WATER CONTENT (%)			
317.7	Top of Ice>																				
0.0	300 mm thick Ice	△																			
317.4																					
0.3	SILT (CL-ML) some sand, some organics, trace clay, greyish brown, wet, very loose -becoming trace sand		1	SS	3																
			2	SS	2														non plastic		
			3	VANE																	
			4	SS	3														0 6 (94)		
315.1																					
2.5	SAND (SW) trace gravel, wet, brown, loose																				
314.5			5	SS	6																
3.2	Split-Spoon and Auger Refusal on Possible Bedrock END OF BOREHOLE NOTES: 1. This drawing is to be read with the subject report and project numbers as presented above. 2. Interpretation assistance by exp is required before use by others. 3. Groundwater level was measured in open borehole.																				

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MTO_EXP RECORD OF BOREHOLE HWY118_SLOPE INSTABILITY.GPJ ONTARIO MOT.GDT 4/9/13

Brampton, Ontario

RECORD OF BOREHOLE No 2-6

1 OF 1

METRIC

W.P. ADM-00210117-A0 LOCATION Highway 118, Haliburton ON, MTM 17T 4990675.5, 382398.2; Area 2 Sta. 16+960 ORIGINATED BY EF
 DIST Huntsville 52 HWY 118 BOREHOLE TYPE CME-850 Track, Continuous hollow stem augering COMPILED BY TSA
 DATUM GBM 778012 Elev. 322.366 m DATE 2.4.13 - 2.4.13 CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV/ DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
317.7	Top of Ice					20	40	60	80	100	10	20	30				
0.0	300 mm thick Ice	△															
317.4																	
0.3	SANDY SILT (ML) some organics, greyish brown, wet, loose		1	AS												40.2	
			2	SS	6												○
315.6			3A	SS	2											○	
2.1	SAND AND GRAVEL some cobble and boulder, wet, brown, compact	○	3B	SS	19											○	
315.3																	
2.4	Split-Spoon and Auger Refusal NQ Coring COBBLE AND BOULDER length of 1.07 m		4	NQ													
313.9																	
3.8	BEDROCK Granitic layering (Gneiss), light grey/pink		5	NQ													
	Length (m) RQD (%) Run 1 1.27 42 Run 2 0.45 61 Run 3 1.49 86		6	NQ													
			7	NQ													
310.7																	
7.0	END OF BOREHOLE																
	NOTES: 1. This drawing is to be read with the subject report and project numbers as presented above. 2. Interpretation assistance by exp is required before use by others. 3. Groundwater level was measured in open borehole.																

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MTO_EXP RECORD OF BOREHOLE HWY118_SLOPE INSTABILITY.GPJ ONTARIO MOT.GDT 4/9/13

W.P.	ADM-00210117-A0	LOCATION	Highway 118, Haliburton ON, MTM 17T 4990613.0, 382409.2; Area 2 Sta. 17+024	ORIGINATED BY	EF
DIST	Huntsville 52 HWY 118	BOREHOLE TYPE	CME-850 Track, Continuous hollow stem augering	COMPILED BY	TSA
DATUM	GBM 778012 Elev. 322.366 m	DATE	2.6.13 - 2.6.13	CHECKED BY	SM

[illegible]

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MTO_EXP RECORD OF BOREHOLE HWY118_SLOPE INSTABILITY.GPJ ONTARIO MOT.GDT 4/9/13

Brampton, Ontario

RECORD OF BOREHOLE No 3-1

1 OF 1

METRIC

W.P. ADM-00210117-A0 LOCATION Highway 118, Haliburton ON, MTM 17T 4990568.7, 382428.8; Area 3 Sta. 17+071 ORIGINATED BY EF
 DIST Huntsville 52 HWY 118 BOREHOLE TYPE CME-850 Track, Continuous hollow stem augering COMPILED BY TSA
 DATUM GBM 778012 Elev. 322.366 m DATE 1.16.13 - 1.16.13 CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV/ DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)			GR	SA	SI	CL
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	20					40	60	80				
322.6	Ground Surface																						
0.0322.5	150 mm Asphalt Pavement		1	AS																			
0.2	FILL: SAND AND GRAVEL (SW) occasional cobble, frozen, brown, loose to compact		2	AS																			
321.8																							
0.8		SILT (ML) some fine sand, trace peat, moist to wet, brown, very loose to compact		3	SS	11												0 11 (89)					
				4	SS	5																	
			5	SS	2												4 26 65 5						
	- becoming more sand																						
			6	SS	5												0 22 (78)						
318.8																							
3.8	SAND(SW) trace gravel, moist to wet, brown, compact		7	SS	13																		
		-becoming some gravel, trace silt, wet, brown, compact to dense		8A	SS	18																	
				8B	SS	13																	
				9	SS	>50																	
317.1																							
5.5	Split-Spoon and Auger Refusal NQ Coring BEDROCK Granitic layering (Gneiss), light grey/pink		10	NQ																			
		Length (m) RQD (%)																					
		Run 1 0.53 37																					
	Run 2 1.55 38																						
	Run 3 0.97 79																						
			11	NQ																			
			12	NQ																			
314.0																							
8.6	END OF BOREHOLE																						
	NOTES: 1. This drawing is to be read with the subject report and project numbers as presented above. 2. Interpretation assistance by exp is required before use by others. 3. Groundwater level was measured in open borehole.																						

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MTO_EXP RECORD OF BOREHOLE HWY118_SLOPE INSTABILITY.GPJ ONTARIO MOT.GDT 4/9/13

Brampton, Ontario

RECORD OF BOREHOLE No 3-2

1 OF 1

METRIC

W.P. ADM-00210117-A0 LOCATION Highway 118, Haliburton ON, MTM 17T 4990548.0, 382433.1; Area 3 Sta. 17+092 ORIGINATED BY EF
 DIST Huntsville 52 HWY 118 BOREHOLE TYPE CME-850 Track, Continuous hollow stem augering COMPILED BY TSA
 DATUM GBM 778012 Elev. 322.366 m DATE 1.17.13 - 1.17.13 CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV/ DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)		
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE								
322.7	Ground Surface					20	40	60	80	100	10	20	30						
0.0 322.5	200 mm Asphalt Pavement																		
0.2	FILL: GRAVELLY SAND (SW) occasional cobble, frozen, brown, compact -becoming moist, trace asphalt		1	AS							○				20 53 (27)				
			2	AS							○								
			3	SS	16							○							
321.3																			
1.4	SILT (ML) some sand, trace gravel, moist, brown, loose		4A	SS	6							○							
320.9																			
1.8	SAND AND GRAVEL (SW) damp, brown, compact - becoming very dense	○	4B	SS	11						○				320				
			5	SS	75							○							
319.7		○																	
3.0	SILT() (ML) trace sand, trace clay, wet, brown, loose to very loose		6	SS	6								○		319				
			7	SS	4								○						
			8	SS	5								○						
317.4																			
5.4	SAND (SW) fine grain, trace silt, wet, brown, loose -Split-Spoon refusal at a 6.48 m (very dense gravel) past by auger - becoming some gravel, compact to very dense - cobble and boulder encountered depth from 6.86 to 8.08		9	SS	5								○		317				
			10A	SS	5														
			10B	SS	>50							○	○						
			11	SS	11								○						
314.6			12	SS	>50							○							
8.1	Split-Spoon and Auger Refusal NQ Coring BEDROCK Granitic layering (Gneiss), light grey/pink Length (m) RQD (%) Run 1 1.52 87 Run 2 1.53 95		13	NQ											314				
			14	NQ															
311.6																			
1.1	END OF BOREHOLE NOTES: 1. This drawing is to be read with the subject report and project numbers as presented above. 2. Interpretation assistance by exp is required before use by others. 3. Groundwater level was measured in open borehole.																		

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MTO_EXP RECORD OF BOREHOLE HWY118_SLOPE INSTABILITY.GPJ ONTARIO MOT.GDT 4/9/13

Brampton, Ontario

RECORD OF BOREHOLE No 3-3

1 OF 1

METRIC

W.P. ADM-00210117-A0 LOCATION Highway 118, Haliburton ON, MTM 17T 4990569.6, 382435.6; Area 3 Sta. 17+071 ORIGINATED BY EF
 DIST Huntsville 52 HWY 118 BOREHOLE TYPE CME-850 Track, Continuous hollow stem augering COMPILED BY TSA
 DATUM GBM 778012 Elev. 322.366 m DATE 1.27.13 - 1.27.13 CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV/ DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
322.8	Ground Surface							20	40	60	80	100								
0.0 322.6	200 mm Asphalt Pavement																			
0.2	FILL: SAND AND GRAVEL (SW) frozen, brown - becoming damp, compact		1	AS			322							○						
			2A	SS	15									○						
321.7	SILT (ML) trace sand, trace gravel, moist to wet, greyish brown, loose to compact		2B	SS	10										○					
320.9			3A	SS	10		321								○					
1.8	SAND (SW) some gravel, trace silt, greyish brown, damp, loose - becoming more sand, fine grain, loose - fine to coarse grains, compact - becoming more gravel, compact to very dense		3B	SS	19									○						
			4	SS	8		320							○			2 95 (3)			
			5	SS	11									○						
318.7			6	SS	>50		319								○					
4.1	Split-Spoon and Auger Refusal on Possible Bedrock END OF BOREHOLE NOTES: 1. This drawing is to be read with the subject report and project numbers as presented above. 2. Interpretation assistance by exp is required before use by others. 3. Groundwater level was measured in open hole.																			

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MTO_EXP RECORD OF BOREHOLE HWY118_SLOPE INSTABILITY.GPJ ONTARIO MOT.GDT 4/9/13

Brampton, Ontario

RECORD OF BOREHOLE No 3-4

1 OF 1

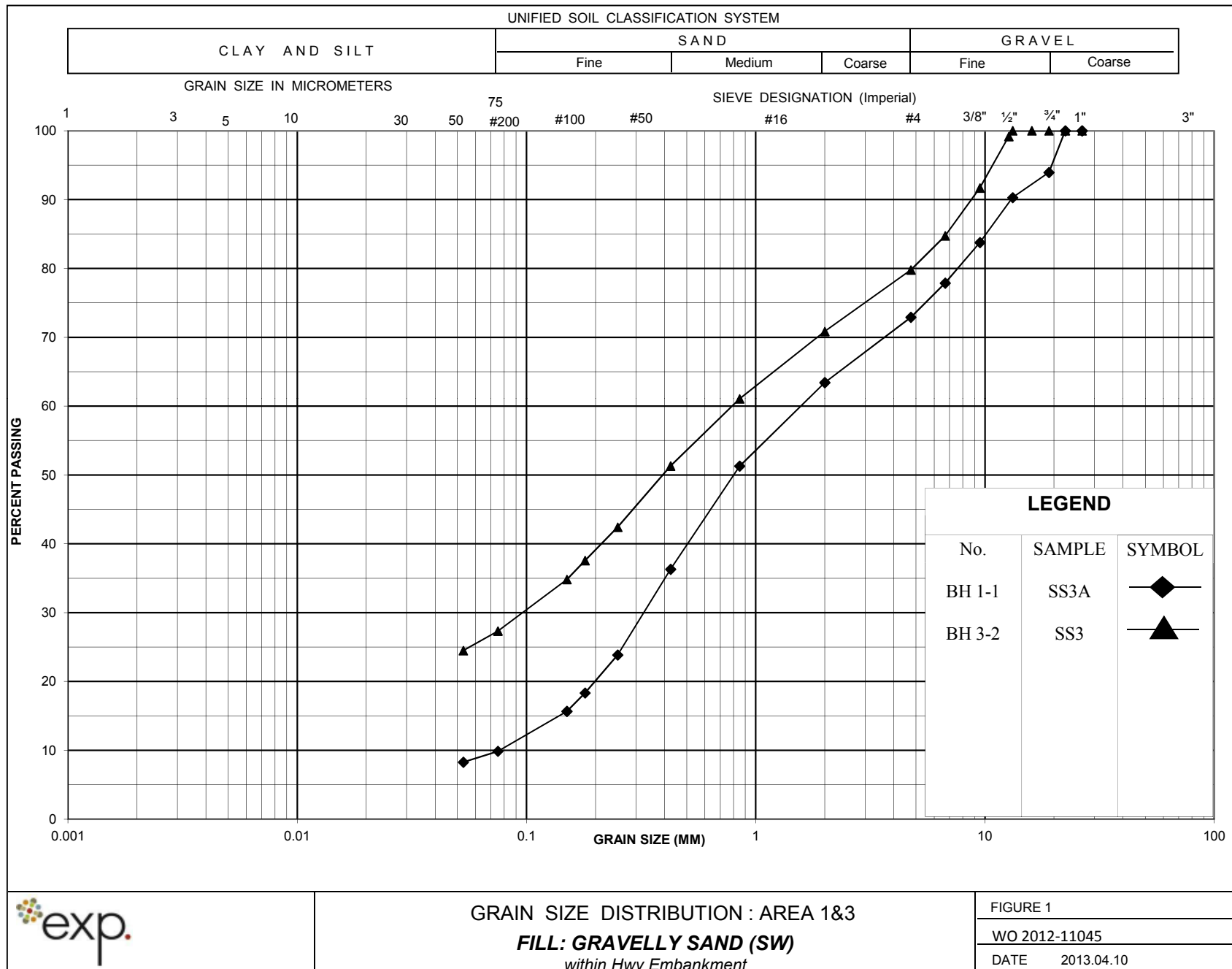
METRIC

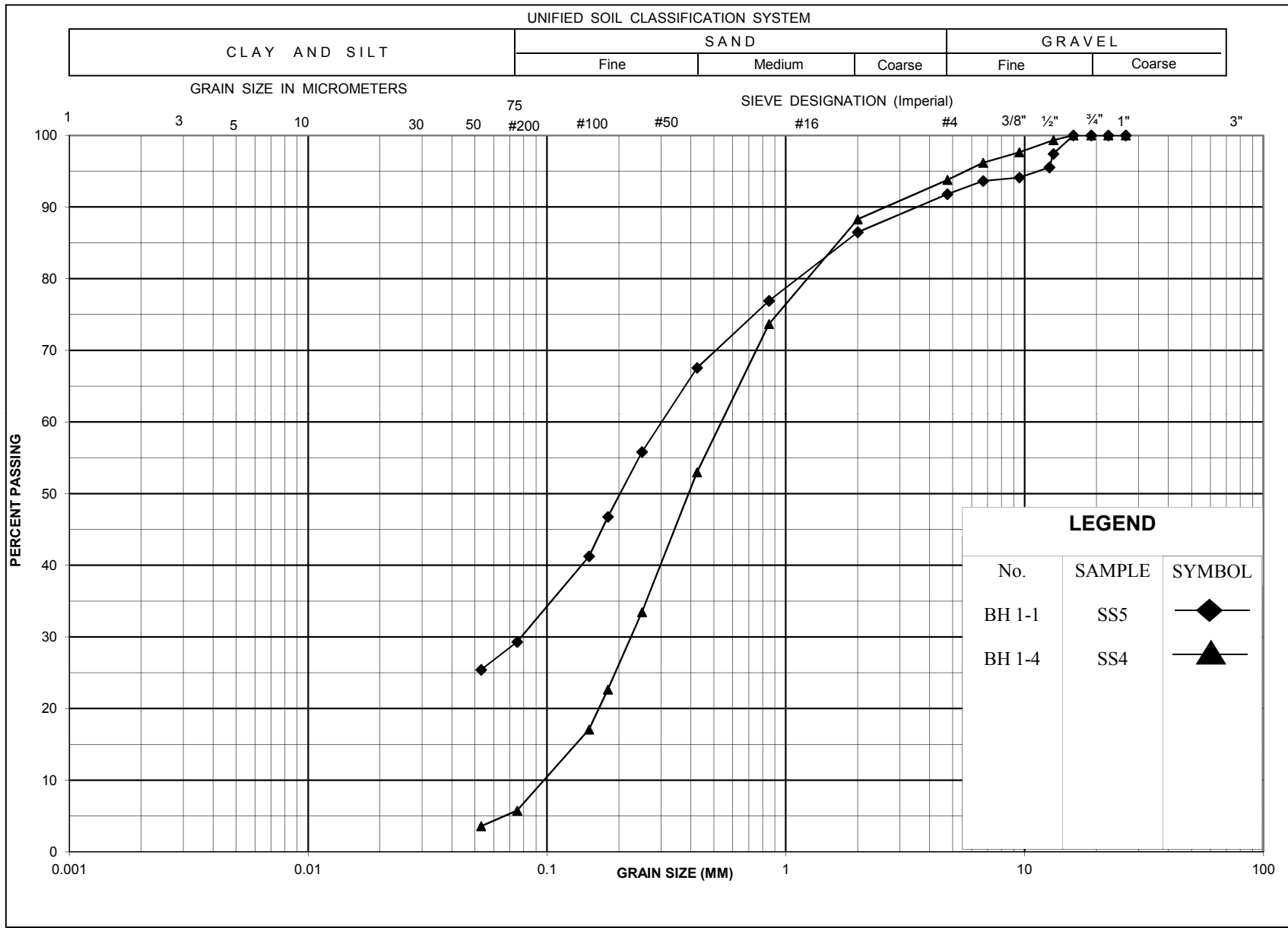
W.P. ADM-00210117-A0 LOCATION Highway 118, Haliburton ON, MTM 17T 4990567.1, 382418.7; Area 3 Sta. 17+071 ORIGINATED BY EF
 DIST Huntsville 52 HWY 118 BOREHOLE TYPE CME-850 Track, Continuous hollow stem augering COMPILED BY TSA
 DATUM GBM 778012 Elev. 322.366 m DATE 1.31.13 - 1.31.13 CHECKED BY SM

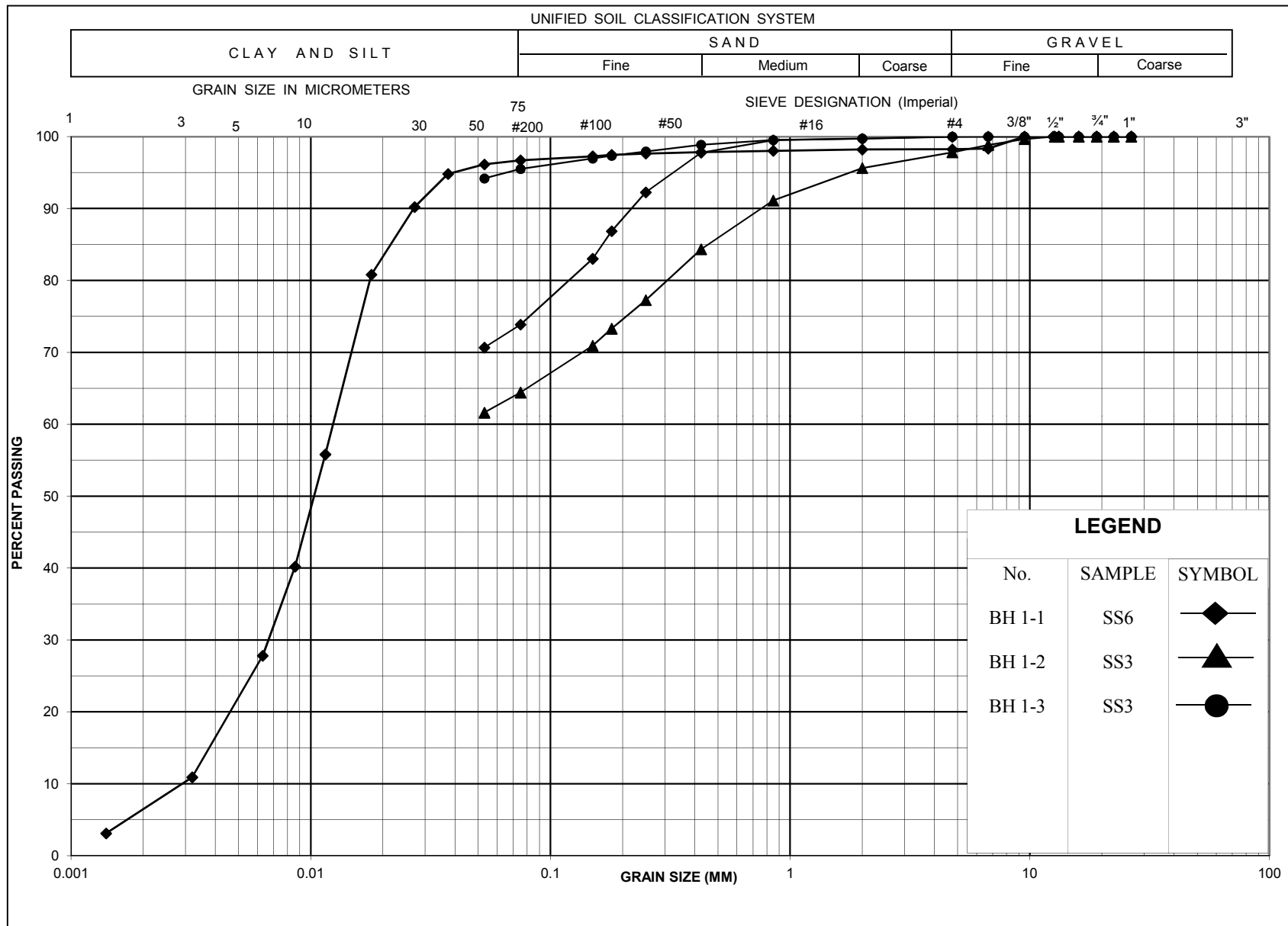
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV/ DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED		+ FIELD VANE		● QUICK TRIAXIAL						× LAB VANE		
318.3	Ground Surface					20	40	60	80	100	10	20	30							
0.0	FILL: SAND AND GRAVEL (SW) some silt, occasional to some blast rock, peat, root and rootlets, frozen (0.3 m), wet, brown, loose -becoming trace silt, trace peat		1	AS											○					
317.6			2	AS								○								
0.8	SILTY SAND (SM) some organics, wet, grey, loose		3	SS	6								○							
316.7			4A	SS	12							○								
1.7	SILT (ML) trace sand, wet, greyish brown, compact		4B	SS	13								○							
			5	VANE					+					○						
315.5	- Interbedded sand seam		6A	SS	8									○						
2.8	SAND AND GRAVEL (SW) wet, brown, loose		6B	SS	9								○							
	-cobble or boulder at 3.66 - 3.81 m -becoming trace silt		7	SS	8								○							
	-cobble or boulder at 4.27-4.58, -becoming very dense		8	SS	11								○							
313.4			9	SS	>50								○							
5.0	Split-Spoon and Auger Refusal on Possible Bedrock END OF BOREHOLE NOTES: 1. This drawing is to be read with the subject report and project numbers as presented above. 2. Interpretation assistance by exp is required before use by others. 3. Groundwater level was measured in open borehole.																			

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MTO_EXP RECORD OF BOREHOLE HWY118_SLOPE INSTABILITY.GPJ ONTARIO MOT.GDT 4/9/13





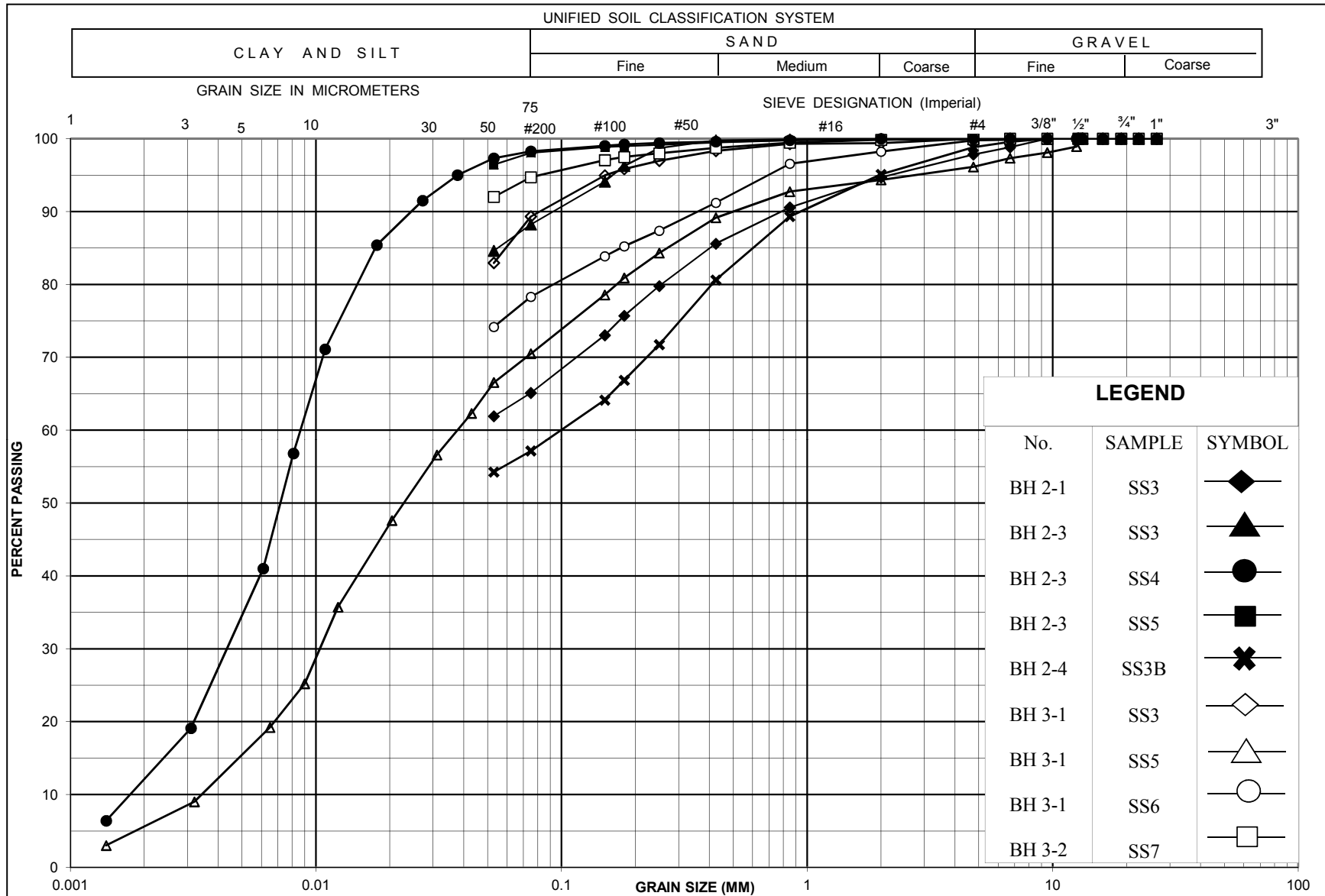


GRAIN SIZE DISTRIBUTION: AREA 1
SILT (ML) to SANDY SILT (ML)
within Hwy Embankment

FIGURE 3

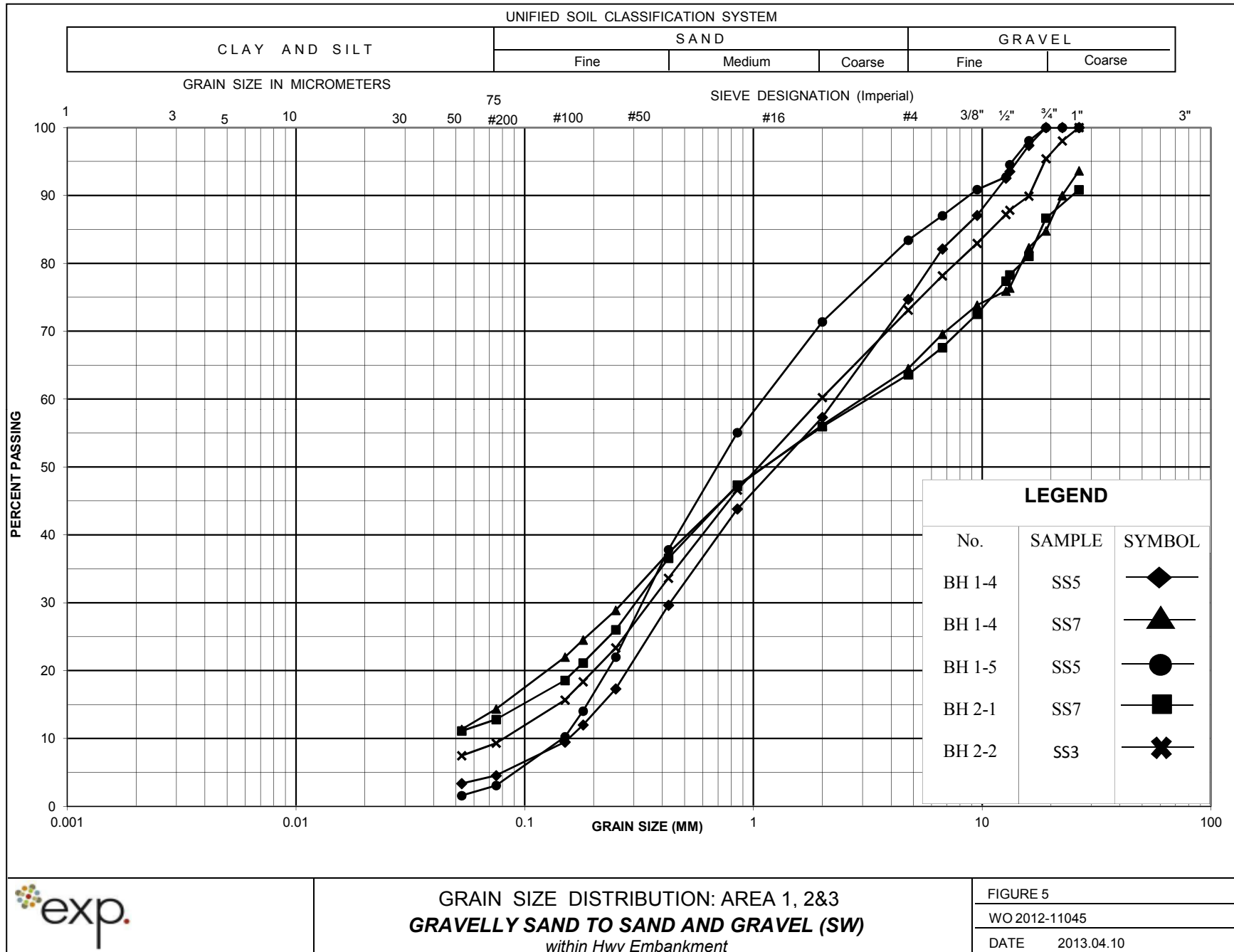
WO 2013-11045

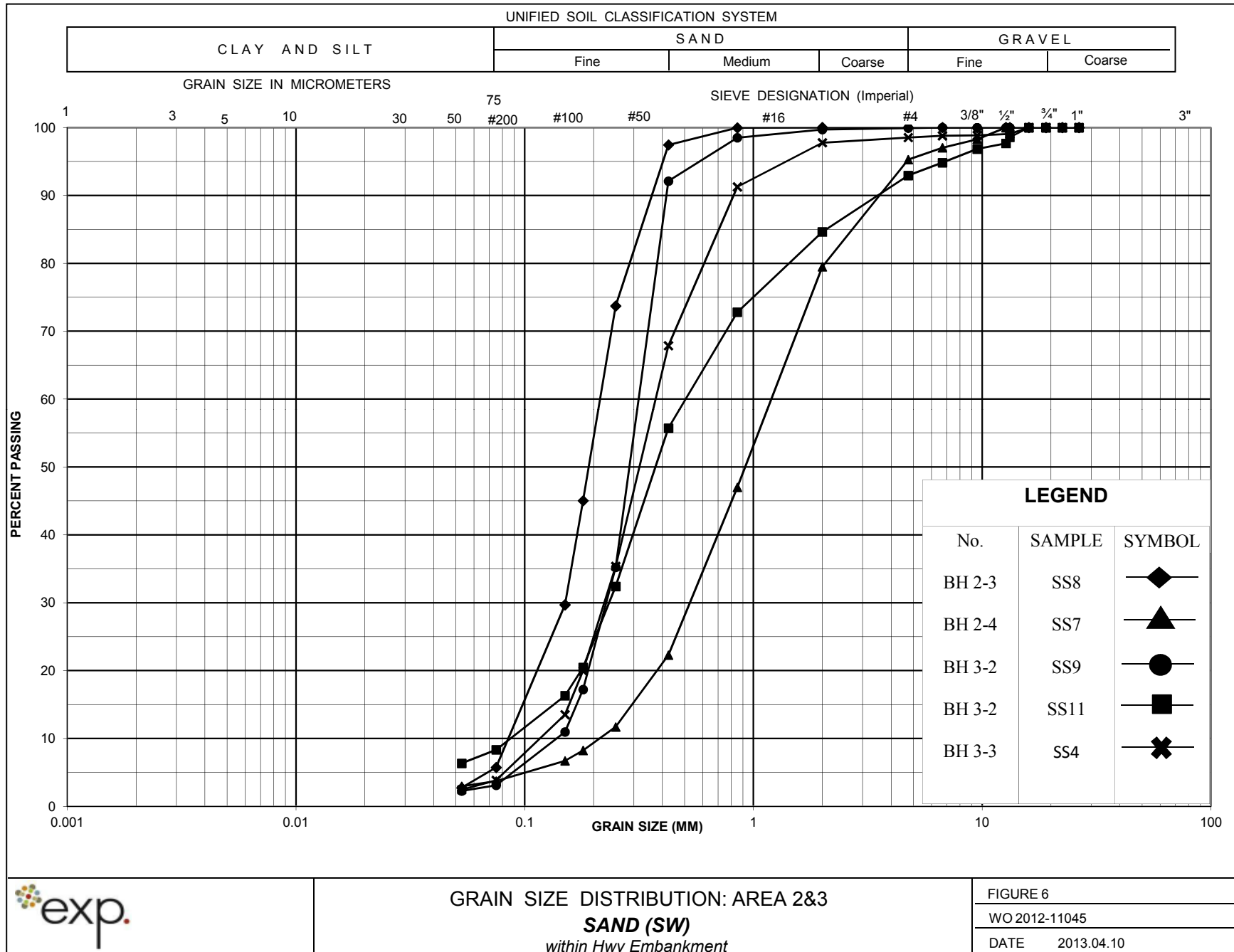
DATE 2013.04.10

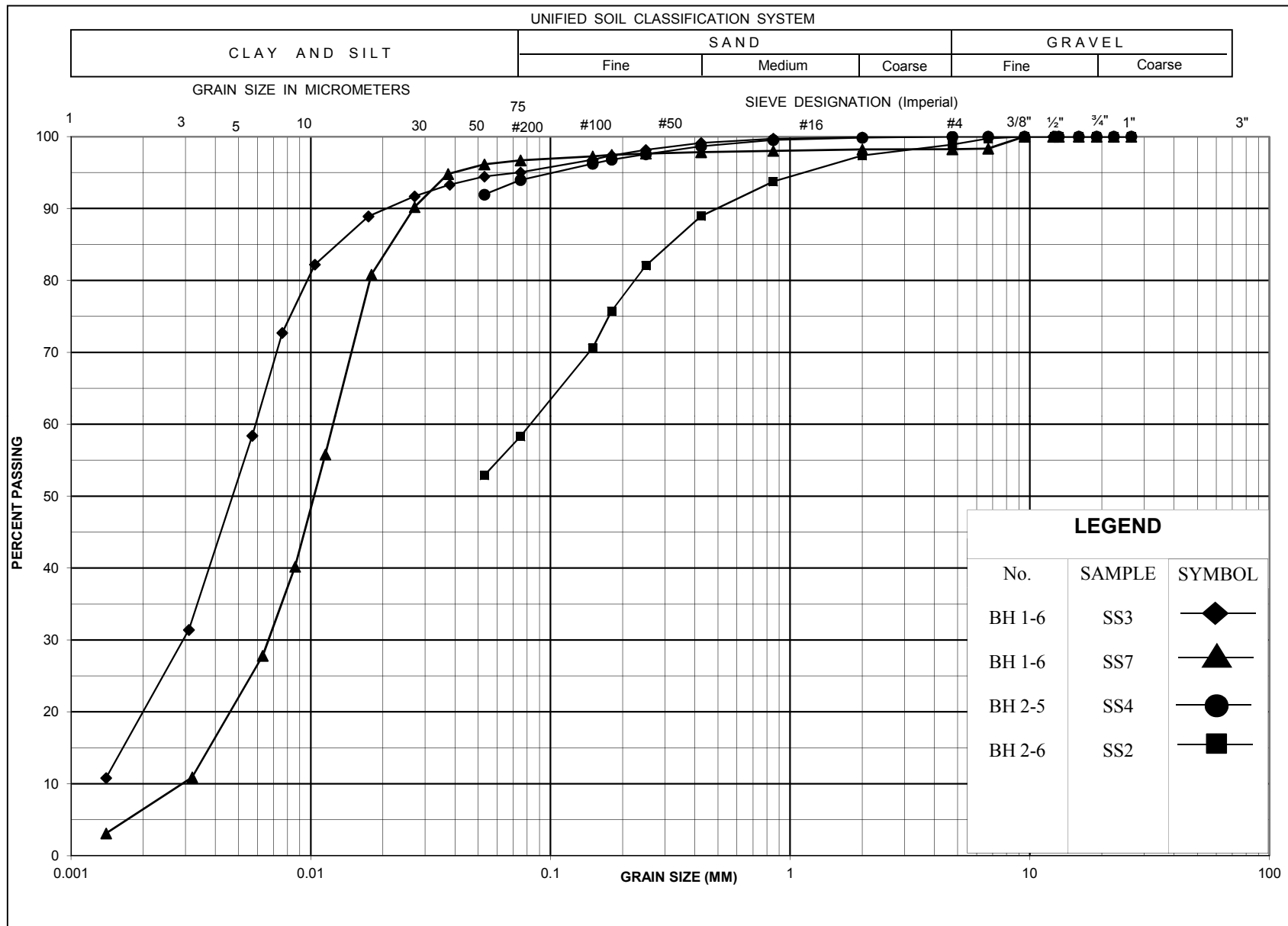


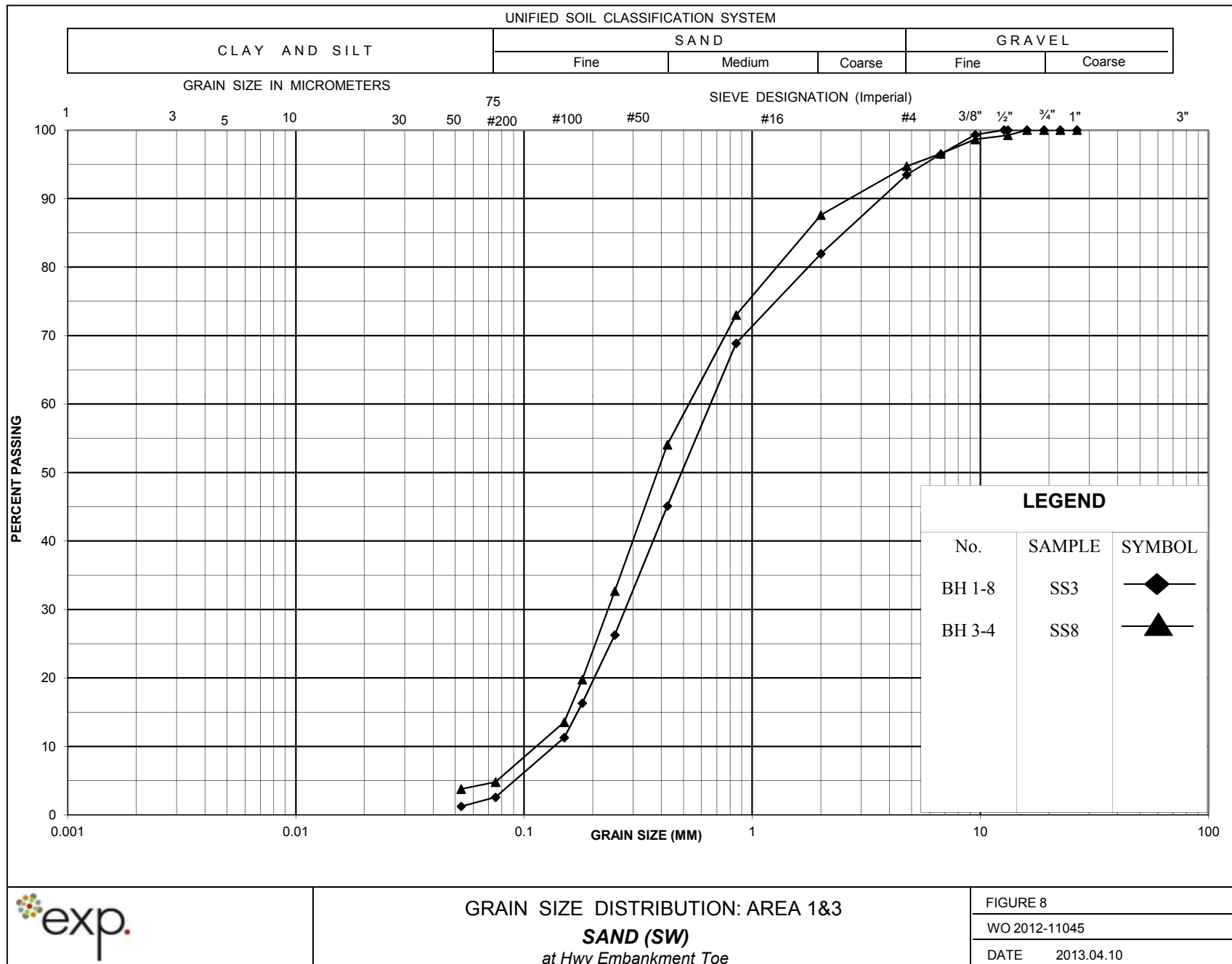
GRAIN SIZE DISTRIBUTION: AREA 2&3
SILT (ML) to SANDY SILT (ML)
within Hwy Embankment

FIGURE 4
 WO 2012-11045
 DATE 2013.04.10

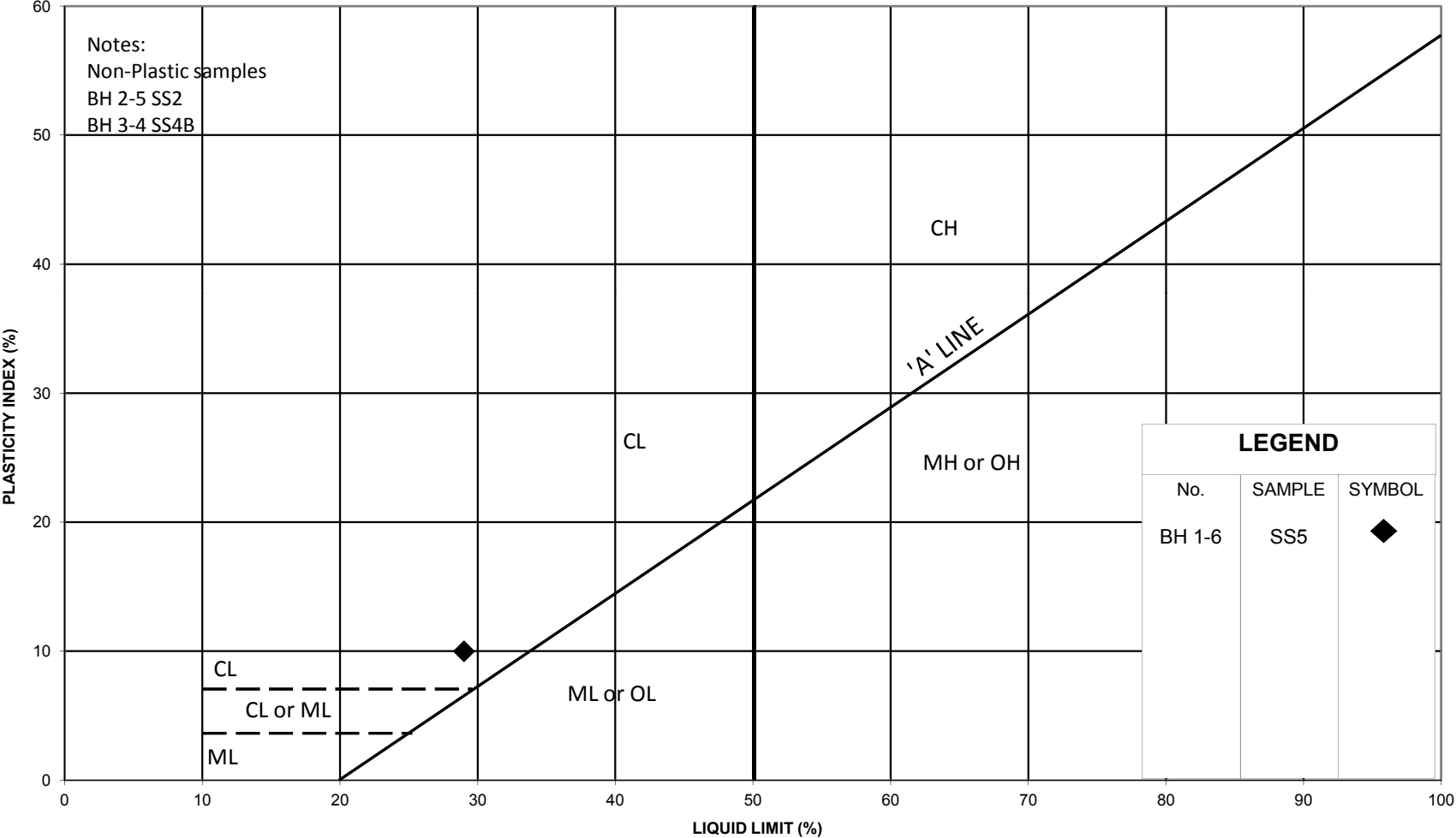








HWY 118, Haliburton ON



PLASTICITY CHART: AREA 1
SILT (CL)
at Hwy Embankment Toe

FIGURE 9
WO 2012-11045
DATE 2013.04.10

ADM-00210117-A0
BH 1-5



ADM-00210117-A0
BH 1-6



ADM-00210117-A0
BH 1-8



ADM-00210117-A0
BH 2-1



ADM-00210117-A0
BH 2-4



ADM-00210117-A0
BH 2-6



April 10, 2013

ADM-00210117-AO
BH 3-1



ADM-00210117-AO
BH 3-2





Appendix F

Comparison of Slope Rehabilitation Alternatives

Comparison of Slope Rehabilitation Alternatives

Rehabilitation Alternative	Advantages	Disadvantages	Recommendation
Slope Flattening and Toe Berm	<ul style="list-style-type: none"> i. Ease of construction. ii. Cheaper than other alternatives. iii. Fill material may be locally available. iv. Potentially minimum traffic disruption. v. Provides erosion protection of slope. vi. Maintenance free after construction. 	<ul style="list-style-type: none"> i. Environmental and social impacts must be assessed. ii. Fill will extend into the lake. iii. Access preparation along edge of water may be required. 	Recommended
Soil Nailing	<ul style="list-style-type: none"> i. Minimum disruption to traffic. ii. Less costly than other alternatives except slope flattening. iii. Ability to accommodate challenging site conditions. iv. Spacing and length of nails may be optimized based on slope movement mechanism. v. Flexible facing allows slope vegetation to redevelop following rehabilitation. vi. Allows existing steep slopes to remain. 	<ul style="list-style-type: none"> i. Nail installation may require access to the toe of slope. ii. Use of flexible facing may increase number of nails required to stabilize existing slope. iii. Drilling into strong granitic bedrock may be difficult and time-consuming. iv. Not effective for deep-seated slope movement. 	Feasible
Reinforced Soil Systems (RSS)	<ul style="list-style-type: none"> i. Local experience is available. ii. Shallow instability may be prevented. iii. Encroachment into lake is not required. 	<ul style="list-style-type: none"> i. Requires deep excavation and possibly dewatering to construct. ii. A robust roadway protection system will be needed to maintain highway traffic. iii. Risk exists if slope movement mechanism is developing at soil-rock interface. iv. May require replacement of existing utilities. 	Not Recommended
Light-Weight Fill	<ul style="list-style-type: none"> i. Local experience is available. ii. Reduces potential for embankment sliding along sloping rock surface. iii. Encroachment into lake is not required. 	<ul style="list-style-type: none"> i. Requires deep excavation. ii. A robust roadway protection system will be needed to maintain highway traffic. iii. Risk exists if slope movement mechanism is developing at soil-rock interface. iv. Minimum soil cover is required. v. May require replacement of existing utilities. 	Not Recommended

Rehabilitation Alternative	Advantages	Disadvantages	Recommendation
Caisson Wall	<ul style="list-style-type: none"> i. Minimum excavation required. ii. Minimizes creep movement due to wall rigidity if socketed into bedrock. iii. Allows existing steep slopes to remain. 	<ul style="list-style-type: none"> i. More expensive than other alternatives. ii. May require full roadway closure. iii. Caisson installation through cohesionless soils under water table will require steel liner to maintain borehole stability. 	Not Recommended
Micropiles	<ul style="list-style-type: none"> i. Minimum excavation required. ii. Allows existing steep slope to remain. iii. Local experience is available. 	<ul style="list-style-type: none"> i. Micropiles are structurally flexible. ii. A large quantity of micropiles may be required to achieve slope stabilization and associated cost may be prohibitively high. iii. Installation of micropiles through cohesionless soils under water table will require steel liner to maintain borehole stability. iv. Socketing micropiles into bedrock to achieve toe fixity will be difficult and slow. 	Not Recommended
Permeation grouting	<ul style="list-style-type: none"> i. Soil strength will be improved. ii. Allows existing steep slope to remain. 	<ul style="list-style-type: none"> i. Permeation grouting in fine-grained soil matrix (i.e. silt) will likely not be successful. ii. May induce pavement heave and damage. iii. Grout may leak into lake through coarse granular soils and bedrock fracture zones. iv. Degree of soil improvement will be uncertain. v. Risk exists if slope moves at soil-rock interface. 	Not Recommended

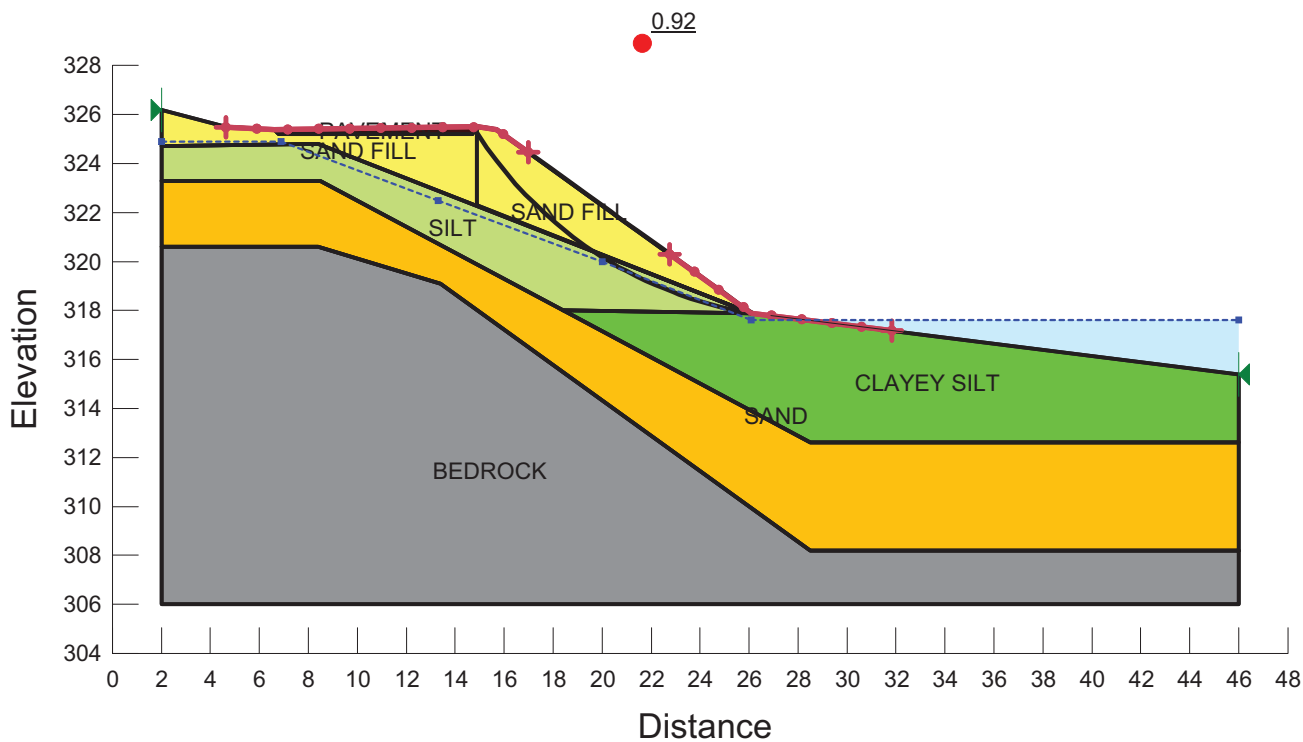


Appendix G

Select Stability Analysis Runs

FIGURE G1 (Effective Stress Analysis)

Section C-C - Existing Conditions
Method of Analysis: Morgenstern-Price
Factor of Safety = 0.92



SAND FILL
Unit Weight = 20 kN/m³
Friction Angle = 32 °
Cohesion = 0 kPa

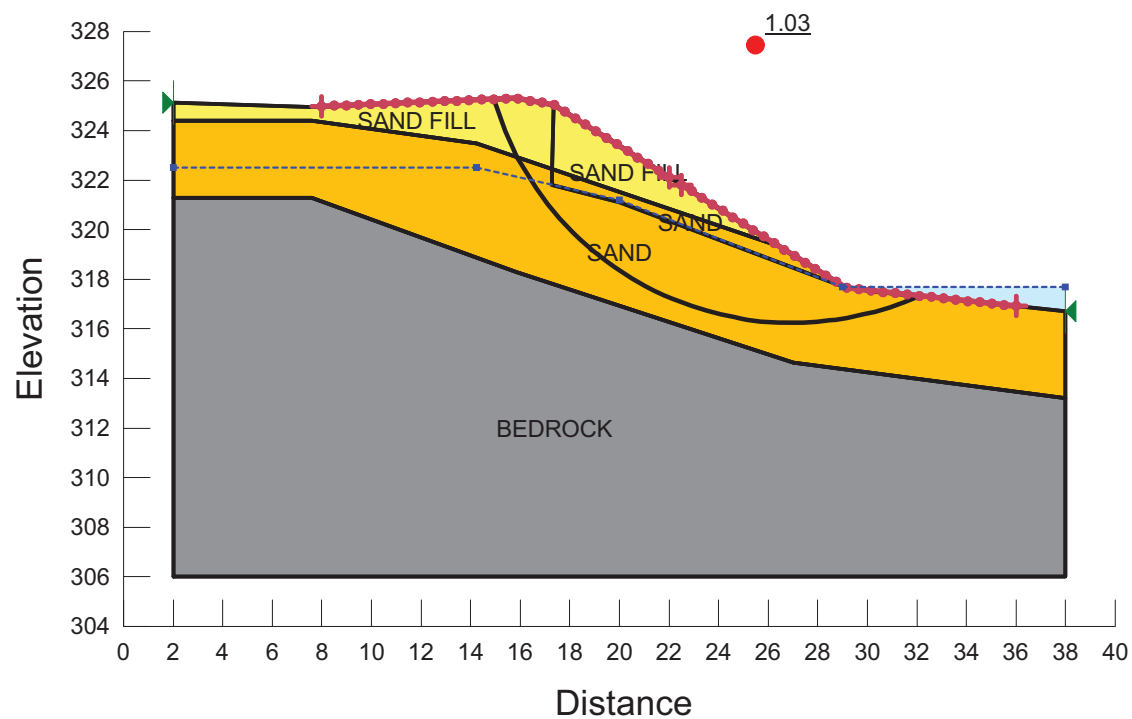
SILT
Unit Weight = 18 kN/m³
Friction Angle = 29 °
Cohesion = 0 kPa

CLAYEY SILT
Unit Weight = 18 kN/m³
Friction Angle = 28 °
Cohesion = 2 kPa

SAND
Unit Weight = 19 kN/m³
Friction Angle = 32 °
Cohesion = 0 kPa

FIGURE G2 (Effective Stress Analysis)

Section E-E - Existing Conditions
Method of Analysis: Morgenstern-Price
Factor of Safety = 1.03



SAND FILL
Unit Weight = 20 kN/m³
Friction Angle = 32 °
Cohesion = 0 kPa

SAND
Unit Weight = 19 kN/m³
Friction Angle = 32 °
Cohesion = 0 kPa

FIGURE G3 (Effective Stress Analysis)

Section F-F - Existing Conditions
Method of Analysis: Morgenstern-Price
Factor of Safety = 0.95

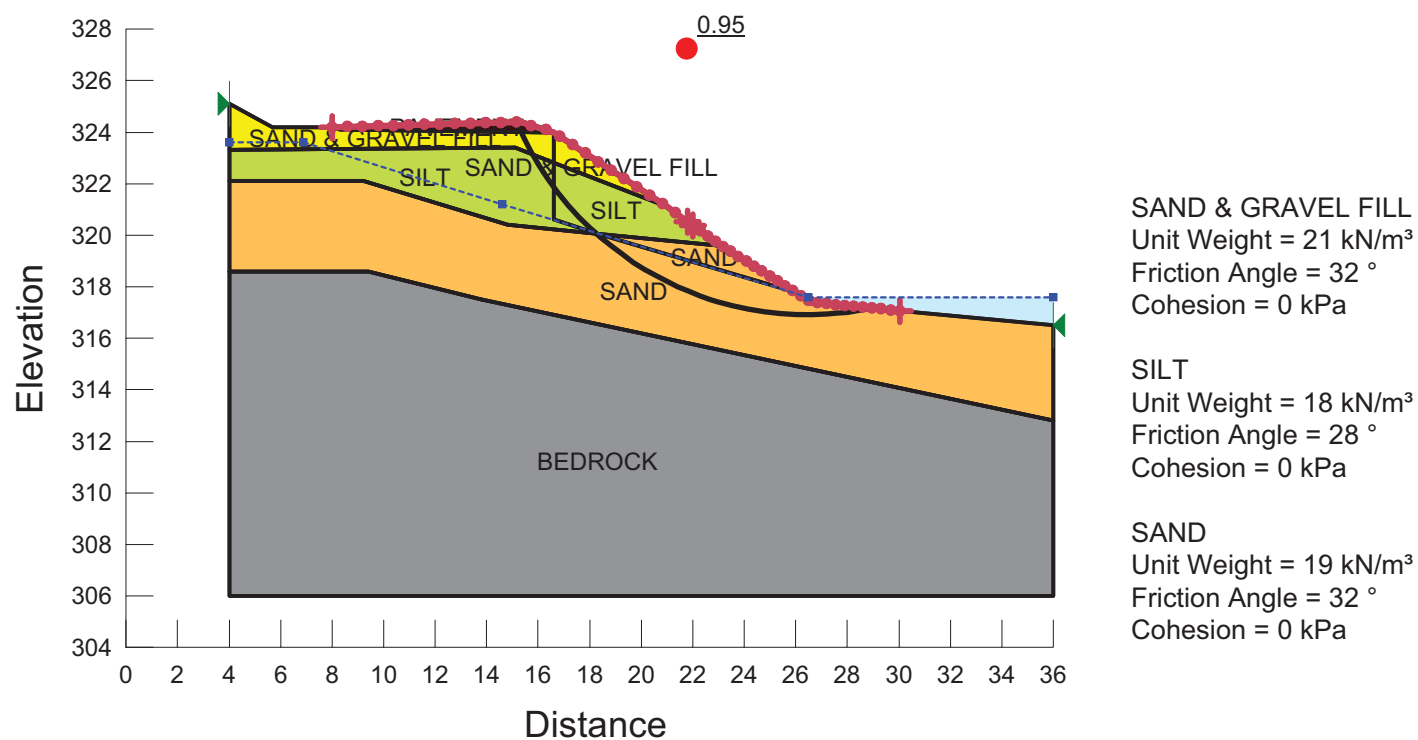


FIGURE G4 (Effective Stress Analysis)

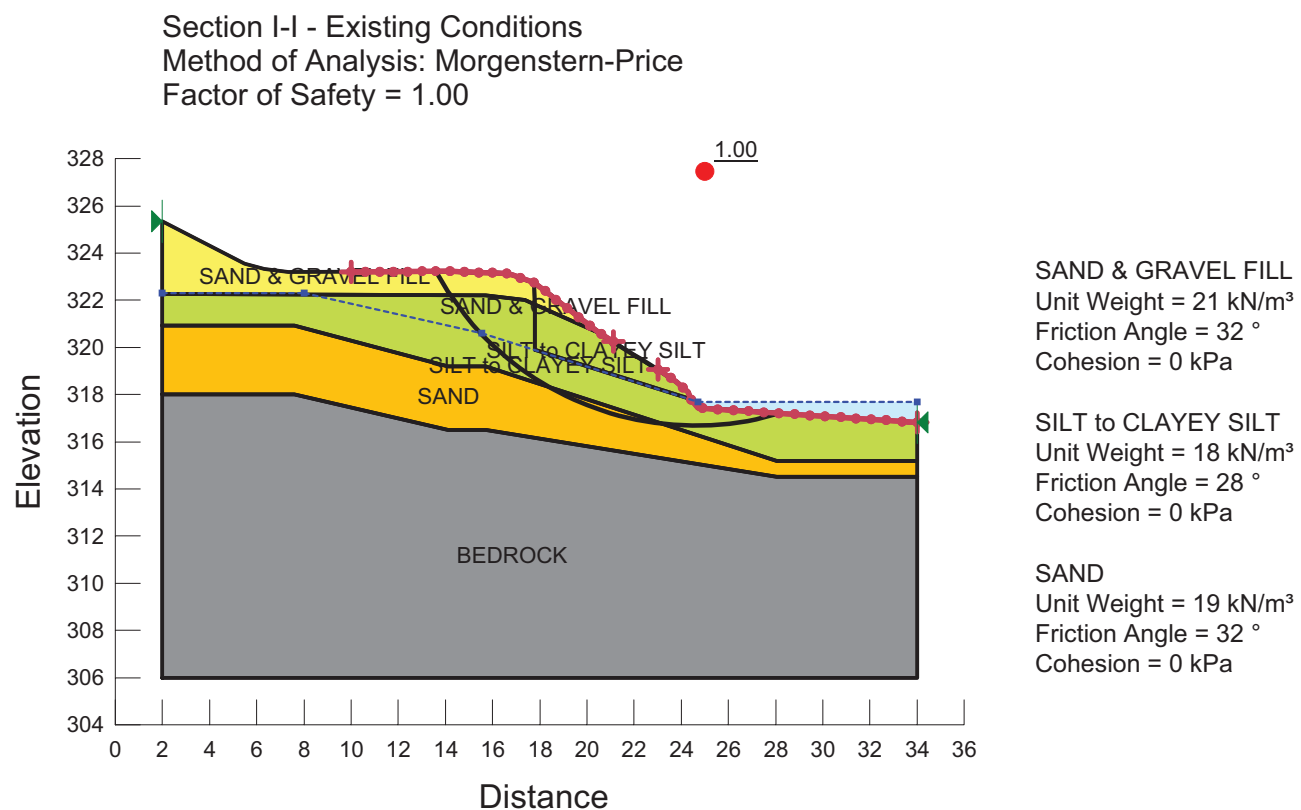


FIGURE G5 (Effective Stress Analysis)

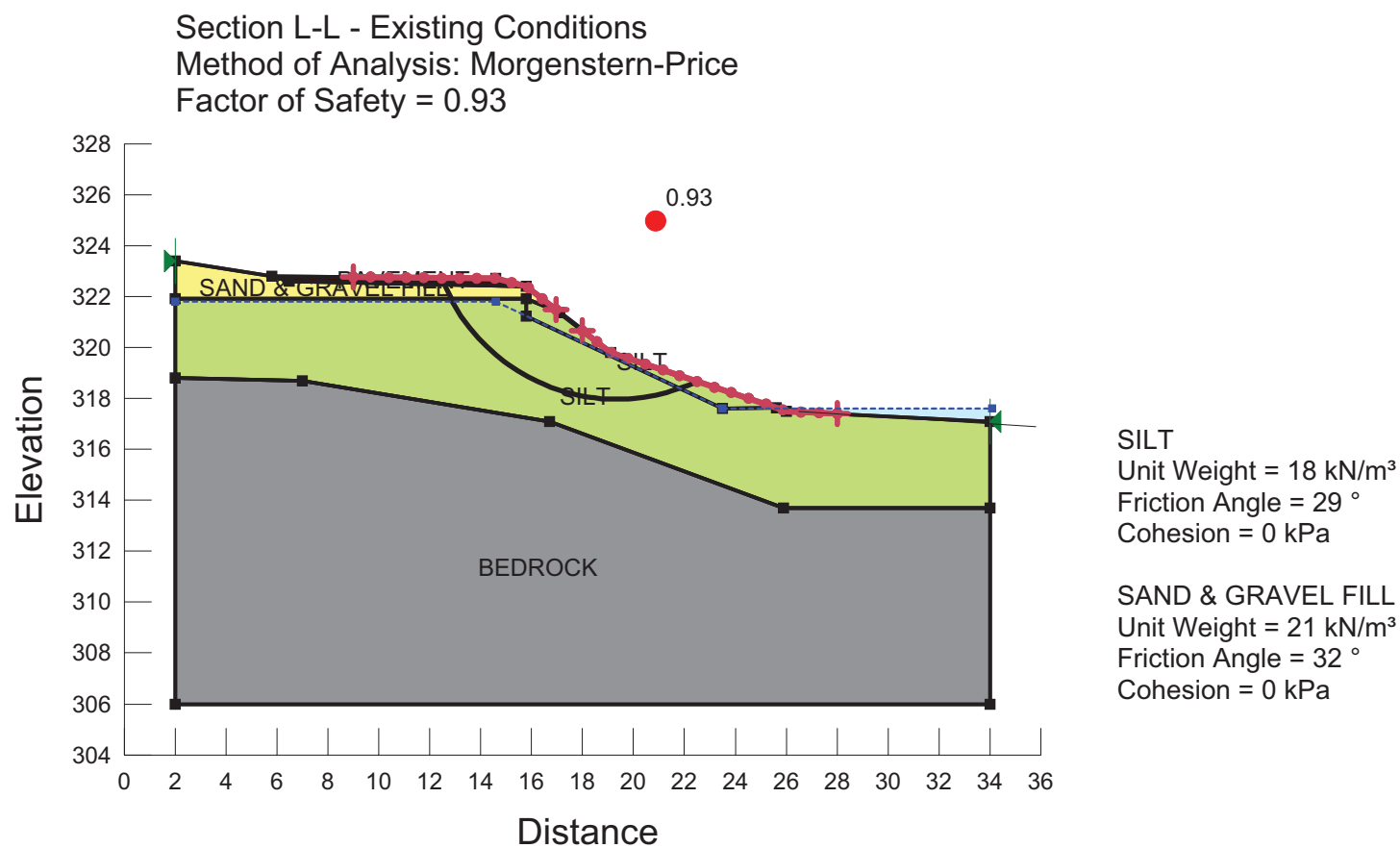
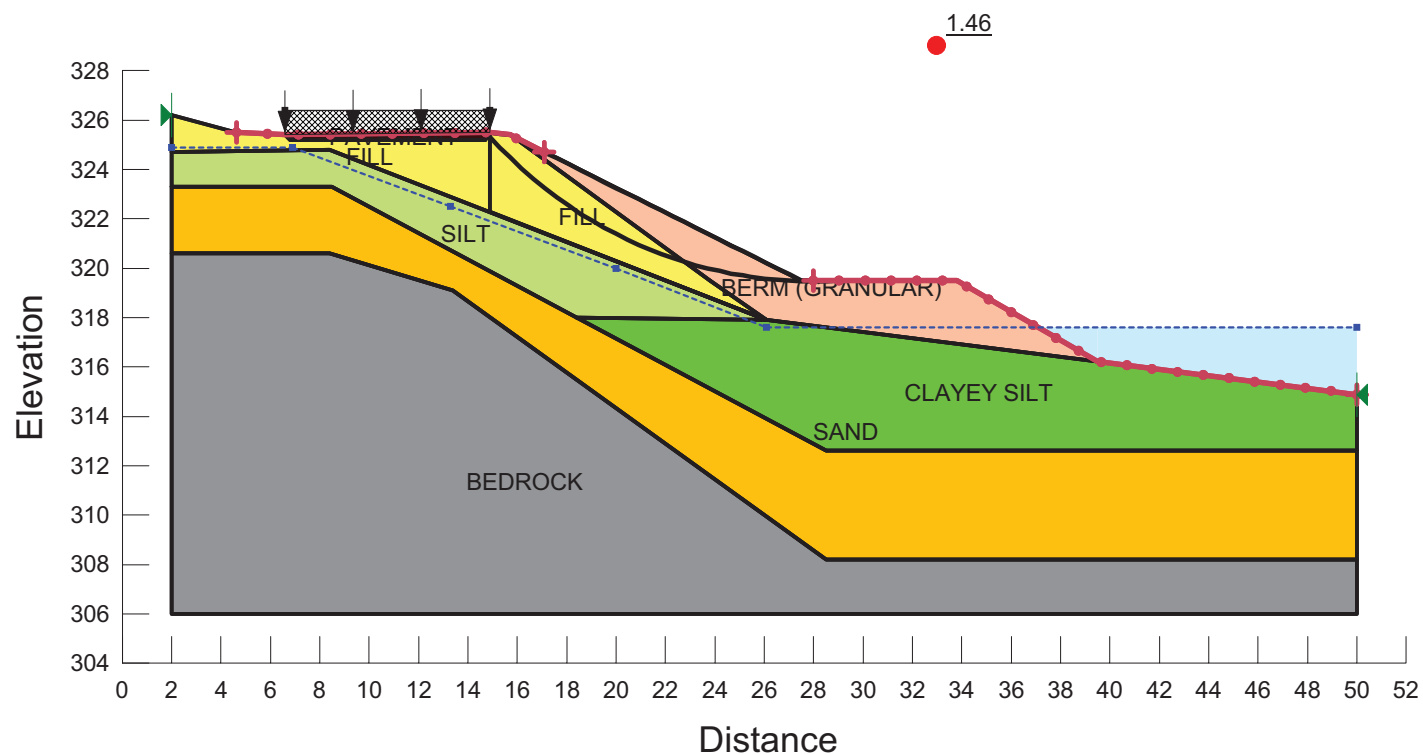


FIGURE G6 (Effective Stress Analysis)

Section C-C - Slope Flattening (Sand and Gravel)
Method of Analysis: Morgenstern-Price
Factor of Safety = 1.46



FILL
Unit Weight = 20 kN/m³
Friction Angle = 32 °
Cohesion = 0 kPa

SILT
Unit Weight = 18 kN/m³
Friction Angle = 29 °
Cohesion = 0 kPa

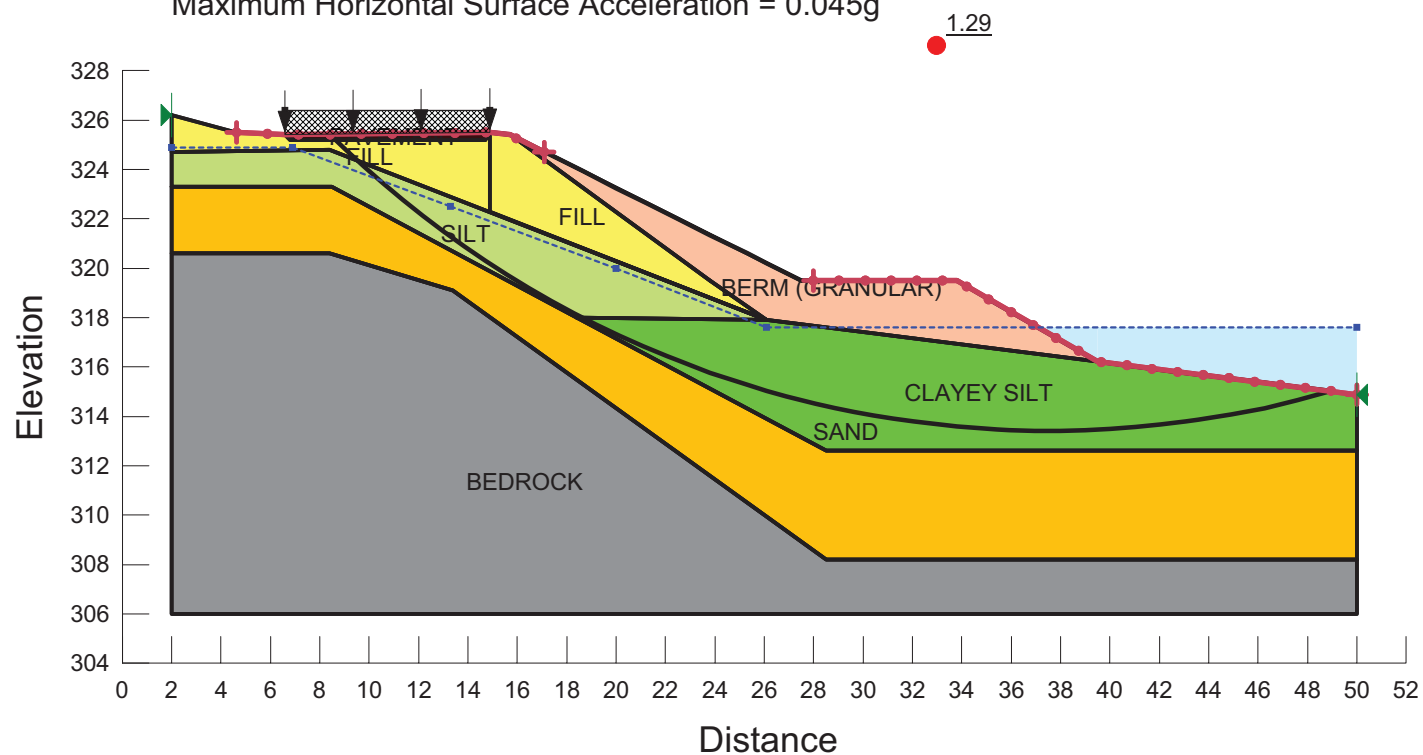
CLAYEY SILT
Unit Weight = 18 kN/m³
Friction Angle = 28 °
Cohesion = 2 kPa

SAND
Unit Weight = 19 kN/m³
Friction Angle = 32 °
Cohesion = 0 kPa

BERM (GRANULAR)
Unit Weight = 20 kN/m³
Friction Angle = 35 °
Cohesion = 0 kPa

FIGURE G7 (Effective Stress Analysis)

Section C-C - Slope Flatening (Sand and Gravel)
Method of Analysis: Morgenstern-Price
Factor of Safety = 1.29
Maximum Horizontal Surface Acceleration = 0.045g



FILL
Unit Weight = 20 kN/m³
Friction Angle = 32 °
Cohesion = 0 kPa

SILT
Unit Weight = 18 kN/m³
Friction Angle = 29 °
Cohesion = 0 kPa

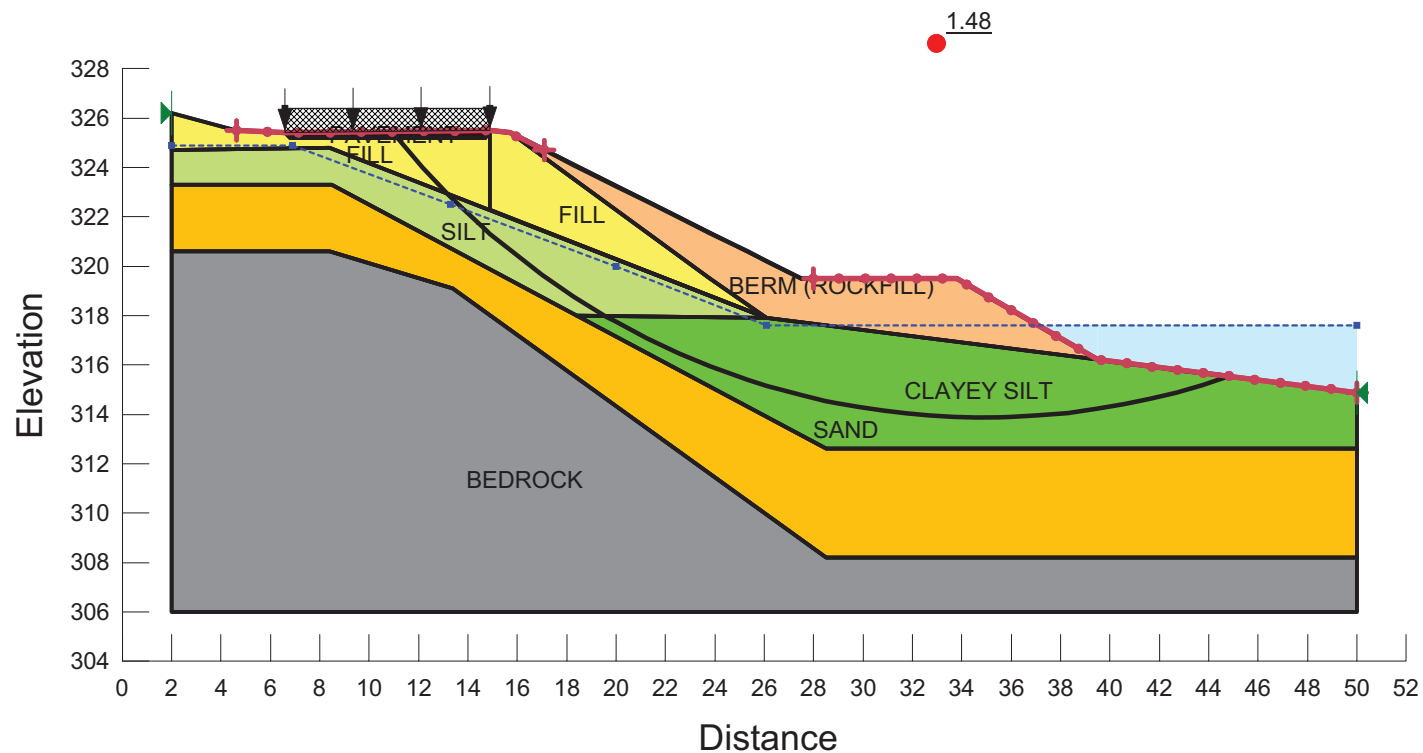
CLAYEY SILT
Unit Weight = 18 kN/m³
Friction Angle = 28 °
Cohesion = 2 kPa

SAND
Unit Weight = 19 kN/m³
Friction Angle = 32 °
Cohesion = 0 kPa

BERM (GRANULAR)
Unit Weight = 20 kN/m³
Friction Angle = 35 °
Cohesion = 0 kPa

FIGURE G8 (Effective Stress Analysis)

Section C-C - Slope Flattening (Rock Fill)
Method of Analysis: Morgenstern-Price
Factor of Safety = 1.48



FILL
Unit Weight = 20 kN/m³
Friction Angle = 32 °
Cohesion = 0 kPa

SILT
Unit Weight = 18 kN/m³
Friction Angle = 29 °
Cohesion = 0 kPa

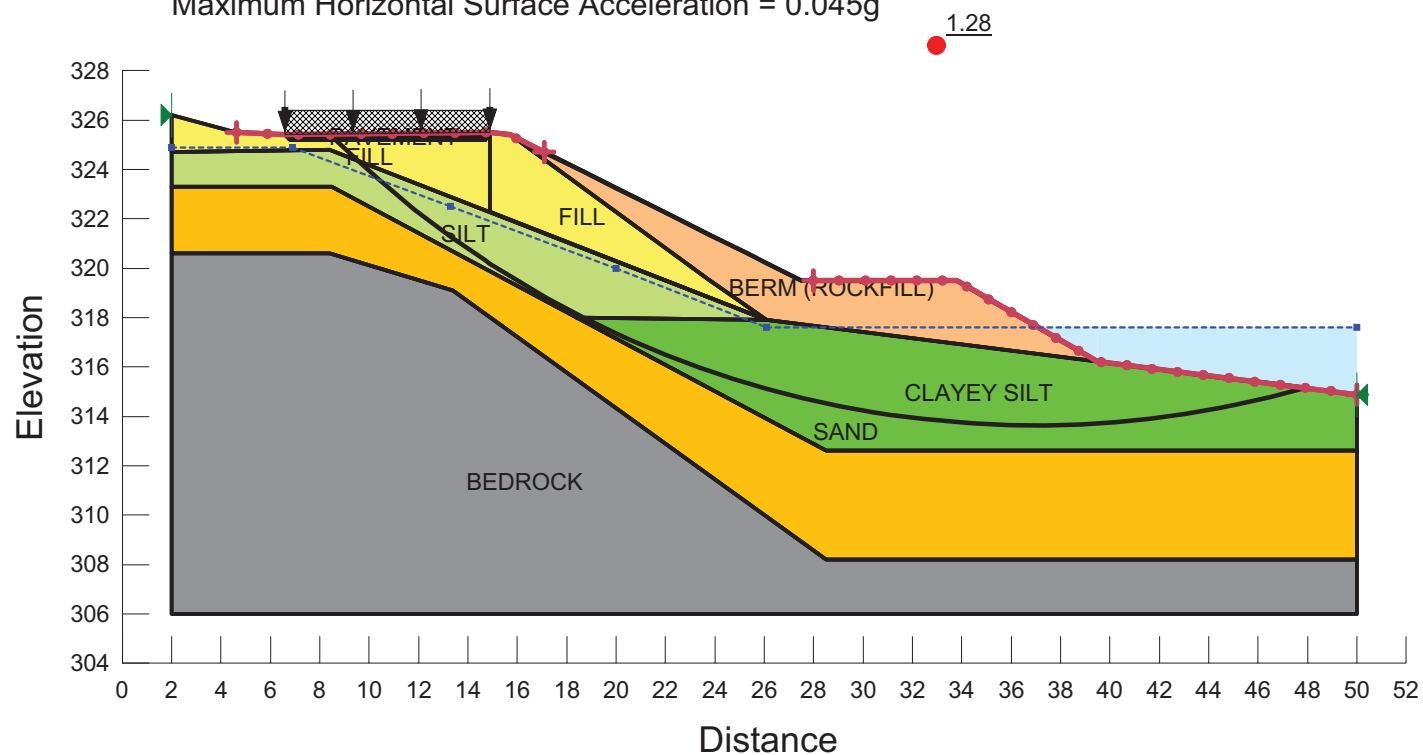
CLAYEY SILT
Unit Weight = 18 kN/m³
Friction Angle = 28 °
Cohesion = 2 kPa

SAND
Unit Weight = 19 kN/m³
Friction Angle = 32 °
Cohesion = 0 kPa

BERM (ROCKFILL)
Unit Weight = 19 kN/m³
Friction Angle = 42 °
Cohesion = 0 kPa

FIGURE G9 (Effective Stress Analysis)

Section C-C - Slope Flatening (Rock Fill)
Method of Analysis: Morgenstern-Price
Factor of Safety = 1.28
Maximum Horizontal Surface Acceleration = 0.045g



FILL
Unit Weight = 20 kN/m³
Friction Angle = 32 °
Cohesion = 0 kPa

SILT
Unit Weight = 18 kN/m³
Friction Angle = 29 °
Cohesion = 0 kPa

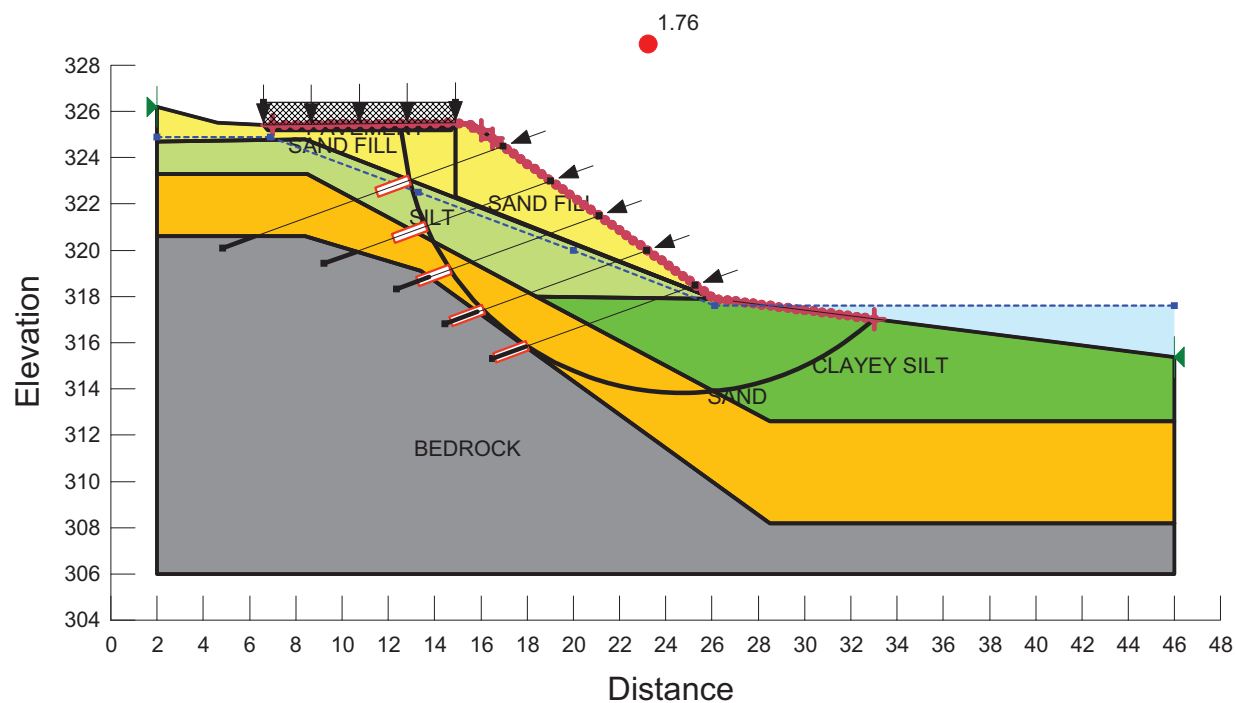
CLAYEY SILT
Unit Weight = 18 kN/m³
Friction Angle = 28 °
Cohesion = 2 kPa

SAND
Unit Weight = 19 kN/m³
Friction Angle = 32 °
Cohesion = 0 kPa

BERM (ROCKFILL)
Unit Weight = 19 kN/m³
Friction Angle = 42 °
Cohesion = 0 kPa

FIGURE G10 (Effective Stress Analysis)

Section C-C - Improved using Soil Nails
Method of Analysis: Morgenstern-Price
Factor of Safety = 1.76



SAND FILL
Unit Weight = 20 kN/m³
Friction Angle = 32 °
Cohesion = 0 kPa

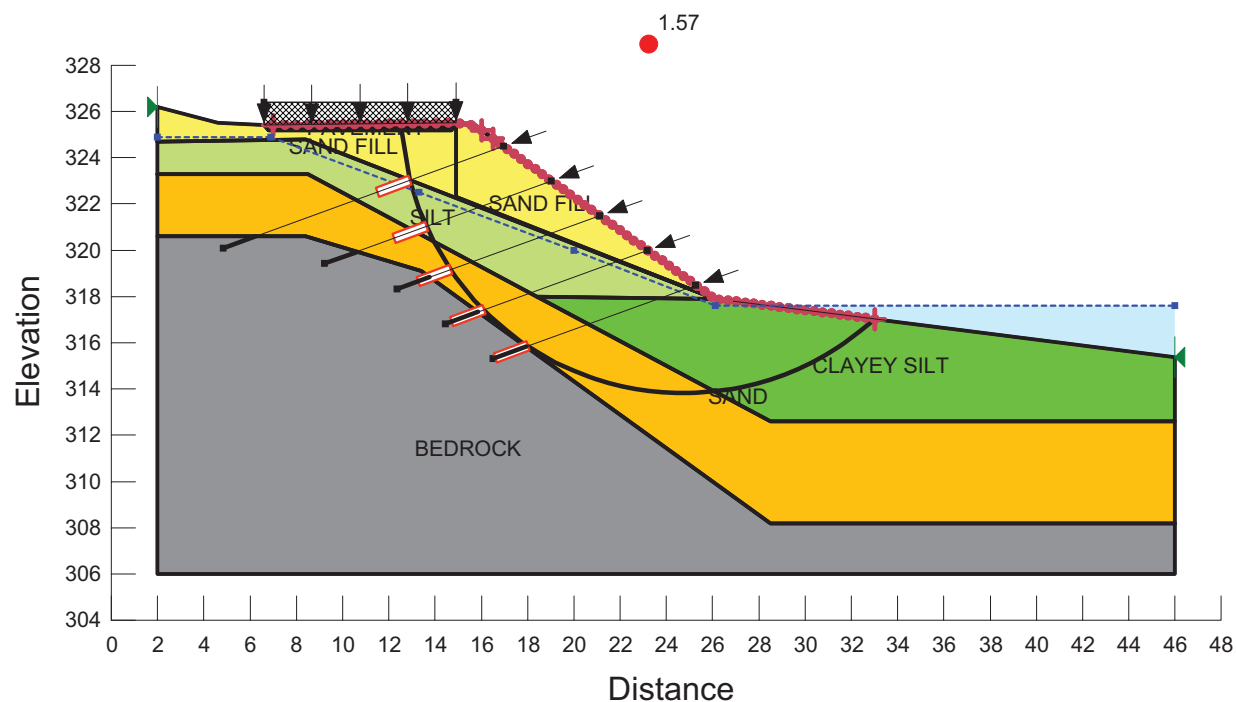
SILT
Unit Weight = 18 kN/m³
Friction Angle = 29 °
Cohesion = 0 kPa

CLAYEY SILT
Unit Weight = 18 kN/m³
Friction Angle = 28 °
Cohesion = 2 kPa

SAND
Unit Weight = 19 kN/m³
Friction Angle = 32 °
Cohesion = 0 kPa

FIGURE G11 (Effective Stress Analysis)

Section C-C - Improved using Soil Nails
Method of Analysis: Morgenstern-Price
Factor of Safety = 1.57
Maximum Horizontal Surface Acceleration = 0.045g



SAND FILL
Unit Weight = 20 kN/m³
Friction Angle = 32 °
Cohesion = 0 kPa

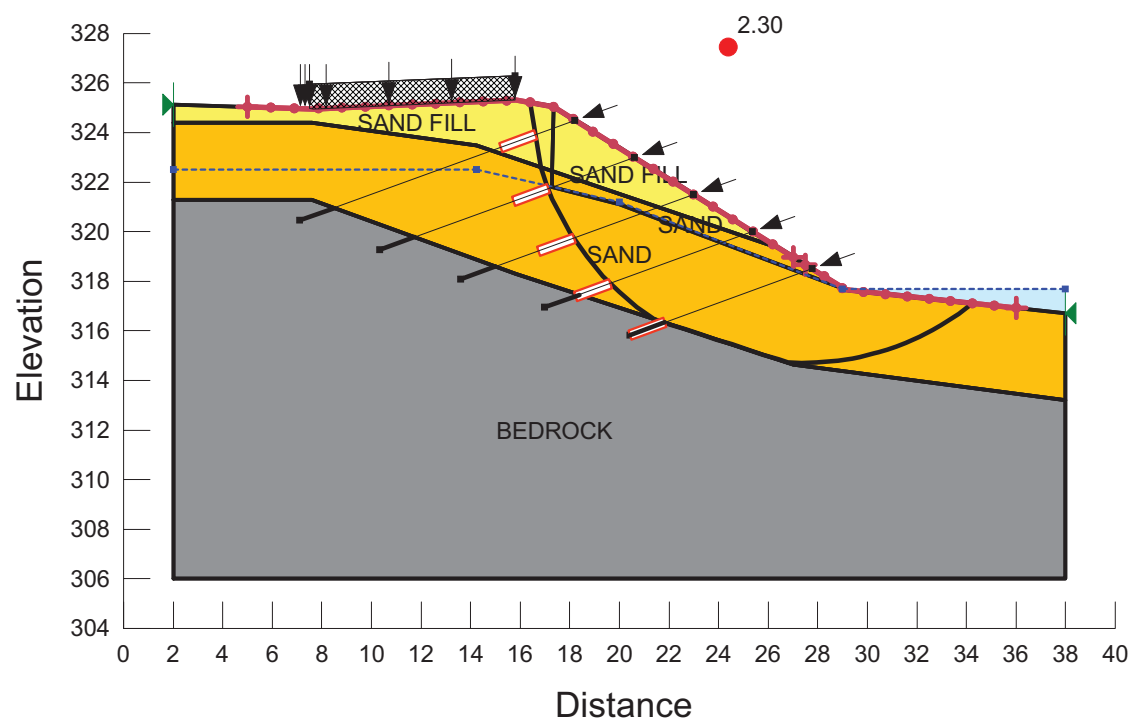
SILT
Unit Weight = 18 kN/m³
Friction Angle = 29 °
Cohesion = 0 kPa

CLAYEY SILT
Unit Weight = 18 kN/m³
Friction Angle = 28 °
Cohesion = 2 kPa

SAND
Unit Weight = 19 kN/m³
Friction Angle = 32 °
Cohesion = 0 kPa

FIGURE G12 (Effective Stress Analysis)

Section E-E - Improved using Soil Nails
Method of Analysis: Morgenstern-Price
Factor of Safety = 2.30



SAND FILL
Unit Weight = 20 kN/m³
Friction Angle = 32 °
Cohesion = 0 kPa

SAND
Unit Weight = 19 kN/m³
Friction Angle = 32 °
Cohesion = 0 kPa

FIGURE G13 (Effective Stress Analysis)

Section E-E - Improved using Soil Nails
Method of Analysis: Morgenstern-Price
Factor of Safety = 1.98
Maximum Horizontal Surface Acceleration = 0.045g

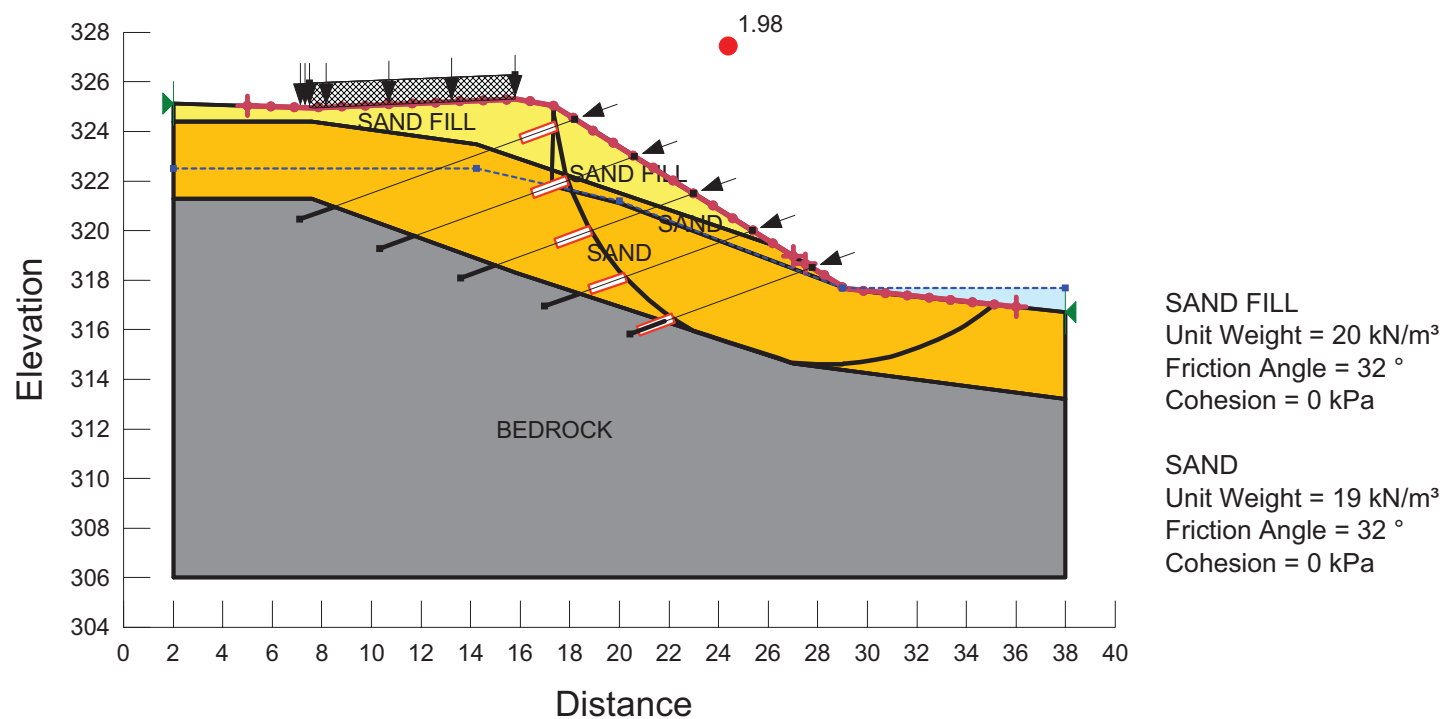
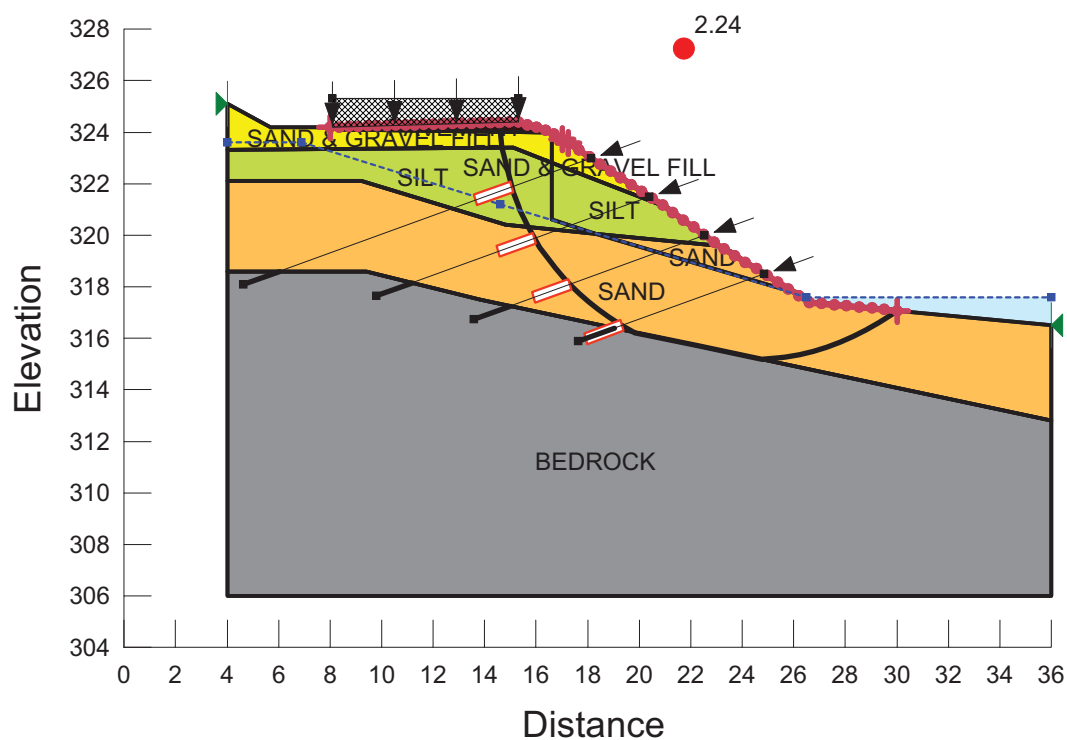


FIGURE G14 (Effective Stress Analysis)

Section F-F - Improved using Soil Nails
Method of Analysis: Morgenstern-Price
Factor of Safety = 2.24



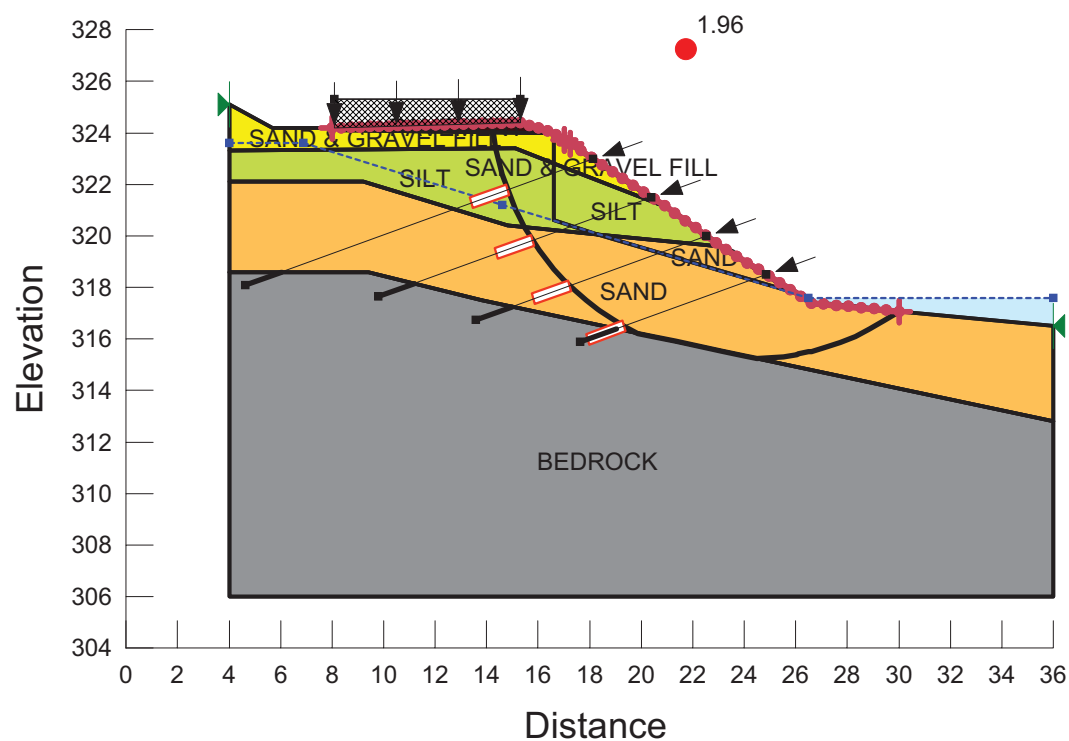
SAND & GRAVEL FILL
Unit Weight = 21 kN/m³
Friction Angle = 32 °
Cohesion = 0 kPa

SILT
Unit Weight = 18 kN/m³
Friction Angle = 28 °
Cohesion = 0 kPa

SAND
Unit Weight = 19 kN/m³
Friction Angle = 32 °
Cohesion = 0 kPa

FIGURE G15 (Effective Stress Analysis)

Section F-F - Improved using Soil Nails
Method of Analysis: Morgenstern-Price
Factor of Safety = 1.96
Maximum Horizontal Surface Acceleration = 0.045g



SAND & GRAVEL FILL
Unit Weight = 21 kN/m³
Friction Angle = 32 °
Cohesion = 0 kPa

SILT
Unit Weight = 18 kN/m³
Friction Angle = 28 °
Cohesion = 0 kPa

SAND
Unit Weight = 19 kN/m³
Friction Angle = 32 °
Cohesion = 0 kPa

FIGURE G16 (Effective Stress Analysis)

Section I-I - Improved using Soil Nails
Method of Analysis: Morgenstern-Price
Factor of Safety = 1.93

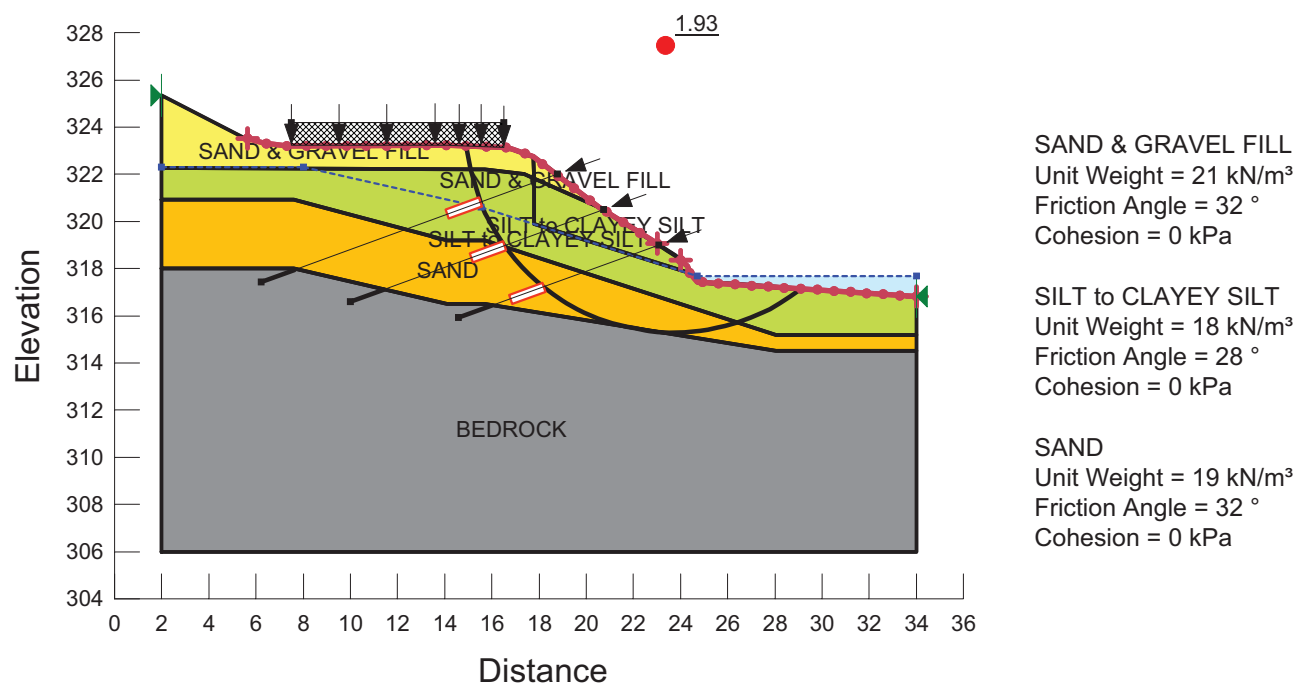
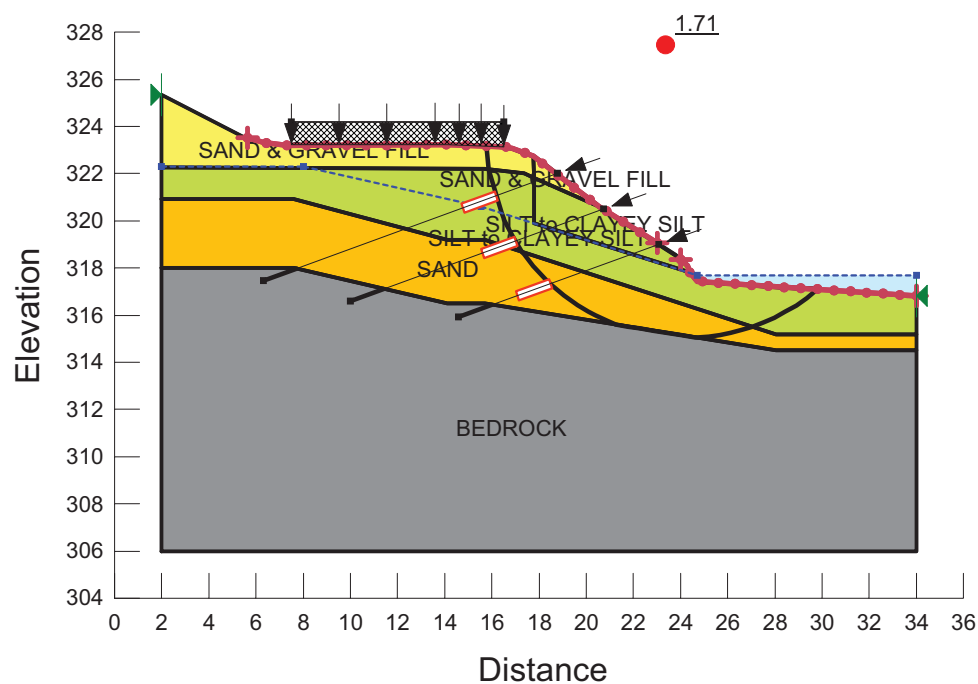


FIGURE G17 (Effective Stress Analysis)

Section I-I - Improved using Soil Nails
Method of Analysis: Morgenstern-Price
Factor of Safety = 1.71
Maximum Horizontal Surface Acceleration = 0.045g



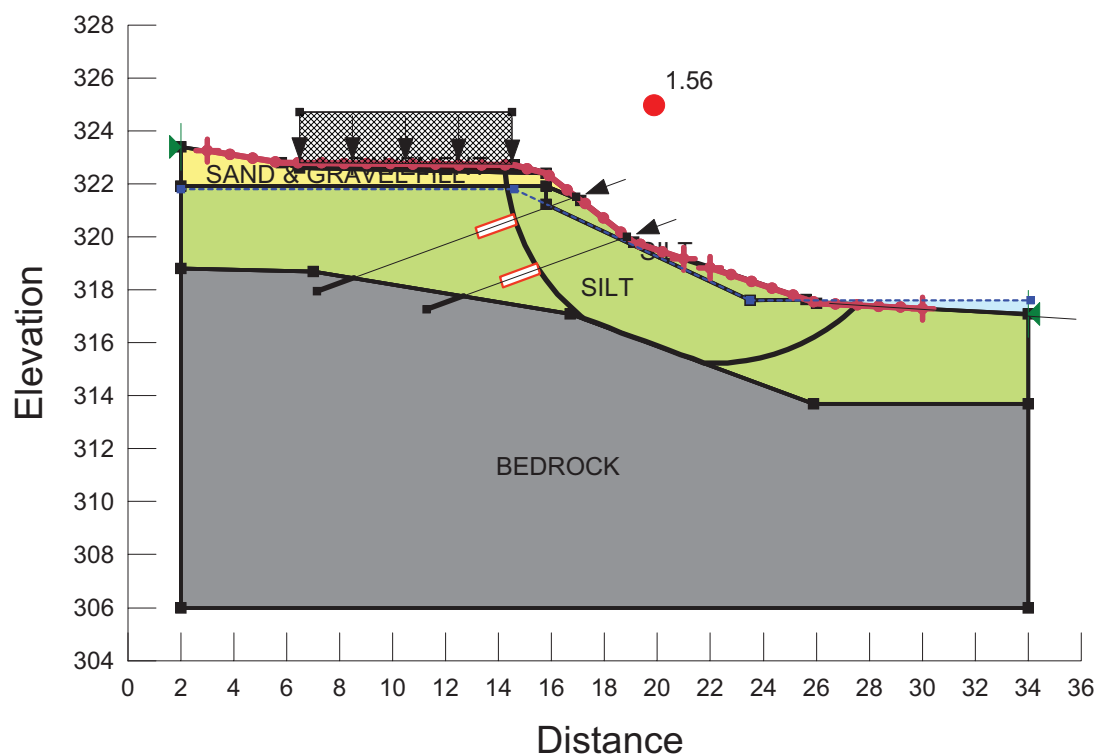
SAND & GRAVEL FILL
Unit Weight = 21 kN/m³
Friction Angle = 32 °
Cohesion = 0 kPa

SILT to CLAYEY SILT
Unit Weight = 18 kN/m³
Friction Angle = 28 °
Cohesion = 0 kPa

SAND
Unit Weight = 19 kN/m³
Friction Angle = 32 °
Cohesion = 0 kPa

FIGURE G18 (Effective Stress Analysis)

Section L-L - Improved using Soil Nails
Method of Analysis: Morgenstern-Price
Factor of Safety = 1.56

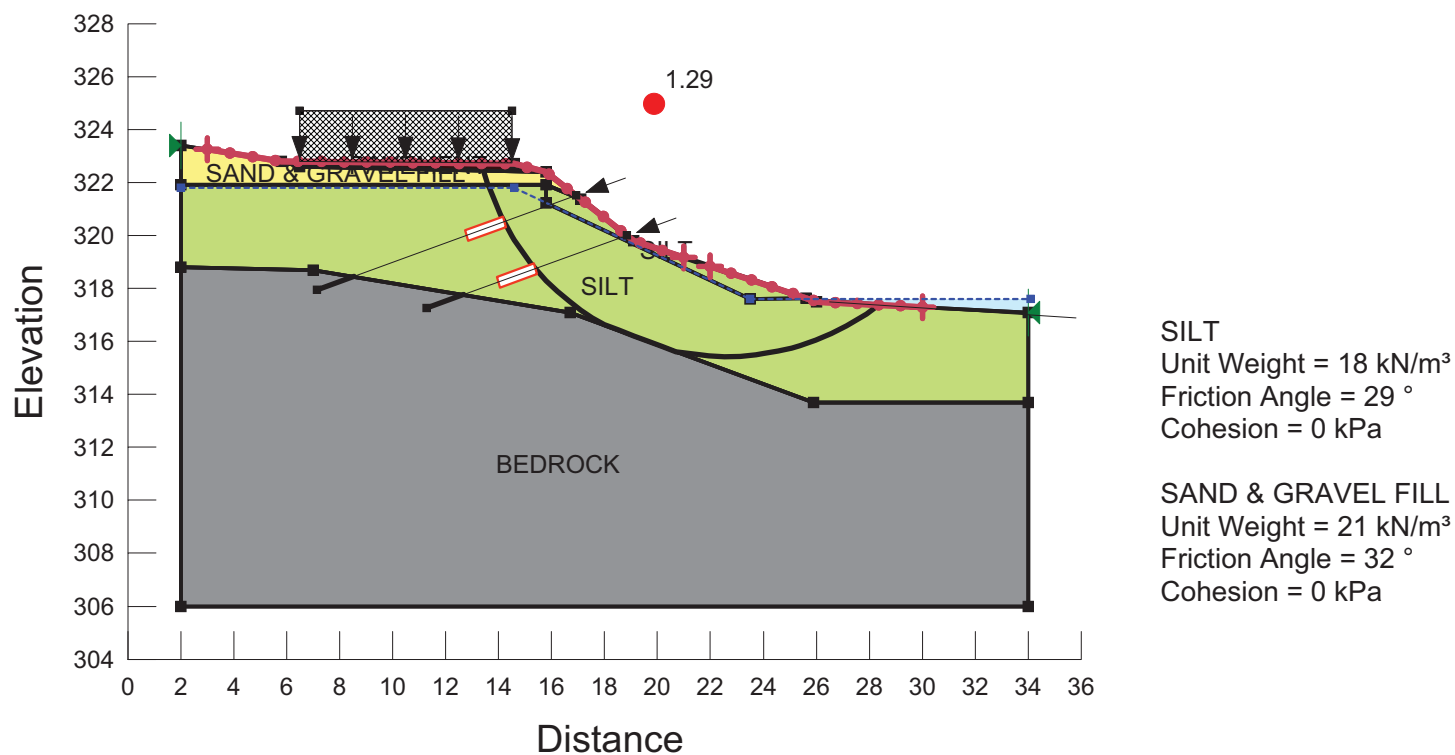


SILT
Unit Weight = 18 kN/m³
Friction Angle = 29 °
Cohesion = 0 kPa

SAND & GRAVEL FILL
Unit Weight = 21 kN/m³
Friction Angle = 32 °
Cohesion = 0 kPa

FIGURE G19 (Effective Stress Analysis)

Section L-L - Improved using Soil Nails
Method of Analysis: Morgenstern-Price
Factor of Safety = 1.29
Maximum Horizontal Surface Acceleration = 0.045g

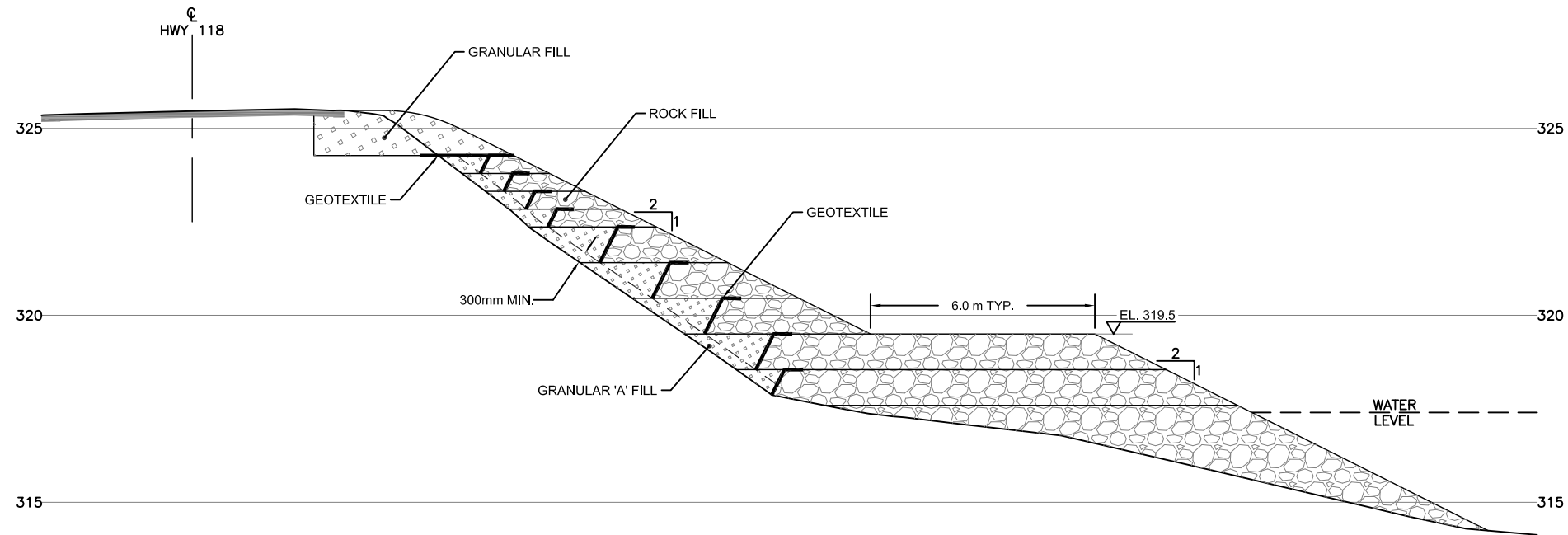




Appendix H

Slope Flattening and Toe Berm Sketch (Figure 1)

Soil Nail Configurations (Drawings)



- NOTES:
- 1) ROCK FILL TOE BERM SHALL BE CONSTRUCTED TO EL. 319.5m PRIOR TO PLACING FILL ON EXISTING SLOPE.
 - 2) CLOSE CUT CLEARING OF TREES ON EXISTING SLOPE.
 - 3) A MINIMUM 300mm THICK LAYER OF OPSS GRANULAR 'A' MATERIAL SHALL BE PLACED BETWEEN ROCK FILL AND EXISTING SLOPE. GRANULAR 'A' MATERIAL SHALL BE PLACED AND COMPACTED IN LAYERS NOT EXCEEDING 300mm IN THICKNESS PRIOR TO COMPACTION AS PER OPSS.PROV 501.
 - 4) THE GRANULAR FILTER AND ROCK FILL SHOULD BE BUILT IN LIFTS SIMULTANEOUSLY AND SEPARATED BY GEOTEXTILE. THE GEOTEXTILE SHALL BE CLASS II NON-WOVEN TYPE AS PER OPSS 1860. PLACEMENT OF GEOTEXTILES SHALL BE AS PER OPSS 511.
 - 5) BOUNDARIES BETWEEN LIFTS OF ROCK FILL ARE SCHEMATIC. ROCK FILL PLACEMENT, LIFT THICKNESS AND LAYER COMPACTION SHALL BE AS PER OPSS.PROV 206.

SLOPE FLATTENING AND
TOE BERM USING ROCK FILL
(TYPICAL CROSS-SECTION)

JOB# 19-6887-0



THURBER ENGINEERING LTD.

ENGINEER: KS	DRAWN: MFA	APPROVED: PKC
DATE: OCTOBER 2017	SCALE: N.T.S.	DRAWING No. FIGURE 1

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

CONT No 5014-E-0004
WP No 5339-11-00



HIGHWAY 118
SLOPE REHABILITATION
BOREHOLE LOCATIONS PLAN

SHEET



KEYPLAN

LEGEND

- Borehole by Thurber
- Borehole by Others
- DCPT by Others
- Water Level During Drilling
- Water Level In Piezometer

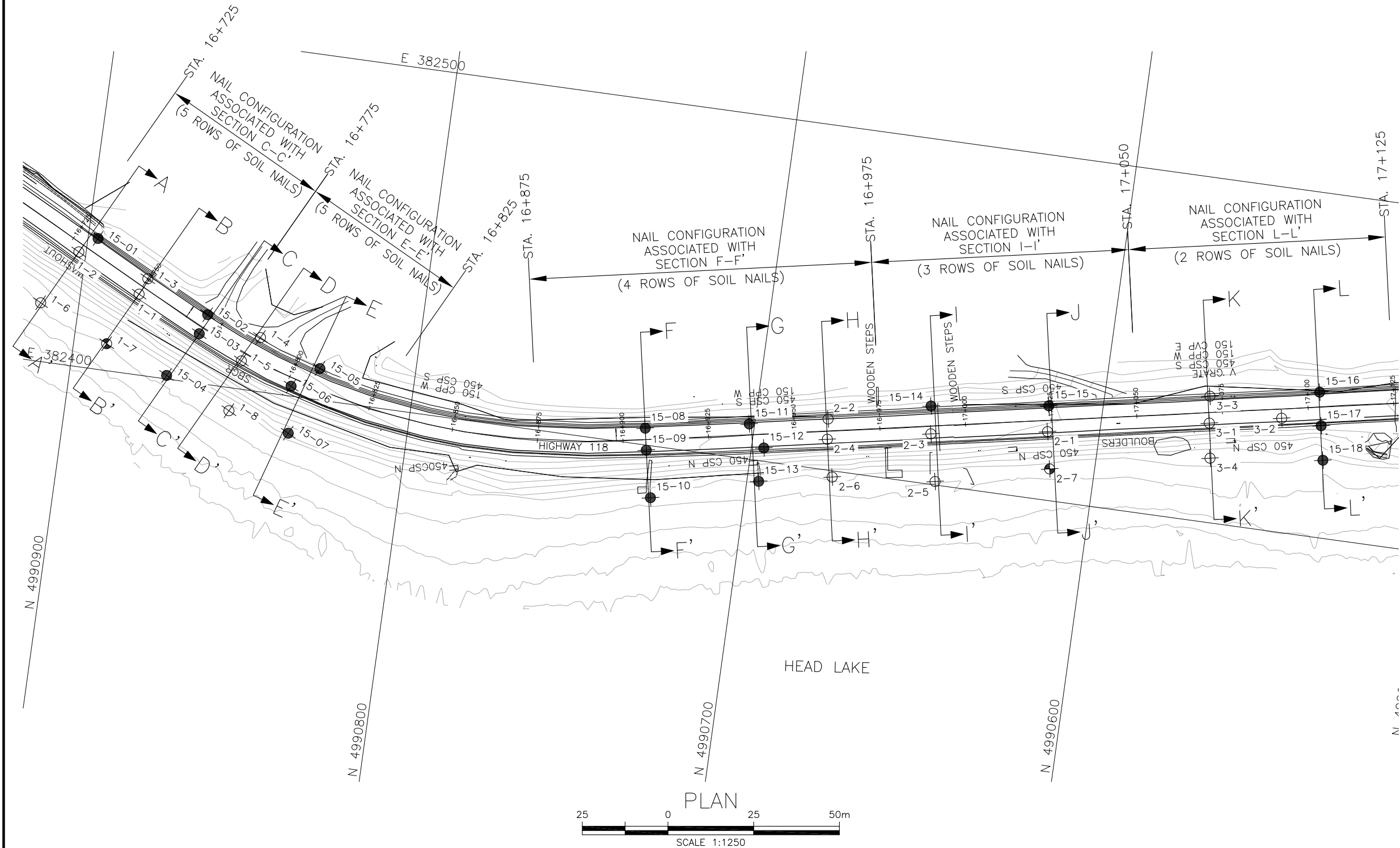
NO	ELEVATION	NORTHING (MTM)	EASTING (MTM)

-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No.

REVISIONS		DATE	BY	DESCRIPTION
DESIGN	ME	CHK	KS	CODE
DRAWN	MFA	CHK	ME	SITE
		LOAD	DATE	SEP 2017
		STRUCT	FIGURE	H1



DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No 5014-E-0004
WP No 5339-11-00

HIGHWAY 118
SLOPE REHABILITATION
SOIL NAILING CONFIGURATION

SHEET









THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

- | | |
|---|-----------------------------|
|  | Borehole by Thurber |
|  | Borehole by Others |
|  | DCPT by Others |
|  | Water Level During Drilling |
|  | Water Level In |
|  | Piezometer |

[illegible]

-NOTES-

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No.

[illegible]

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PLOTDATE: 9/29/2017 11:24 AM



Appendix I

List of OPSS and OPSD, and Suggested Text for Selected NSSPs

1. List of OPSS and OPSD Documents Referenced in this Report

- OPSS.PROV 206
- OPSS.PROV 501
- OPSS.PROV 511
- OPSS 804
- OPSS.PROV 1010
- OPSS 1860
- OPSD 601.010

2. Suggested text for NSSP on “Construction of Slope Flattening and Toe Berm using Rock Fill”

Rock fill toe berm shall be constructed from bottom up to Elevation 319.5 m prior to placing fill on the existing slope. Rock fill for slope flattening shall be placed from the toe up towards the highway. Close cut clearing of all existing trees shall be carried out. All existing stumps and root masses shall be left in place. Stripping or grubbing of the existing slope shall not be carried out.

OPSS Granular ‘A’ material with a minimum thickness of 300 mm shall be placed between the rock fill and the existing slope, and compacted in layers not exceeding 300 mm in thickness prior to compaction. Compaction of OPSS Granular ‘A’ material shall be carried out as per OPSS.PROV 501. The granular filter and rock fill shall be built in lifts simultaneously such that the potential for new fill sliding on the existing slope is minimized. Geotextile shall be used to separate the granular filter from the rock fill. The geotextile shall be Class II non-woven type with filtration opening size (FOS) range of 105-210 µm as per OPSS 1860 and placed as per OPSS 511. Rock fill placement, lift thickness and layer compaction shall be as per OPSS.PROV 206.

Positive control and discharge of all surface water shall be provided throughout construction. All existing ditches, drainage pipes, culverts, or conduits shall be maintained operational during construction. The contractor shall provide effective sediment control measures during construction.

3. Draft NSSPs

- 1) Geotechnical Instrumentation and Monitoring Program
 - Supply and Installation of Monitoring Equipment
 - Monitoring Program
- 2) Slope Stabilization by Soil Nailing

DRAFT
GEOTECHNICAL INSTRUMENTATION AND MONITORING PROGRAM

SUPPLY AND INSTALLATION OF MONITORING EQUIPMENT

1.0 SCOPE

This special provision contains the requirements for the supply and installation of the geotechnical instruments for the purpose of monitoring slope movement of Highway 118 in three areas of potentially unstable embankment sections between Sta. 16+730 and Sta. 17+100 prior to and following the slope rehabilitation.

2.0 REFERENCES

2.1 General

OPSS 1205 - Material Specification for Clay Seal
OPSS 1301 - Material Specification for Cementing Materials

Ontario Water Resources Act, R.R.O. 1990, Regulation 903.

2.2 Project-specific Reference

The subsurface conditions at the site are described in the foundation investigation report: "Slope Rehabilitation on Highway 118, 0.5 km North of Haliburton County Road 121, Huntsville District", prepared by Thurber Engineering Ltd.

3.0 EQUIPMENT AND MATERIALS

3.1 Inclinometers (SI) - Supply

3.1.1 General

The Installer shall supply inclinometer casing. Fittings for the casing shall be consistent in manufacturer and system.

3.1.2 Casing

Casing shall be 70 mm Outside Diameter non-recycled ABS or PVC casing with snap-type flush joint to engage full inner circumference of casings. Casings shall be sealed at joints to prevent entry of grout.

Four grooves on the inside wall of casing, aligned in two orthogonal directions, shall be straight throughout the entire length of an inclinometer to permit accurate tracking of inclinometer probe between successive casing sections, and have a width compatible with probe wheels to prevent the lateral movement of the probe.

The following table provides the minimum requirements for the casing:

Casing OD	70 mm (2.75")
Casing ID	59 mm (2.32")
Collapse Rating	15 bar (220 psi)
Load Rating	400 kg (900 lbs)
Temperature Range	-29 to 88 °C (-20 to 190 °F)
Spiral	≤ 0.33° per 3m (10') section

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3.1.3 Splice

If required, splice kit shall be consistent with the casing in manufacturer and system.

3.1.4 Bottom Cap

Bottom caps shall be consistent with the casing in manufacturer and system. Tight fit between bottom cap and casing shall be ensured to prevent entry of grout into the bottom of casing.

3.1.5 Top Cap

Top caps shall be consistent with the casing in manufacturer and system. Top cap shall prevent the rain and snow from entering the casing.

3.1.6 Telescopic Section

Telescopic section shall be consistent with the casing in manufacturer and system. Each telescopic section shall be inserted appropriately, extended, to accommodate up to 150 mm of settlement.

3.1.7 Anchor

If required, casing anchor shall be consistent with the casing in manufacturer and system.

3.1.8 Dummy Probe

The Installer shall provide a dummy probe compatible with the inclinometer casings.

3.1.9 Flush-mount Protective Cover

The Installer shall supply protective cover installed flush with the ground surface at each inclinometer location. The protective cover shall be lockable.

3.1.10 Grout

The annular space between the inclinometer casing and the borehole shall be filled with cement-bentonite grout prepared as follows: 12 kg of bentonite (OPSS 1205), 100 litres of water and 40 kg of cement (Type 10 - OPSS 1301) or Water-Cement-Bentonite of 2.5-1-0.3 (ratio by weight).

4.0 CONSTRUCTION

4.1 General

4.1.1 Personnel

The Instrument Installer shall be a Geotechnical Consultant with MTO R.A.Q.S. classification of: Geotechnical (Structures and Embankments) – **Medium Complexity** to carry out the supply and installation of geotechnical instruments.

4.1.2 Equipment Operation and Weather Conditions

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All installation and monitoring equipment and associated materials shall be capable of withstanding the range of temperatures and all types of weather conditions possible for their location within the ground or on the surface. The instruments shall be capable of operating within the manufacturer's stated accuracy throughout the temperature range. Monitoring shall be conducted year round.

4.2 Installation

Table 1 – Quantities and Locations of Slope Inclinator

Area (Station Limits)	Station	Offset from Centreline	Instrument Type	Instrument Quantity
1 (Sta. 16+730 to 16+830)	16+770	4 m Right	Inclinometer	1
2 (Sta. 16+910 to 17+040)	16+910	4 m Right	Inclinometer	1
3 (Sta. 17+040 to 17+100)	17+100	4 m Right	Inclinometer	1
Total				3

4.2.1 Instrument Location

Prior to the installation of instruments, the Installer shall accurately survey and stake the location of each instrument and record the ground elevation at each instrument location.

4.2.2 Accuracy of Surveying for Elevations

Elevations shall be surveyed to an accuracy of ± 2 mm.

4.2.3 Protection of Instruments

All instruments shall be adequately protected by the Installer such that they are not damaged during the entire duration of the monitoring.

4.2.4 Boreholes for Instruments

The Installer shall make a basic stratigraphic log of boreholes as they are being drilled. In-situ or laboratory testing is not required.

Boreholes shall be advanced using conventional drilling methods and shall be as straight and vertical as practical.

4.3 Inclimeters (SI) - Installation

4.3.1 General

4.3.1.1 Scope

This Section contains the requirements for the installation of inclinometer casing and accessories.

The location and approximate installation depths of the inclinometers are given in Table 2:

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Table 2 - Inclinometer Locations and Approximate Installation Depths

Location	Station	Approximate Ground Elevation (m)	Estimated Bottom Elevation (m) *	Estimated Length of Casing (m) **
Area 1	16+770	325.5	315	12.5
Area 2	16+910	324.3	315	11.3
Area 3	17+100	322.7	315	9.7

Note: * The actual bottom elevation of the inclinometer shall be determined during drilling of the borehole. Bottom of inclinometer shall be socketed a minimum 2 m into bedrock.

** Estimated casing length includes 2 m socket into bedrock and 2 m for incidental.

4.3.2 Installation - Inclinometers

4.3.2.1 General

Installation of the inclinometer casing shall be as per the manufacturer's recommendations in addition to what is stated or emphasised below.

Highway traffic during instrument installation shall be managed as required, using short term lane closures in accordance with the Ontario Traffic Manual (OTM), Book 7.

Standard inclinometer casing lengths shall be used.

Boreholes for inclinometers shall be $\pm 2\%$ of vertical. The boreholes shall be of sufficient diameter to enable installation of the inclinometer casing and grouting of the annular space between the inclinometer casing and borehole.

The 'A' inclinometer casing grooves shall be aligned perpendicular to the highway centreline, with the A+ direction towards the Head Lake.

The 'B' inclinometer casing grooves shall be aligned parallel to the highway centreline, with the B+ direction 90 degree positive (clockwise) from the A+ direction.

A+ and B+ direction grooves shall be permanently marked and identified on each casing.

Care shall be taken not to apply torsion to the inclinometer casing during installation.

Inclinometer casing shall not be exposed to prolonged direct sunlight as it will cause deformation to the casing.

The inclinometer socket length (in bedrock) shall be a minimum of 2 m and shall be confirmed by the Installer during drilling of the borehole.

4.3.2.2 Telescopic Sections

A minimum of one (1) telescopic section shall be included per inclinometer. The telescopic sections shall each accommodate up to 150 mm of contraction.

Table 3 gives the approximate depths of telescopic sections for the inclinometers.

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Table 3 - Recommended Inclinometer Telescopic Section Depths

Location	Station	Approximate Depth of Telescopic Section from Ground Level (m)
Area 1	16+770	5.0
Area 2	16+910	4.5
Area 3	17+100	4.0

Telescopic sections are not required within the socket length in bedrock.

4.3.2.3 Grouting

Prior to grouting, the Installer shall lower a dummy probe to confirm that all grooves are properly aligned and that the probe can reach the bottom of the casing.

The annulus between the borehole and casing shall be grouted up to the ground level. All drilling slurry shall be flushed out of the borehole. Grout shall displace any water from the borehole.

When grouting around the inclinometer casing, the buoyancy force acting on the casing must be opposed. Clean water can be added inside the inclinometer casing but additional force may be required. If so, the force shall be ideally applied at the base of the inclinometer casing. The casing shall not be pushed down from the top as this will likely distort the casing profile.

Once grouting is completed and the grout has set, the Installer shall lower the dummy probe to the bottom of the inclinometer casing to confirm that it has been correctly installed.

Once the grout has set, the water level inside the casing shall be lowered to approximately 6 m below the ground to prevent freezing.

4.3.2.4 Flush-mount Protective Cover

The protective cover shall allow easy access to the top of the inclinometer casing by hand.

4.3.3 Coordination with Monitoring

4.3.3.1 Notification

The Installer shall notify the Design team and MTO no later than 3 days after grouting of an inclinometer. At this time, the Installer shall also supply the following information to the Design team and MTO.

- Magnetic and grid bearings of A+ and B+ groove directions;
- Difference between A-axis bearing and line parallel to centreline;
- Stratigraphic log of subsurface conditions at the inclinometer, including drilling method notes;
- Telescopic sections and socket details;
- Depths of casing and stick up;
- Installation notes / grouting notes.

4.3.3.2 Baseline Readings

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Baseline readings of the inclinometers shall be done by a Foundation Engineering Consultant retained by the Design team and MTO. The Installer should be prepared to wait for a period of 10 to 15 days after completion of installation of instruments for the baseline readings to stabilize. Stabilization of readings shall be deemed to have reached when:

- a) Changes in the incremental deflection at the same depth are within ± 0.5 mm; and
- b) Changes in the cumulative deflection at the same depth are within ± 1 mm;
- c) Failing either of the two above criteria, as determined by the Design team and MTO.

for three consecutive readings, in both A and B directions.

4.3.3.3 Monitoring

The Installer shall provide installation information as specified above and provide access to the inclinometer for monitoring including snow clearing and traffic protection.

4.3.4 Reporting

The Installer shall report relevant inclinometer installation details to the Design team and MTO no later than 5 days after installation. The report shall include:

- Inclinometer location, easting, northing;
- Elevation of ground levels and top of casing;
- Magnetic and grid bearings of A+ and B+ groove directions;
- Difference between A-axis bearing and line parallel to embankment centreline;
- Dates of installation;
- Details of flush-mount protective cover;
- Installation / grouting notes and the results of the dummy probe runs.

4.4 Decommissioning of Instruments

The Installer shall decommission the inclinometers, as applicable to the Contract, at the end of the monitoring program following the completion of post-construction monitoring unless specified otherwise in the Contract Documents:

Decommissioning of instrumentation shall be carried out according to the Ontario Water Resources Act, R.R.O. 1990, Regulation 903.

5.0 BASIS OF PAYMENT

Payment at the tender price for this tender item shall be full compensation for all Labour, Equipment and Material to do the work.

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GEOTECHNICAL INSTRUMENTATION AND MONITORING PROGRAM

MONITORING PROGRAM

1.0 GENERAL

Requirements specified for Specialist Qualifications; Services, Deliverables and Records; and the Foundation Monitoring Plan apply to all the Instrumentation Monitoring. Instrumentation monitoring is required for the following items:

- Inclinometers (SI)

The instrumentation monitoring services includes:

1. Requirements for data collection, data reduction and reporting;
2. Adherence to criteria used to assess the slope movement based on the monitoring data collected from the instrumentation installed by others.

1.1 Specialist Qualifications

The Foundation Engineering category consultant services required for this assignment have been categorized as (*medium*) complexity *Geotechnical* specialty.

The Foundation Engineering Consultants that are registered in MTO's consultant acquisition system (RAQS) at complexity ratings in the required specialty that meet or exceed the identified complexity requirement for this assignment are eligible to provide Foundation Engineering services for this project.

The Foundation Engineer shall have a minimum of five (5) years experience in the supply, installation and monitoring of slope inclinometers and survey benchmarks or alternatively demonstrated expertise through providing satisfactory supply, installation and monitoring services for the instrumentation specified for a minimum of two (2) projects in which the work was of similar scope to that in the Contract.

1.2 Services, Deliverables and Records

The Foundation Engineering Consultant shall:

- Review the Monitoring Program and, if deemed necessary, submit in writing to the Design team and MTO recommendations for modifications to the Monitoring Program;
- Calibrate and maintain monitoring equipment;
- Take instrument readings, reduce data and prepare reports;
- Provide transmittal of instrument readings and reports to the Design team and MTO;
- Interpret instrument readings as needed for the purposes of slope rehabilitation;
- Interpret instrument readings for confirmation of slope stability following rehabilitation.

A monitoring update shall be provided to the Design team and MTO once every three months.

1.3 Submission of Foundation Monitoring Plan

The Foundation Engineering Consultant shall, in a brief narrative, discuss the applicable experience and qualifications of specialist staff, the role that each will play in administration of the contract, the authority to be assumed, and the reporting relationships with the construction administration staff.

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The Consultant shall also complete the Foundation Monitoring Plan table in the format provided below.

Foundation Monitoring Plan		
<i>Major Inspection Tasks</i>	<i>Level of Inspection</i>	<i>Deliverable Record(s)</i>
List major inspection tasks associated with foundation monitoring.	State frequency/level of inspection.	List associated Deliverable Records for each task.

2.0 PURPOSE

The purpose of these instruments is to monitor lateral movement of the embankment slope within the three areas of potentially unstable highway embankment along the Head Lake and to conform embankment stability following the rehabilitation of the slope.

The instrumentation shall not be decommissioned unless instructed by the Design team and MTO.

3.0 DRAWINGS

Reference shall be made to the following contract drawings that are contained in the Contract Documents Package:

- Monitoring Section Location Plan
- Monitoring Instrument Installation Details

4.0 SUBSURFACE CONDITIONS

The subsurface conditions at the site are described in the foundation investigation report: "Slope Rehabilitation on Highway 118, 0.5 km North of Haliburton County Road 121, Huntsville District", prepared by Thurber Engineering Ltd.

5.0 EQUIPMENT OPERATION

Monitoring shall be conducted year round. All monitoring equipment shall be maintained and rendered operational throughout the entire monitoring period.

Any equipment malfunction shall be investigated and attempts shall be made to remedy the malfunction. Notification of any equipment malfunction and irreparable equipment shall be made to the Design team and MTO. Documentation of the possible causes and suggested remedial measures shall be forwarded to the Design team and MTO.

6.0 READING SCHEDULE AND FREQUENCY

6.1 The Foundation Engineering Consultant shall save and archive raw data in electronic and hard copy format.

6.2 Monitoring shall commence immediately after the installation of an instrument. Monitoring is to continue for the period indicated in Table 1 below.

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Highway traffic during monitoring shall be managed as required, using short term lane closures in accordance with the Ontario Traffic Manual (OTM), Book 7.

- 6.3** The minimum monitoring frequencies along with the anticipated number of readings are given in Table 1 below. The monitoring frequency is the same for each individual instrument in the following table. Instruments shall be read more or less frequently if judged to be required by the Design team and MTO.
- 6.4** It should be noted that the numbers of readings given in Table 1 are approximate and may vary due to uncertainties associated with the construction schedule.

Table 1 - Minimum Monitoring Frequency

STAGE	FREQUENCY	ANTICIPATED NO. OF READINGS PER MONITORING INSTRUMENT
Baseline Reading (*)	3 readings on 3 consecutive days, no sooner than 7 days following installation of instrument.	3
Pre-rehabilitation Monitoring (anticipated duration: 24 months)	Monthly (3) ▪ 1 st month to 3 rd month Once every three months (7) ▪ 4 th month to 24 th month	10
Re-establish Baseline Reading following rehabilitation (*)	3 readings on 3 consecutive days, no sooner than 7 days following completion of rehabilitation.	3
Post-rehabilitation Monitoring (anticipated duration: 24 months)	Monthly (3) ▪ 1 st month to 3 rd month Once every three months (7) ▪ 4 th month to 24 th month	10

(*) Baseline Readings: Instrument readings taken after installation to provide a baseline value against which all subsequent readings are compared to assess slope movement.

7.0 INSTRUMENTATION SPECIFIC REQUIREMENTS

7.1 INCLINOMETERS (SI)

7.1.1 Equipment

Inclinometers shall be read with a bi-axial inclinometer probe (force balanced servo accelerometer type) that is compatible with the casing installed. For example: Digitilt AT Inclinometer Probe model 50332510 (metric) or 50332500 (imperial) - or equal.

A Digitilt Toughpad Reader, Slope Indicator model 50330945 - or equal, shall be used as a readout unit.

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Appropriate software, DigiPro2 for Windows, Slope Indicator model 50310199 - or equal, shall be available along with a suitable computer to process, store and view the cumulative and incremental deflection plots on site.

The probe control cable shall be Slope Indicator model 50331225 (metric) or 50331250 (imperial) - or equal. The control cable shall be of sufficient length for reading inclinometers and have connectors for the readout unit and probe.

It is critical to use one inclinometer probe, one control cable and one readout unit exclusively. If any of this equipment is to be exchanged for another, two datasets shall be taken one immediately after the other, the first with the old equipment and the second with the new equipment. Comparison and corrections shall then be made if required.

The probe, cable and readout unit shall be calibrated prior to taking baseline readings. Calibration records shall be supplied to the Design team and MTO.

Inclinometer readings shall be taken consistently in either metric or imperial units, never a mixture.

7.1.2 Data Collection

Data collection shall be carried out in accordance with the inclinometer probe manufacturer's recommendations and instructions.

Care shall be taken not to take readings with the probe wheels in a casing joint.

One complete dataset shall consist of two runs:

- Run 1 - in the A+ direction, with the uppermost wheel in the A+ groove;
- Run 2 - rotate probe 180°, with the uppermost wheel in the groove opposite the A+ groove.

The convention for the direction and sign of lateral movements shall be:

- 'A' direction shall be the direction perpendicular to the highway alignment;
- Positive 'A' direction (A+) and positive displacement shall be oriented towards the lake.

The readings shall be taken from the bottom of inclinometer casing up.

7.1.3 Reporting

As a minimum the following shall be reported to the Design team and MTO within five (5) working days of obtaining a set of readings from each inclinometer:

- Cumulative and incremental lateral displacement versus depth plots in both A and B directions;
- Cumulative and incremental lateral displacement versus time plots at the elevation of maximum lateral displacement in both A and B directions;

A brief interpretation of recorded displacements shall be provided.

Plots shall clearly show and identify each dataset.

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GEOTECHNICAL INSTRUMENTATION AND MONITORING PROGRAM

A sign convention of positive (+) lateral displacement towards the lake shall be employed.

7.1.4 Review and Alert Levels

The following lateral displacement levels relative to the baseline or zero readings are to be observed:

Instrument	Review Level	Alert Level
All Inclinometers	6 mm	12 mm

Review Level – If the Review Level is exceeded, the Foundation Monitoring Consultant shall immediately notify the CA and MTO.

Alert Level – If the Alert Level is reached, the Foundation Monitoring Consultant shall immediately notify the CA and MTO. The Foundation Monitoring Consultant shall discuss immediately with the CA and MTO a plan of action.

8.0 INTERIM AND FINAL REPORTS

At the completion of the pre-rehabilitation monitoring, an interim monitoring report shall be issued to the Design team and MTO. The monitoring results shall be presented in tabular and graphical forms. Interpretation of the monitoring readings shall be included in the report.

At the completion of the post-rehabilitation monitoring, a final monitoring report shall be issued to the Design team and MTO. The monitoring results shall be presented in tabular and graphical forms. Interpretation of the monitoring readings shall be included in the report.

SLOPE STABILIZATION BY SOIL NAILING

Item No.

Non-Standard Special Provision

TABLE OF CONTENTS

1.0	SCOPE
2.0	REFERENCES
3.0	QUALIFICATIONS
4.0	SUBMISSION REQUIREMENTS
5.0	EQUIPMENT AND MATERIALS
6.0	CONSTRUCTION
7.0	NAIL TESTING
8.0	HYDRO-SEEDING
9.0	MANAGEMENT OF EXCESS MATERIAL
10.0	AS-BUILT DRAWINGS AND SUBMISSIONS
11.0	MEASUREMENT FOR PAYMENT
12.0	BASIS OF PAYMENT

1.0 SCOPE

This non-standard special provision specifies the requirements for materials, construction sequence and testing for slope stabilization using soil nails in the three areas between Station 16+730 and 17+100 on Highway 118, 0.5 km north of Haliburton County Road 121, in Huntsville District, Ontario. The three areas identified with potentially unstable embankment slopes along Highway 118 are listed below:

- Area 1: Station 16+730 to 16+830, Township of Dysart
- Area 2: Station 16+910 to 17+040, Township of Dysart
- Area 3: Station 17+040 to 17+100, Township of Dysart

The work shall consist of furnishing, installing, and testing a soil nailed slope stabilization system at locations shown on the design drawings. The scope of work for this project includes, but is not limited to, the following:

- Access preparation
- Performing independent utility clearance check
- Clearing and profiling of slope surface
- Supply and installation of soil nails and accessories
- Verification and proof testing of soil nails
- Grout mix design and grout strength testing
- Supply and installation of steel wire mesh and accessories
- Hydro-seeding of slope surface after soil nail installations

2.0 REFERENCES

The subsurface conditions at the site are described in the foundation investigation report: "Slope Rehabilitation on Highway 118, 0.5 km North of Haliburton County Road 121, Huntsville District", prepared by Thurber Engineering Ltd.

This non-standard special provision refers to the following publications:

- MTO HIFP -120, Soil Nailing for Highway Construction in Ontario
- FHWA-NHI-14-007, Soil Nail Walls Reference Manual
- NCHRP Report 701, Proposed Specifications for LRFD Soil-Nailing Design and Construction

3.0 QUALIFICATIONS

The Contractor must demonstrate satisfactory completion of at least five (5) permanent soil nailing projects during the past three (3) years, totaling at least 1,000 m² of wall face area and at least 500 permanent soil nails. The Contractor shall submit a brief description of each project including the owner's name, contact person, and current telephone number or email address.

The Contractor shall provide a Quality Verification Engineer (QVE), who is a licensed professional engineer with experience in constructing at least three (3) soil nail retaining wall or slope stabilization projects over the past five (5) years. The Contractor shall also provide on-site supervisors and drill operators with experience installing permanent soil nails on at least three (3) projects over the past five (5) years.

At least 30 days before starting the soil nail work, the Contractor shall identify the QVE, on-site supervisors, and drill operators assigned to the project and submit a summary of each individual's experience.

A mandatory site visit by the Contractor is required prior to bid submission. The Contractor shall take into consideration in his bid preparation the site conditions, which include but are not limited to ground topography, access constraints, operation space restrictions.

4.0 SUBMISSION REQUIREMENTS

The Contractor shall submit a construction plan and shop drawings for CA's review at least 30 days before commencing any construction activity, including but not limited to the following:

- Construction start date and construction staging/sequence;
- Temporary access and/or platform, if required, for drilling and installation;
- Road closure and traffic protection, if required, for access preparation and soil nail installation;
- Surface runoff management and drainage control measures during construction;
- Soil nail locations (XYZ coordinates) and ID numbers, including nail spacing and pattern, etc., as per design requirements;
- Drilling methods and equipment;
- Nail grout mix design, placement procedures, equipment and grout testing procedure;
- Soil nail testing methods and equipment setup;
- ID number and calibration test results for each test jack, pressure gauge, and load cell;
- Ultimate strength of proposed soil nail tendons.

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5.0 EQUIPMENT AND MATERIALS

5.1. Steel Wire Mesh

Steel wire mesh used in the construction of the Soil Nailed Slope Stabilization System shall be the high-tensile steel wire TECCO mesh supplied by Geobrugg North America, LLC (or an approved equivalent). The technical data sheets as well as related product information of the TECCO mesh, or equal, shall be submitted to the CA for review. The term, or equal, shall be understood to indicate that the equal product is the same or better than the specified product in function, performance, reliability, quality and general configuration.

TECCO Mesh shall be furnished complete with all accessories including spike plate, connectors, boundary ropes, wire rope anchor, and press claw. The TECCO Mesh shall be installed as per design drawings as well as Manufacturer's Specifications. TECCO spike plates and connectors shall be compatible with the mesh and soil nails specified for this project. The elements of the TECCO Mesh system shall meet the following requirements:

Element	Model Type	Corrosion Protection
Mesh	TECCO System G65/4	Geobrugg Super Coating
Spike Plate	TECCO System Spike Plate P66	Hot-dip galvanized
Connection Clip	TECCO System Press Claws Type 2	Hot-dip galvanized
Boundary Rope	Wire Rope with a minimum diameter of 12 mm	Hot-dip galvanized
Compression Claw	Press claw Type 2	Hot-dip galvanized
Rope Anchor	Rope anchor with a minimum diameter of 14.5 mm	Hot-dip galvanized

5.2. Soil Nails

Nails used in the construction of the Soil Nailed Slope Stabilization System shall be DYWIDAG THREADBAR supplied by DYWIDAG Systems International (or an approved equivalent). The soil nails shall be full-length Double Corrosion Protection (DCP), fully threaded steel bar with a nominal outer diameter of 32 mm (#10 Steel Grade 75). The product details of the soil nails should be submitted to the CA for review.

Soil nails shall be furnished complete with all accessories, including centralizers and couplers, and shall be compatible with the specified TECCO mesh and spike plates. Drill bits shall have a minimum diameter of 150 mm capable of advancing a minimum of 1.5 m into strong to very strong sound granitic bedrock. The elements of the soil nail shall meet the following requirements:

Element	Model Type	Corrosion Protection	Specification
Steel Tendon	DSI DYWIDAG THREADBAR #10	Full Length Double Corrosion Protection (DCP)	Nominal O.D. = 32 mm Maximum O.D. = 36 mm Minimum Yield Load = 420 kN Minimum Ultimate Load = 560 kN

Nail grout shall be a non-shrinkable cemented-based grout with a minimum three-day compressive strength of 10.5 MPa and a minimum 28-day compressive strength of 21 MPa.

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All the soil nails shall be grouted to about 100 mm below the top of the nail hole or the face of the slope to allow for pre-tensioning of the TECCO mesh.

6.0 CONSTRUCTION

The Contractor shall install the soil nailed slope stabilization system in accordance with the project specifications and design drawings. Soil nails shall be installed in sections with manageable work area in order to limit slope erosion.

The locations and elevations of the soil nails must be verified by the QVE during construction. Field adjustments may be necessary. Any modified soil nail location must be approved by the CA prior to installation.

The Contractor shall determine the installation sequence of the nails and the steel wire mesh based on slope conditions at the time of construction.

6.1. Site Preparation

The existing vegetation on the slope surface shall be trimmed and cut down but all existing root masses shall be left in place. Existing trees may be cut with the stumps left in place. Complete removal of vegetation and root masses could result in slope instability and is therefore not recommended.

Positive control and discharge of all surface water that will adversely affect slope stability and the installation of soil nailed slope system shall be provided throughout construction. All the existing ditches, drainage pipes, culverts, or conduits used to control surface water shall be maintained operational during construction. The contractor shall provide effective sediment control measures during construction.

Upon substantial completion of the soil nailed slope stabilization system as determined by the CA, temporary surface water control and sediment control measures may be removed from the site.

6.2. Nail Installation

The Contractor shall store and handle soil nail tendons such that potential for damage and corrosion is minimized. Any tendons exhibiting abrasions, cuts, weld splatter, corrosion or pitting, or damage to the encapsulation or epoxy coating must be replaced.

Soil nails shall be installed at the locations, elevations, orientations, and a minimum 1.5 m socketed into the bedrock as shown on the design drawings. The Contractor shall select drilling equipment and methods suitable for the ground conditions. The drill bit diameter shall not be smaller than the specified hole diameter of 150 mm. The hole shall be drilled at an inclination of 20° from the horizontal within a 2° tolerance.

The grouting operation shall be performed after the completion of drilling. Each drill hole shall be grouted within two hours of completion of drilling unless otherwise approved by the CA. To prevent the formation of voids, the hole shall be filled with grout progressively from the lowest point of each drill hole to the top.

Grouting equipment shall be capable of continuous mixing and producing grout free of lumps. The grouting equipment shall be sized to enable each individual nail to be grouted in one continuous operation. Cold joints in the grout column are not allowed except at the top of the test bond length of the proof tested production nails. The grout shall be placed within 60 minute after mixing or within the time recommended by admixture manufacturer if admixtures are used. Grout not placed within the allowable time limit must be rejected.

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Grout test shall be performed at a frequency of one test per mix design and a minimum of one test for every 40 m³ of grout placed. Results of the grout test shall be provided to the CA within 24 hours of testing.

6.3. Steel Wire Mesh Installation

Depression shall be formed around each nail head in preparation for mesh placement and pre-stressing. The depressions shall be approximately 600 mm in diameter and 200 mm in depth. The threads of the exposed nail shall be free of grout remnant.

Lay the mesh on the slope by positioning the mesh roll at the top of the slope and unrolling down the slope. Adjacent mesh sheets shall be interlinked with connection clips as per manufacturer's specifications.

Boundary ropes shall be installed to secure edges of the mesh as per manufacturer's specifications.

The spike plate and nail nut shall be fitted over each nail head and pre-stressed to a load of 50 kN or as approved by the CA.

7.0 NAIL TESTING

Verification tests shall be performed on sacrificial test nails before installation of production nails to confirm the appropriateness of the Contractor's construction techniques and to verify the design nail pullout resistance. Design Test Load is 190 kN per soil nail.

Verification test to a maximum tensile load of 380 kN (2.0 times Design Test Load) on non-production nails shall be performed on 2% of the total number of production nails and a minimum two tests in each area identified on the design drawings. The locations of sacrificial test nails shall be submitted for CA's review prior to installation.

Proof test by incrementally loading the proof test nail to a maximum tensile load of 285 kN (1.5 times Design Test Load) on production nails shall be performed on 5% of the total number of production nails. The locations of proof test nails shall be submitted for CA's review prior to testing.

Nail testing shall not be performed until the nail grout has cured for at least 72 hours or attained at least the specified 3-day compressive strength.

All field testing of the soil nails shall be witnessed by a foundation specialist retained by the CA.

7.1. Testing Equipment

Testing equipment shall include two (2) dial gauges, dial gauge support, jack and pressure gauge, electronic load cell, and a reaction frame. The pressure gauges shall be graduated in 500 kPa increments or finer. Measure the nail head movement with a minimum of two (2) dial gauges capable of measuring to 0.025mm accuracy. The stroke of the dial gauge shall be at least 100 mm.

7.2. Verification Testing

Verification test nails shall have both bonded and unbonded lengths. Along the unbonded length, the nail tendon is not grouted. The unbonded length of the test nails shall be at least 1 m. The bonded length of the test nails shall be at least 3 m but not longer than a maximum bonded length such that the nail load does not exceed 90% of the allowable tensile load of the nail bar during the tests.

Verification test shall be performed by incrementally loading the test nail to failure or a maximum test load of 200% of the Design Test Load (DTL).

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The verification test shall be performed in accordance with the following loading schedule.

Soil Nail Verification Test Loading Schedule

Load	Hold Time
0.05 DTL max. (AL)	1 minute
0.25 DTL	10 minutes
0.50 DTL	10 minutes
0.75 DTL	10 minutes
1.00 DTL	10 minutes
1.25 DTL	10 minutes
1.50 DTL (Creep Test)	60 minutes
1.75 DTL	10 minutes
2.00 DTL or Failure	10 minutes
0.05 DTL max. (AL)	1 minute

The alignment load (AL) should be the minimum load required to align the testing apparatus and should not exceed 5 percent of DTL. Dial gauges should be set to zero after the alignment load has been applied. Following application of the maximum load, the load should be reduced to alignment load and the permanent set should be recorded.

During the verification test, hold each load increment for at least 10 minutes. Creep test shall be carried out in the verification test at the 1.5 DTL increment. Maintain the load during the creep test within 2 percent of the intended load by use of the load cell and record nail movements at 1 minute, 2, 3, 5, 6, 10, 20, 30, 50, and 60 minutes.

7.3. Proof Testing

Proof test nails shall have both bonded and temporary unbonded lengths. The unbonded length of the test nails shall be a minimum 1 m. The bonded length of the test nails shall be at least 3 m but not longer than a maximum bonded length such that the nail load does not exceed 90% of the allowable tensile load of the nail bar during testing.

Proof tests on production nails shall be performed by incrementally loading the test nail to failure or a maximum test load of 150% of the Design Test Load (DTL) in accordance with the following loading schedule.

The alignment load (AL) should be the minimum load required to align the testing apparatus and should not exceed 5 percent of DTL. Dial gauges should be set to zero after the alignment load has been applied.

Soil Nail Proof Test Loading Schedule

Load	Hold Time
0.05 DTL max. (AL)	Until Movement Stabilizes
0.25 DTL	Until Movement Stabilizes
0.50 DTL	Until Movement Stabilizes
0.75 DTL	Until Movement Stabilizes

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Load	Hold Time
1.00 DTL	Until Movement Stabilizes
1.25 DTL	Until Movement Stabilizes
1.50 DTL (Max. Test Load)	Creep Test

The creep test in the proof test shall start as soon as the maximum test load (1.5 DTL) is applied and nail movement shall be measured and recorded at 1 minute, 2, 3, 5, 6, and 10 minutes. Where the nail movement between 1 minute and 10 minutes exceeds 1 mm, maintain the maximum test load for an additional 50 minutes and record movements at 20, 30, 50, and 60 minutes.

After the proof testing is complete and the soil nail has been approved by the CA, the unbonded section of the test nail shall be filled with grout in one continuous operation. Maintaining stability of the temporary unbonded test length for subsequent grouting is the Contractor's responsibility. If the unbonded test length of production proof test nails cannot be satisfactorily grouted subsequent to testing, the proof test nail shall become sacrificial and shall be replaced with an additional production nail installed at no additional cost to the MTO.

7.4. Test Nail Acceptance Criteria

The results of the verification and proof tests shall be provided to the CA for review. A test nail shall be considered acceptable when all of the following criteria are met:

- For verification tests, the total creep movement is less than 2 mm between the 6-minute and 60-minute readings and the creep rate is linear or decreasing throughout the creep test load hold period.
- For proof tests, the total creep movement is less than 1 mm during the 10-minute readings or the total creep movement is less than 2 mm during the 60-minute readings and the creep rate is linear or decreasing throughout the creep test load hold period.
- For verification and proof tests, the total measured movement at the maximum test load exceeds 80% of the theoretical elastic elongation of the test nail unbonded length.
- A pullout failure does not occur at 2.0 DTL under verification testing and 1.5 DTL test load under proof testing. Pullout failure is defined as the inability to further increase the test load while there is continued pullout movement of the test nail. Record the pullout failure load as part of the test data.

If a test nail does not satisfy the acceptance criterion:

- For verification test nails, the CA will evaluate the results of each verification test. Installation methods that do not satisfy the nail testing requirements shall be rejected. The Contractor shall propose alternative methods and install replacement verification test nails. Replacement test nails shall be installed and tested at no additional cost to the MTO.
- For proof test nails, the CA may require the Contractor to replace some or all of the installed production nails between a failed proof test nail and the adjacent passing proof test nail. Alternatively, the CA may require the installation and testing of additional proof test nails to verify that adjacent previously installed production nails have sufficient load carrying capacity. Installation and testing of additional proof test nails or installation of additional or modified nails as a result of proof test nail failure(s) will be at no additional cost to the MTO.

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8.0 HYDRO-SEEDING

Application of seed and cover shall be carried out in accordance with OPSS 804.

The finished slope shall be hydro-seeded to enhance vegetation growth for erosion control. Hydro-seeding shall include the supply of suitable equipment and the application of spray-pumped mixture of water, seed, hydro-mulch and tackifiers at locations as directed by the CA.

The seeding operation shall not commence until the CA has received the Certificate of Seed Analysis and approved the slope surface preparation, layout of permanent seed mix locations, and cover types.

The cover shall be a Bonded Fibre Matrix (BFM) type product, such as HydroSTRAW or equivalent, which is capable of adhering to the soil after being hydraulically applied. BFM shall be applied at a minimum rate of 5,000 kg of dry product for every 10,000 m².

Seed and cover operation shall not be carried out under adverse weather conditions. The Contractor shall maintain effective erosion control measures until final acceptance of the seed and cover by the CA.

9.0 MANAGEMENT OF EXCESS MATERIAL

Management of excess material shall be in accordance with OPSS 180.

10.0 AS-BUILT DRAWINGS AND SUBMISSIONS

As-built drawings shall be prepared by the Contractor to be submitted to the CA upon completion and prior to final acceptance of work including the following:

- All work incorporated in the completed installations that require submission of working drawings;
- All changes from the original contract requirements;
- All nail test results, including verification tests and proof tests;
- Certificate of Conformance (CoC) for each production nail.

The above listed documents shall be sealed and signed by the Quality Verification Engineer (QVE).

11.0 MEASUREMENT FOR PAYMENT

Measurement should be made for the following items for payment purposes:

- Measure treated slope surface by area in square metre;
- Measure verification test nails by number of nails tested. Do not measure failed verification test nails or additional verification test nails installed to verify alternative nail installation methods proposed by the Contractor;
- Measure production soil nails by length in metres. Measure along bar centerline from anchor plate to tip of each individual nail.

12.0 BASIS OF PAYMENT

Payment at the Contract price for the above tender items shall be full compensation for all labour, Equipment, and Material to do the work.