

**FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 11 AT PAN LAKE, 9.5 km NORTH OF HIGHWAY 64
EMBANKMENT FROM STATION 14+550 TO 15+210
TOWNSHIP OF OLIVE, ONTARIO
G.W.P. 5578-04-00**

GEOCRES No.: 31L-151

Report to

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted for the existing embankment carrying Highway 11 at Pan Lake, approximately 9.5 km north of Highway 64, in the Township of Olive, Ontario.

The purpose of the investigation was to explore the subsurface conditions beneath an existing embankment, just east of the shoreline of Pan Lake, from Station 14+550 northerly to 15+210 and an existing culvert, Robin Creek Culvert, located approximately at Station 15+040.

Based on the data obtained from this investigation, a borehole location plan, borehole logs, stratigraphic profiles, cross-sections and a written description of the subsurface conditions are provided. A model of the subsurface conditions was developed through considering a combination of the data obtained in the course of the present investigation and the data obtained from a previous investigation¹ at the project site.

Thurber Engineering Ltd. (Thurber) carried out the investigation as a sub-consultant to MMM Group Limited under MTO Assignment Number 5009-E-0024.

2 SITE DESCRIPTION

The site is located on Highway 11, approximately 9.5 km north of Highway 64. Highway 11 at this location is a two lane road with gravel shoulders. The site location is shown on Drawing 1 in Appendix C. Site photographs are presented in Appendix F of this report.

The highway embankment is located on the east edge of Pan Lake. The areas to the east and northwest consist of a thick vegetation cover of mature trees and brush. Near the north end of the report limit, Robin Creek crosses Highway 11 in an approximate west-east orientation. The east end of the Robin Creek Culvert connects to a swamp. Drainage in the general area is to the northeast and is mainly controlled by Robin Creek.

¹ Foundation Investigation Report – Highway 11 at Pan Lake, 10.6 km north of Highway 64 – Station 14+750 to 14+950, in Olive Township – 03 September 2008, by AMEC, GEOCRES No. 31L-123.

This site lies within the physiographic region known as Laurentian Highlands, located in the southernmost part of the Canadian Shield (Geology of Ontario, Ontario Geological Survey, Special Volume 4, Part 1). The local physiography is characterized by undulating rock outcrops and variable overburden soils, with swamps and lakes covering the low-lying areas. The bedrock at this site consists of Precambrian granite and gneiss.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation for this section of the Highway 11 was carried out in three phases, from April 06, 2011 until May 05, 2011. A total of 19 boreholes were drilled.

All boreholes were advanced to refusal at depths ranging from 1.1 m to 17.3 m. Approximate locations of the boreholes are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix C. The borehole locations and elevations were surveyed by MMM Group Limited.

Boreholes BH11-01 to BH11-06 were drilled using a track-mounted CME 75 drill rig supplied and operated by George Downing Estate Drilling Ltd. of Hawkesbury, Ontario. Hollow stem auger drilling techniques were used to advance the boreholes through the overburden. Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). Undisturbed Shelby tube samples were obtained in Boreholes BH11-04 and 11-06. In-situ vane shear strength tests (MTO-N vane) were conducted in BH11-04.

Boreholes BH11-07 to BH11-10, RCC-01 and RCC-02 were drilled using a portable tripod drill rig on a raft supplied and operated by OGS INC. of Almonte, Ontario. Casing/wash boring drilling techniques were used to advance the boreholes. Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with SPT.

Boreholes BH11-11 to BH11-17 were drilled using a truck-mounted drill rig supplied and operated by George Downing Estate Drilling Ltd. Hollow stem drilling techniques were used to advance the boreholes in the overburden. Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with SPT. NQ size rock cores were retrieved in Boreholes BH11-11, BH11-12 and BH11-15.

The boreholes considered in the preparation of this report are separated in the following groups according to their location and purpose, as shown in the table below.

Location	Boreholes
Pan Lake / West of HWY 11 (Sta. 14+600 and Sta. 14+670)	BH2A, BH4B, BH6B and BH7 (all by AMEC)
Highway 11 West shoulder at Pan Lake	BH11-11, BH11-12
Highway 11 East side (3 to 4 m beyond the existing embankment)	BH11-01, BH11-02, BH11-03, BH11-04, BH11-05, BH11-06, BH11-07, BH11-08, BH11-09, BH11-10

Location	Boreholes
Highway 11 East Shoulder at Robin Creek	BH11-13, BH11-14, BH11-15, BH11-16, BH11-17
Robin Creek Culvert	RCC-1 and RCC-2

The coordinates and elevations of the boreholes are provided on the Borehole Locations and Soil Strata Drawing in Appendix C and on the individual Record of Borehole Sheets in Appendix A.

Standpipe piezometers, consisting of 19 mm and 25 mm PVC pipes with slotted tips, were installed in 6 of the 19 boreholes to monitor the groundwater level. The installation and backfilling details of the piezometers and boreholes are provided below:

Borehole	Piezometer Tip Depth (m)	Installation Details
11-02	8.8	19 mm diameter piezometer with 1.5 m slotted screen installed, sand filter from 8.8 to 4.7 m, bentonite seal from 64.7 m to ground surface.
11-04	7.3	19 mm diameter piezometer with 1.5 m slotted screen installed, sand filter from 7.3 to 4.8 m, bentonite seal from 4.8 m to ground surface.
11-06	8.6	19 mm diameter piezometer with 1.5 m slotted screen installed, sand filter from 8.6 to 5.2 m, bentonite seal from 5.2 m to ground surface.
11-09	4.0	25 mm diameter piezometer with 1.5 m slotted screen installed, sand filter from 4.0 to 1.2 m, bentonite seal 1.2 m to ground surface.
11-12	15.8	19 mm diameter piezometer with 3.0 m slotted screen installed, sand filter from 15.8 to 10.6 m, bentonite seal from 10.6 m to ground surface.
11-13	7.0	19 mm diameter piezometer with 1.5 m slotted screen installed, sand filter from 7.0 to 5.2 m, bentonite seal from 5.2 m to ground surface.

A member of Thurber's engineering staff supervised the borehole drilling and sampling operations on a full time basis. The inspector logged the boreholes and the recovered soil and rock samples and processed them for transport to Thurber's Oakville office.

4 LABORATORY TESTING

All recovered soil samples were subjected to visual identification and to natural moisture content determination. The results of this testing are shown on the Record of Borehole sheets in Appendix A.

Selected samples were subjected to gradation analysis (sieve and hydrometer) and Atterberg Limit tests and the results are shown on the Record of Borehole sheets in Appendix A and on the figures in Appendix B.

All rock cores were logged and core recovery (TCR and SCR) at Rock Quality Designation (RQD) were determined for each core run. This data is presented on the borehole logs.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

5.1 General

Reference is made to the Record of Borehole sheets in Appendix A. Details of the encountered soil stratigraphy are presented in this appendix and on the attached Borehole Locations and Soil Strata Drawing. An overall description of the stratigraphy is provided below. The factual data presented in the borehole logs governs any interpretation of the site conditions.

The general stratigraphy of the area consist of peat, overlying silt and sand, which is underlain by sand and gravel, and then by Precambrian granite and gneiss bedrock.

The subsurface soils encountered below the bed of Pan Lake, at Boreholes BH4B, BH6B and BH7 (drilled by AMEC, shown in Appendix E), consist of peat at the lakebed, underlain by silty clay, silt and sand, which overlies assumed bedrock. Similar conditions were encountered in a fourth borehole (BH2A) drilled by AMEC, located West of HWY 11 at the East edge of Pan Lake.

Along the west shoulder of Highway 11 at Pan Lake, the subsurface soils encountered consist of asphalt, underlain by granular fill and rockfill, then layers of native silt, sand and gravel, cobbles and boulders overlying bedrock.

The general subsurface soils encountered on the east side of Highway 11 (3 to 4 m beyond the existing embankment) consist of native peat/organics, silty clay and clayey silt, silt, sand and gravel, overlying bedrock.

Along the east shoulder of Highway 11 at Robin Creek, the general soil condition encountered was asphalt underlain by granular fill and rockfill, then silt, sand and gravel, overlying bedrock.

Finally, at the location of Robin Creek culvert, the subsurface soils consisted of peat and sand at the creek bed, underlain by layers of clayey silt, silt, gravel, and then bedrock.

More detailed descriptions of the individual strata are presented below.

5.2 Pan Lake (Sta. 14+600 and Sta. 14+670: BH2A, 4B, 6B and 7)

5.2.1 Ice/water

The ice/water surface within the boreholes drilled in the lake ranged between Elevations 289.8 m and 289.9 m. The depth of ice/water was 1.1 to 2.0 m at the time of drilling.

5.2.2 Peat

A layer of peat was encountered at the lakebed in Boreholes BH4B, BH6B and BH7. The thickness of the peat ranges between 1.9 m and 2.6 m with the corresponding underside Elevations of 286.2 m to 285.3 m. The thickness of peat and the nature of the underlying soils were not established in BH-6B. A thin layer of 0.3 m of peat was also encountered in

BH2A adjacent to Pan Lake. A single SPT N-value of 1 was recorded below the lakebed. Based on this data this soil layer is described as very soft.

The peat was brown and dark brown in colour.

5.2.3 Clay and Silt

Silty clay to silt deposits were encountered in Boreholes BH2A, BH4B and BH7. Underlying the peat in Borehole BH2A was a 0.3 m layer of silt and then a 3.9 m layer of silt to silty clay. In Borehole BH4B underlying the peat, there was about 0.9 m of silty clay, and then about 3.8 m of silt. In Borehole BH7, about 1.7 m of silty clay to silt layer underlay the 1.3 m thick silt and sand deposit. The underside of the clay and silt layer, below the lakebed, ranged between Elevations 282.3 m to 281.5 m. The underside of the silty clay layer adjacent to Pan Lake was 289.3 m.

The field vane test performed in this deposit provided values of undrained shear strength ranging from about 24 to 34 kPa, and sensitivity of 1 and 2. Based on these results, the silt was classified as low sensitivity.

The SPT N-value in the silt deposits ranged from 1 to 21, typically 12, being classified as soft to very stiff, typically stiff.

Atterberg Limit test performed on one sample indicates that the silt has low plasticity and is classified as (ML).

The gradation data for selected silt samples are summarized below:

Soil Particles	(%)
Gravel	0
Sand	1 to 4
Silt	83 to 87
Clay	9 to 12

5.2.4 Silt and Sand

Deposits of silt and sand were encountered in Boreholes BH4B and BH7 underlying the peat and clay and silt. The thickness of this soil layer varied between 1.3 m to 2.5 m with underside elevations at 284.0 to 279.1m. Additionally, a layer of silty sand to sandy silt was encountered adjacent to Pan Lake in Borehole BH2A with an undetermined underside elevation.

Based on SPT N-values ranging from 1 to 50 blows for 0.3 m of penetration. These deposits are very loose to very dense, typically very loose.

The results of the grain size distribution analysis of selected samples are summarized below:

Soil Particles	(%)
Sand	10 to 80
Silt	16 to 81
Clay	3 to 6

5.2.5 Silt

A layer of silt, some sand, trace clay and gravel was encountered in Borehole BH7 under the silt and sand layer. The thickness of this silt layer is 0.5 m with an underside elevation at 281.8 m.

Based on an SPT value of 50 blows for 0.10 m of penetration, the silt is classified as very dense. Presence of cobbles was observed.

The soil is described as moist to wet.

The grain size distribution test results of a selected sample of this soil are summarized below:

Soil Particles	(%)
Sand	11
Silt	78
Clay	10

5.2.6 Bedrock

The top of bedrock elevation was inferred from split spoon refusal in Boreholes BH4B and BH7.

Depth to assumed bedrock and top of assumed bedrock elevations from the borehole information are summarized below:

Borehole	Depth to Inferred Bedrock (m)	Elevation of Top of Inferred Bedrock (m)
BH4B	10.9	279.1
BH7	8.1	281.8

5.2.7 Water Levels

The water levels in Boreholes BH4B, BH6B and BH7 were at the lake surface, at Elevation at 289.9 m. Borehole BH2A had a recorded water level at approximately 292.7 m.

5.3 Highway 11 - West shoulder East of Pan Lake (BH 11-11 and 11-12)

5.3.1 Asphalt

Asphalt was encountered at the ground surface in the two boreholes drilled at the west shoulder of Highway 11 at Pan Lake, BH11-11 and BH11-12. The thickness ranged from 100 mm to 113 mm.

5.3.2 Granular Fill

Sand and gravel fill were encountered below the asphalt in the two boreholes. The granular fill layer extends to a depth of 2.2 m with the underside elevation ranging from 292.0 to 290.5 m. This fill layer is described as compact to very dense with SPT N-values ranging between 19 and 71.

The sand and gravel fill was brown and moist. The moisture content ranges from 5% to 10%.

The grain size distribution of the granular fill can be found in Appendix B as Figure B1. The gradation of the fill is presented below:

Soil Particles	(%)
Gravel	16 to 76
Sand	22 to 75
Silt and Clay	2 to 9

5.3.3 Rockfill

Rockfill was encountered below the granular fill, extending to depths ranging from 5.6 m to 6.6 m. The underside of the rockfill ranged from Elevations 288.6 m to 286.1 m.

A 0.4 m thick layer of granular fill was encountered below the rockfill in BH11-12, with the underside at Elevation 285.7 m.

SPT N-values of 10 and 38 were measured in the rockfill, indicating a compact to dense condition.

5.3.4 Silt

The rockfill is underlain by a layer of silt, trace sand to sandy, and trace clay. The thickness of this silt layer varied from 4.1 m to 4.2 m. The underside of the silt layer ranged from Elevations 284.4 m to 281.6 m.

Based on SPT N-values ranging from 4 to 17, this layer is classified as loose to compact. A higher value of 111 blows for 0.30 m of penetration was measured at the base of the silt deposit.

The measured natural moisture contents ranged from 17% to 30%, typically 26% and the soil is described as moist to wet.

The grain size distributions of selected samples of this soil are plotted on the Record of Borehole sheets and shown in Figures B3 and B4 in Appendix B. The gradation data is summarized below:

Soil Particles	(%)
Sand	1 to 18
Silt	78 to 89
Clay	3 to 10

5.3.5 Sand

In BH11-11, the silt deposit is underlain by a layer of sand, some silt and some gravel. The thickness of this layer is 0.9 m. The underside of the sand layer is at Elevation 283.5 m.

Based on a SPT N-value of 29 blows, this soil is classified as compact.

The measured natural moisture content was 20%, and the soil is described as wet.

5.3.6 Cobbles and Boulders

Underlying the silt and sand described above, the boreholes encountered cobbles and boulders. The inferred thicknesses of these layers are 1.5 m to 2.0 m, with underside varying from Elevations 282.0 to 279.6 m.

SPT N-values of 23 and 33 were measured in this layer in BH11-11, indicating a compact to dense condition. This layer had to be cored in BH11-12

5.3.7 Bedrock

Bedrock consisting of granite was encountered underlying the cobbles and boulders in Boreholes BH11-11 and BH11-12. The bedrock is reddish grey and blackish grey in colour, slightly weathered to fresh and strong.

Depth to bedrock and top of bedrock elevations from the borehole information are summarized below:

Borehole	Depth to Bedrock (m)	Elevation of Top of Bedrock (m)
BH11-11	12.2	282.0
BH11-12	13.1	279.6

5.3.8 Water Levels

The groundwater depth and elevation monitored in the piezometer are shown in the following table.

Borehole	May 04, 2011	
	Depth (m)	Elev. (m)
BH11-12	2.4	290.3

Upon completion of Borehole BH11-11, the water level was at a depth of 2.5 m, equivalent to Elevation 291.7 m.

The above values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level will be influenced by the water level in Pan Lake and may fluctuate in elevation after spring snowmelt or after periods of heavy rainfall.

5.4 Highway 11 - East Ditch (BH 11-01 to 11-10 located ~4 m east of embankment toe)

5.4.1 Ice/Water

Ice and water were encountered at the surface in Boreholes BH11-05, BH11-06, BH11-07, BH11-08 and BH11-09. The ice/water surface ranged from Elevations 291.0 m to 290.5 m, with thicknesses varying from 0.4 m to 0.9 m.

5.4.2 Peat/Organics

Layers of peat and organic matter were encountered at the ground surface in Boreholes BH11-01, BH11-02, BH11-03, BH11-04 and BH11-10. In Boreholes BH11-05 and BH11-06 the peat layer was encountered underlying a silty clay layer. In Boreholes BH11-07 and BH11-08 the peat and organic matter were encountered below the ice/water and in Borehole BH11-09 the peat was encountered below a sandy silt layer. The thicknesses of the peat/organics deposits ranged from 50 mm to 2.3 m, typically less than 0.6 m, with underside from Elevations 293.0 m to 287.2 m. These soils are described as very soft to firm based on SPT N-values between 0 and 8.

The peat/organics were dark brown in colour. The moisture content ranges from 22% to 526%, typically higher than 100%.

5.4.3 Clayey Silt/Silty Clay

Layers of clayey silt with organics and roots were encountered below the organics in Boreholes BH11-03 and BH11-04, and layers of silty clay were encountered just below the

ice in Boreholes BH11-05 and BH11-06. These layers extended to depths ranging from 0.6 m to 3.6 m. The underside of the clayey silt deposit ranged from Elevations 290.8 m to 289.4 m. The thickness of the clay deposit ranges from 0.4 m to 0.7 m.

The clayey silt layer is generally soft to very stiff in consistency. The soil is dark brown to grey in colour. The SPT N-values ranged from 2 to 18. The moisture content varied from 24% to 36%, with an upper value of 132% which is likely due to organic content.

In Borehole BH11-06 a 2.0 m thick layer of clayey silt, trace sand was encountered at 5.2 m depth between the silt and sand deposits. This cohesive soil is soft in consistency, with an average SPT N-value of 3. Moisture contents of 26% and 27% were measured in this soil layer.

Additionally, a 0.4 m thick layer of clayey silt, some sand and trace gravel was encountered at 2.5 m depth between the upper and lower deposits of sand in Borehole BH11-10. This cohesive layer is hard in consistency, with an SPT N-value of 37. A moisture content of 27% was measured in this layer.

The grain size distributions of selected samples of these cohesive soils are reported on the Record of Borehole sheets and gradation test results (Figures B5) are summarized below:

Soil Particles	(%)
Gravel	0 to 1
Sand	2 to 16
Silt	61 to 74
Clay	22 to 24

5.4.4 Silt

A deposit of silt, trace clay and trace sand was encountered underlying the clayey silt in Borehole BH11-04 and the peat in Borehole BH11-06. The underside of the silty deposits ranged from Elevations 287.7 m to 285.5 m. The thickness of the silt deposit ranges from 1.6 m to 1.9 m.

This silt layer is generally firm to stiff, with undrained shear strength values measured by in-situ vane tests of 41 and 53 kPa. The moisture content varied from 22% to 43%.

The grain size distributions of selected samples of this soil are reported on the Record of Borehole sheets and gradation test results (Figures B2 and B3) are summarized below:

Soil Particles	(%)
Sand	2
Silt	90 to 94
Clay	4 to 8

Atterberg Limit test (Figure B10) performed on one selected sample indicates that the clayey silt has intermediate plasticity..

5.4.5 Sandy Silt

Deposits of silt, trace sand to sandy, and trace to some clay were encountered underlying the peat layer in Boreholes BH11-01, BH11-02, BH11-05, BH11-07, and BH11-08, below the clayey silt in BH11-03, and below the ice in BH11-09. The underside of the sandy silt layer ranged from Elevations 288.9 m to 281.5 m. The thickness of this cohesionless deposit ranges from 0.6 m to at least 8.2 m. Borehole BH11-02 was terminated within this deposit at Elevations 281.5 m.

This silt is very loose to very dense, typically compact. SPT N-values ranged from 1 to 52, typically 10. The moisture content varied from 11% to 54%.

The grain size distributions of selected samples of this soil are reported on the Record of Borehole sheets and gradation test results (Figures B2 and B3) are summarized below:

Soil Particles	(%)
Gravel	0 to 4
Sand	3 to 29
Silt	61 to 89
Clay	4 to 12

5.4.6 Sand

Deposits of sand, some silt to silt and sand, trace clay, trace gravel were encountered underlying the silt deposits in Boreholes BH11-01, BH11-04, BH11-05, BH11-06, and BH11-07 and below the peat in Borehole BH11-09. The thickness of this soil layer varied from 0.6 m to 4.7 m. Boreholes BH11-04, BH11-05, BH11-06 and BH11-09 were terminated within this deposit at Elevations ranging from 288.1 m to 280.0 m.

Based on SPT N-values ranging from 8 to 59, this soil is classified as loose to very dense. High blow counts of more than 100 blows for less than 0.30 m penetration was noted at the refusal depths.

The measured natural moisture contents ranged from 11% to 38% and the soil is described as moist to wet.

The grain size distributions of selected samples of this soil are reported on the Record of Borehole sheets and shown in Figure B7 in Appendix B. The gradation data is summarized below:

Soil Particles	(%)
Gravel	1 to 9
Sand	42 to 86
Silt and Clay	10 to 57

5.4.7 Sand and Gravel

Deposits of Sand and Gravel, Sandy Gravel and Gravelly Sand were encountered in Boreholes BH11-01, BH11-03, BH11-07, BH11-08 and BH11-10. These boreholes were terminated within these layers at Elevations ranging from 287.2 m to 280 m. The thickness of these layers ranged from at least 0.2 m to 1.7 m.

SPT N-values of 8 to more than 100 blows for less than 0.30 m of penetration were measured, indicating a loose to very dense conditions.

The measured natural moisture contents were between 6 to 15% and the soil is described as wet.

The grain size distributions of selected samples of this soil are reported on the Record of Borehole sheets and shown in Figure B9 in Appendix B. The gradation data is summarized below:

Soil Particles	(%)
Gravel	33 to 38
Sand	47 to 57
Silt & Clay	13 to 16

5.4.8 Bedrock

The top of bedrock elevation was inferred from auger refusal. Some of the referred depths may be on a probable boulder. Depth to inferred bedrock and top of bedrock elevations from the borehole information are summarized below:

Borehole	Depth to Inferred Bedrock (m)	Elevation of Top of Inferred Bedrock (m)
BH11-01	4.3	285.9
BH11-02	8.8	281.5
BH11-03	6.3	285.0
BH11-04	7.3	285.7
BH11-05	2.9	288.1
BH11-06	8.6	282.0
BH11-07	10.5	280.0
BH11-08	3.4	287.2
BH11-09	4.0	286.9
BH11-10	4.1	287.2

5.4.9 Water Levels

The groundwater depths and elevations monitored in the piezometers are shown in the following table.

Borehole	April 07 and 12, 2011		May 04, 2011		May 05, 2011	
	Depth (m)	Elev. (m)	Depth (m)	Elev. (m)	Depth (m)	Elev. (m)
BH11-02	0.9	289.4	0.6	289.7	0.7	289.6
BH11-04	1.7	291.3	1.7	291.3	1.6	291.4
BH11-06	0.0	290.7	0.1	290.6	0.2	290.5
BH11-09	0.0	290.9	-	-	-	-

The water levels measured in the borehole at the completion of drilling is shown in the following table:

Borehole	April 06 to 15, 2011	
	Depth (m)	Elev. (m)
BH11-01	0.9	289.3
BH11-02	1.2	289.1
BH11-03	2.0	289.4
BH11-04	2.1	290.9
BH11-05	0.2	290.8

Borehole	April 06 to 15, 2011	
	Depth (m)	Elev. (m)
BH11-06	0.0	290.7
BH11-07	0.0	290.5
BH11-08	0.0	290.6
BH11-09	0.0	290.9
BH11-10	0.1	291.2

The above values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level will be influenced by water level in Pan Lake and may fluctuate in elevation after spring snowmelt or after periods of heavy rainfall.

5.5 Highway 11 - East Shoulder North of Robin Creek (BH 11-13 to 11-17)

5.5.1 Asphalt

Asphalt was encountered at the ground surface in Boreholes BH11-13 to BH11-17. The thickness ranged from 38 mm to 50 mm.

5.5.2 Granular Fill

Sand fill with trace gravel to gravelly and trace silt was encountered below the asphalt in Boreholes BH11-13 to BH11-17. The granular fill layer extends to depths varying from 1.1 m to 4.4 m with the underside Elevations ranging from 296.8 m to 291.3 m. Boreholes BH11-16 and BH11-17 were terminated within this fill at Elevations 296.8 m and 295.3 m respectively. This fill layer is described as very loose to very dense with SPT values between 1 blow for 0.30 m of penetration to more than 100 blows for less than 0.30 m of penetration.

This fill was brown in colour. The moisture content ranges from 1% to 12%, being typically described as moist.

The grain size distribution of the granular fill can be found in Appendix B as Figure B1. The gradation of the fill is summarized as follows:

Soil Particles	(%)
Gravel	21 to 31
Sand	65 to 72
Silt and Clay	4 to 9

5.5.3 Rockfill

Rockfill was encountered below the granular fill in Borehole BH11-13. The thickness of this fill was 3.1 m, with underside at Elevation 288.3 m.

5.5.4 Silt

A deposit of silt, some sand, trace gravel and trace clay, was encountered underlying the rockfill in BH11-13. The thickness of this cohesionless deposit was 2.4 m. Borehole BH11-13 was terminated in this deposit at Elevation 286.0 m.

This silt is loose to compact, becoming very dense at the refusal depth. SPT N-values ranged from 9 to 60. The moisture content varied from 17% to 25%.

The grain size distributions of selected samples of this soil are reported on the Record of Borehole sheets and gradation test results (Figures B4) are summarized below:

Soil Particles	(%)
Gravel	2 to 4
Sand	12
Silt	80 to 81
Clay	4 to 5

5.5.5 Sand and Silt

Deposits of sand and silt, trace gravel and trace clay were encountered below the gravelly sand deposit in Borehole BH11-14 and underlying the granular fill in Borehole BH11-15. The thickness of this soil layer was 1.1 m and 0.9 m. The underside of this cohesionless layer is at Elevations 289.0 m and 292.7 m.

Based on SPT N-values ranging from 10 to 28, this soil is classified as compact.

The measured natural moisture contents ranged from 18% to 25% and the soil is described as wet to moist.

A 1.1 m thick layer of sand, some gravel and trace silt was encountered at 7.6m depth in BH11-14. This soil was loose to very dense, with SPT N-values of 7 blows and 156 blows for 0.20 m of penetration. The measured moisture contents were 13% and 16%, being described as wet. Borehole BH11-14 was terminated within this deposit at Elevation 284.9 m.

The grain size distributions of selected samples of these soils are reported on the Record of Borehole sheets and shown in Figures B7 and B8 in Appendix B. The gradation data is summarized below:

Soil Particles	(%)
Gravel	0 to 11
Sand	44 to 82
Silt	7 to 38
Clay	9 to 14

5.5.6 Gravelly Sand/Gravel

A layer of Gravelly Sand was encountered below the granular fill in Borehole BH11-14 and underlying the sand and silt layer in BH11-15. The thickness of these layers was 1.2 m and 0.6 m, with underside at Elevations 290.1 m and 292.2 m. A 3 m thick layer of Gravel with Cobbles, with underside at Elevation 286.0 m, was encountered underlying the sand and silt layer in Borehole BH11-14.

SPT N-values of 3 to 50 blows for 0.15 m of penetration were measured, indicating a loose to very dense condition.

The measured natural moisture content ranged from 6% to 17% and the soil is described as wet.

The grain size distributions of selected samples of this soil are plotted on the Record of Borehole sheets and shown in Figure B9 in Appendix B. The gradation data is summarized below:

Soil Particles	(%)
Gravel	31
Sand	58
Silt & Clay	11

5.5.7 Bedrock

Bedrock was cored in Borehole BH11-15 and the bedrock is described as granite. The bedrock is blackish grey in colour, slightly weathered to fresh and strong.

In a number of the boreholes, the top of bedrock elevation was inferred from auger refusal.

Depth to bedrock and top of bedrock elevations from the borehole information are summarized below:

Borehole	Depth to Bedrock (m)	Elevation of Top of Bedrock (m)
BH11-13	7.4	286.0*
BH11-14	8.7	284.9*
BH11-15	3.6	292.2**
BH11-16	1.1	296.8*
BH11-17	4.4	295.3*

* resual on probable boulder or inferred bedrock

** bedrock cored

5.5.8 Water Levels

The groundwater depths and elevations monitored in the piezometers are shown in the following table.

Borehole	May 05, 2011	
	Depth (m)	Elev. (m)
BH11-13	2.50	290.8

The water level measured at the completion of boreholes without piezometer installation is showing as following:

Borehole	May 04 and 05, 2011	
	Depth (m)	Elev. (m)
BH11-14	2.6	291.0
BH11-15	2.9	292.9
BH11-17	Dry	

The above values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level will be influenced by the water level in Robins Creek and may fluctuate in elevation after spring snowmelt or after periods of heavy rainfall.

5.6 Robin Creek Culvert (BH RCC-1 and RCC-2)

5.6.1 Water

Standing water was encountered at the surface in Boreholes RCC-1 and RCC-2. The water surface was at Elevation 290.8 m, and the depth of water ranged from 1.4 to 1.5m.

5.6.2 Peat

Peat was encountered in Borehole RCC-2 only. The thickness of the peat deposit was 0.6 m, with underside at Elevation 288.7 m. This soil is described as very soft based on one SPT N-value of 1.

The peat/organics was dark brown in colour. The measured moisture content was 129%.

5.6.3 Sand

A 0.4 m thick layer of sand, trace gravel and trace silt was encountered in Borehole RCC-1. The underside of this deposit was at Elevation 289.0 m.

Based on one SPT N-value of 7, this soil is classified as loose. The moisture content of this layer is about 52%.

5.6.4 Clayey Silt

A 1.3 m thick layer of clayey silt was encountered below the peat deposit in Borehole RCC-2. This soil extends to a depth of 3.4 m, with underside at Elevation 287.4 m.

The clayey silt layer is soft to firm in consistency and it is grey in colour. The SPT N-values were 2 and 8. The measured water contents were 32% and 47%.

The grain size distribution of one sample of this soil is reported on the Record of Borehole sheets and gradation test results (Figures B5) are summarized below:

Soil Particles	(%)
Sand	6
Silt	67
Clay	27

5.6.5 Sandy Silt

Deposits of silt, trace sand to sandy, and trace to some clay were encountered underlying the sand layer in Borehole RCC-1 and the clayey silt in Borehole RCC-2. The underside of the silt deposits ranged from Elevations 281.6 m to 281.3 m. The thickness of this cohesionless deposit ranges from 7.3 m to 6.0 m. Borehole RCC-1 was terminated within this deposit at Elevation 281.6 m.

This silt is loose to very dense, typically compact. SPT N-values ranged from 4 to 127. The moisture content varied from 10% to 28%.

The grain size distributions of selected samples of this soil are reported on the Record of Borehole sheets and gradation test results (Figures B4 and B8) are summarized below:

Soil Particles	(%)
Gravel	0 to 17
Sand	23 to 50
Silt	29 to 72
Clay	4 to 5

5.6.6 Gravel

A deposit of gravel was encountered below the sandy silt in Borehole RCC-2. This borehole was terminated within this layer at Elevation 280.7 m. This layer is 0.7 m thick.

SPT N-values of 78 and 100 blows for 0.025 m of penetration were measured, indicating a very dense layer.

The measured natural moisture content was about 10% and the soil is described as wet.

The grain size distribution of one selected sample of this soil is reported on the Record of Borehole sheets and shown in Figure B9 in Appendix B. The gradation data is summarized below:

Soil Particles	(%)
Gravel	44
Sand	24
Silt & Clay	32

5.6.7 Bedrock

The top of bedrock elevation was inferred from auger refusal. Depth to bedrock and top of bedrock elevations from the borehole information are summarized below:

Borehole	Depth to Inferred Bedrock (m)	Elevation of Top of Inferred Bedrock (m)
RCC-1	9.1	281.6
RCC-2	10.1	280.7

5.6.8 Water Levels

The water level at the completion of Boreholes RCC-1 and RCC-2 was at surface, at Elevation 290.8 m.

6 MISCELLANEOUS

Surveying of the locations and elevations of the boreholes was provided by MMM Group Limited.

Full time supervision of field drilling, including obtaining utility clearances was carried out by Ms. Eckie Siu of Thurber.

Overall supervision of the field program, interpretation of the data and preparation of the report were carried out by Ms. Luciana Thomasi, M. Sc., Mr. Stephen Peters, E.I.T., and Mr. Jason Lee, P.Eng..

The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

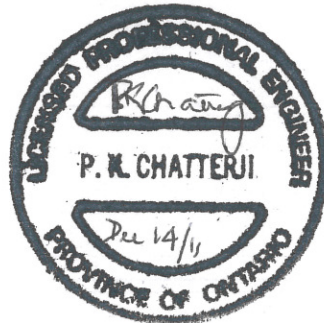
Thurber Engineering Ltd.

Stephen Peters, E.I.T., M.A.Sc.

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Geotechnical Engineer



P.K. Chatterji, P.Eng., Ph.D.
Review Principal.



FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 11 AT PAN LAKE, 9.5 km NORTH OF HIGHWAY 64
EMBANKMENT FROM STATION 14+550 TO 15+210
TOWNSHIP OF OLIVE, ONTARIO
G.W.P 5578-04-00
GEOCREs No.: 31L-151

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 INTRODUCTION

This report presents interpretation of the geotechnical data in the factual report and presents a geotechnical assessment of the stability of the existing Highway 11 embankment adjacent to Pan Lake.

According to the Terms of Reference, the existing embankment (near Sta. 14+550 to 14+770) is thought to have undergone historical slope movement and settlement. A previous foundation investigation report prepared by AMEC in 2008² indicates marginal stability of the highway embankment at around Sta. 14+600 and photographs in the report indicate signs of cracking and distress in the south bound lane. The potential movement noted at that time was towards Pan Lake. AMEC reported that the instability in this area may be due to there being a soft layer of soil buried under the embankment rockfill and to the embankment side slope being too steep. The presence of the buried, soft layer was not confirmed in the AMEC investigation.

This report presents the results of embankment stability analysis in the subject zone between Sta. 14+550 and 14+770 using additional data collected during the present investigation. Boreholes BH 11-11 and 11-12 drilled during the present investigation did not encounter any soft clay or peat trapped underneath the rockfill embankment as suspected previously. Potential remediation measures to increase the factor of safety against slope movement are described and a recommendation is presented for the preferred course of action.

The discussion and recommendations presented in this report are based on the highway geometric information provided by MMM Group Limited and on the factual data obtained in the course of the current investigation and the data obtained from the AMEC investigation.

8 ENGINEERING ANALYSIS

The preparation of the subsurface models used in the stability analysis involved a compilation of the available borehole data plus field and laboratory tests. Subsurface conditions and soil properties along Highway 11 between Sta. 14+550 and 14+770 (i.e. area of concern) have been summarized

² Foundation Investigation Report – Highway 11 at Pan Lake, 10.6 km north of Highway 64 – Station 14+750 to 14+950, in Olive Township – 03 September 2008 GEOCREs No. 31L-123.

on the Borehole Locations and Soil Strata Drawing in Appendix C and on the stability analysis output plots shown in Appendix D.

8.1 Stability Analysis

In the areas of concern, embankment and foundation stability was evaluated by limit equilibrium analysis. All slope stability analyses were carried out using the commercially available software G-Slope (Version 4.12), developed by Mitre Software Corporation. The embankment geometry (i.e. height and width at the pavement level) was determined from the highway profiles and survey data provided by MMM Group.

The stability analysis was carried out based on the following assumptions:

- Method of Analysis: Bishop's Modified Method (using Circular Slip Surface)
- Soil Shear Strength:
 - Undrained shear strength (S_u) for cohesive foundation soils is based on shear vane data.
 - The drained parameters of cohesion (c') and friction angle (ϕ') were estimated based on empirical correlations.
- Groundwater Table:
 - Based on the groundwater levels measured in the field.

The analysis was carried out in terms of both total and effective stresses in the foundation soils. The results of the analysis are presented in Appendix D and summarized as follows:

Station	Fill Height (m)	Case	Factor of Safety	Figure in Appendix D
14+560	5.5	Effective Stress Analysis	1.44	D1
		Total Stress Analysis	1.44	D4
14+600	4.7	Effective Stress Analysis	1.20	D2
		Total Stress Analysis	1.20	D5
14+670	2.7	Effective Stress Analysis	1.40	D3
		Total Stress Analysis	1.40	D6

8.2 Significance of Stability Analysis Results

The above results indicate that the existing stability of the Highway 11 embankment at the north and south limits of the area of concern is generally satisfactory with estimated factor of safety (FS) values equal to or greater than 1.4. However, there is a short section around Sta. 14+600 where the calculated FS is 1.2. This value is lower than the target minimum value for FS of 1.3 and is considered to be indicative of marginally stable conditions with the possibility of creep movement occurring in the slope. However, the stability calculation is based on assessed strength parameters and on an assumed failure geometry.

The analytical section that yielded the FS = 1.2 result coincides with the area in which pavement cracking and outward bowing of highway guiderail indicate that the embankment has likely undergone some lateral movement. It is also the area with the locally steepened side slope and evidence of cracking in the pavement.

However, the following factors also need to be taken into consideration:

- No maintenance reports have been made available to indicate an on-going problem
- The pavement does not appear to have been patched since the last paving contract in the area
- Although the pavement has evidently settled and cracked in the past, there is no evidence of recent movement

Considering all the above factors, there does not appear to be an immediate warrant for remedial construction work in this area and it is recommended that the stability of the slope be monitored for a period of 2 years before any commitment is made to remedial work. The advantages of monitoring are:

1. The data collected during monitoring will allow an assessment to be made as to whether there is on-going movement that warrants remedial work
2. The location of the plane of movement will be determined and that, in turn, will allow a more accurate analysis of the factor of safety in the slope.
3. Knowing the location of the plane of movement will also assist in refining the option for remedial work.

It is recommended that the monitoring program be based on an inclinometer installed in the Southbound shoulder at the critical section of the embankment. The proposed program has been addressed separately.

8.3 Potential Remedial Options

It is recommended that remedial work only be carried out after the results of the monitoring program have been studied and it is determined that there is on-going movement that warrants such work.

The following five possible options have been considered for the remedial work:

- Option 1: Flattening of the embankment slope below the highway to 2H:1V to increase resisting force. This will require fill placement in Pan Lake;
- Option 2: Berm construction at the highway embankment toe to increase resisting force. This will require fill placement in Pan Lake;
- Option 3: Installation of retaining structure to increase resisting force;
- Option 4: Use of geosynthetic reinforcement to increase resisting force;
- Option 5: Use of light weight fill in the top half of the embankment to reduce driving force.

The advantages and disadvantages of the above options are provided in a tabulated form in Appendix G.

8.4 Engineering Assessment

Option 1 or Option 2 is the most effective solution from a geotechnical standpoint. However MTO have advised that encroachment into Pan Lake is not allowed therefore these two options have not been developed further.

The three remedial measures that can meet the criterion of staying out of the water are summarized in the table below:

Treatment Option	Treatment Technique	Treatment Details ⁽¹⁾
3	Increase resisting forces	Installation of a single row of soldier piles parallel to the highway centreline and located immediately behind the SBL guiderail and with toes of piles advanced 1.5m into bedrock.
4	Increase resisting forces	Installation of geosynthetic reinforcement near the base of the sand fill layer at approximate elevation 292.5m. Width of treatment (perpendicular to the roadway) must extend from the outside edge of the northbound shoulder to the edge of the embankment on the west facing slope.
5	Decrease driving forces	Partial replacement of sand fill with a 1m thick layer of EPS ⁽³⁾ . Width of treatment (perpendicular to the roadway) must extend from the centerline of the highway to near the edge of the embankment on the west facing slope. A minimum soil cover of 0.5 m is required above the EPS.

Notes: (1) Length of treatment parallel to roadway is from approximate sta. 14+560 to sta. 14+670,
 (2) Tensile strength shown for geosynthetic is the long term design strength (LTDS), considering material durability, installation damage and creep effect,
 (3) EPS29 or better

The feasibility and effectiveness of each option are discussed below.

Option 3 (Installation of retaining structure)

Option 3 consists of installing a single row of soldier piles in the slope in order to retain the mass of soil within the potential zone of movement and to push any possible failure surface deeper and thus increase the factor of safety. Stability analysis, using the back-calculated strength parameters, shows that a resisting force of 50 kN per metre length acting perpendicular to the highway centreline is required to bring the factor of safety to 1.3, which is regarded as the minimum acceptable value for long term stability.

Drilled soldier piles have been assumed due to the consideration of constructability for piles installed through rock fill. To provide sufficient factor of safety in the slope, the pile toes must be advanced 1.5 m into bedrock.

A range of possible pile diameter has been considered ranging from 340 mm to 900 mm. The lateral capacities of various pile diameters are listed below:

Pile Diameter, D (m)	Ultimate Capacity, P_u (kN)	Factored Capacity P_f (kN)
0.9	500	250
0.6	410	205
0.34	100	50

Based on these factored capacities, a pile spacing was calculated and, in the case of the 0.34 m diameter pile, corrected to account for capacity reduction due to pile interaction. The resulting numbers of piles are as shown below.

Pile Diameter, D (m)	Initial Calculation of Pile Spacing (m)	Pile Spacing Adjusted for Interaction (m)	Final Number of Piles
0.9	3.6	3.6	29
0.6	2.4	2.4	43
0.34	1.0	0.9	113

The larger diameter piles have the benefit of being structurally stiffer, but the 340 mm diameter pile is recommended since it can be installed using smaller equipment and occupying only one lane of the highway. The above analysis shows that to increase the estimated factor of safety from 1.2 to a minimum of 1.3 requires 340 mm diameter piles installed into bedrock and a spacing of 900 mm on center. The piles can be installed in a line immediately behind the guiderail and should be cut off just below ground level. It is recommended that the tips of the piles be advanced 1.5 m into bedrock. The elevation of bedrock, for estimating purposes, is available on Borehole Location and Soil Strata Drawing No. 2 (Profile along Southbound Shoulder).

These piles must be designed structurally to resist a lateral load of 150 kN per pile. The piles have to be installed through sand fill, rock fill and the underlying native soils. It is recommended that a cased hole be advanced and that the casing be left in place permanently.

Of the three options remaining under consideration, this is the geotechnically preferred option as it provides positive resistance to ongoing, deep-seated movement. If the remedial work is warranted, the final pile diameter and spacing must be re-visited based on the monitoring results of the slope inclinometer. The depth of lateral movement in the embankment is key information for the final pile design.

Option 4 (Use of geosynthetic reinforcement)

In this option, reinforcement of the upper levels of the embankment is provided by a single layer of UX 1800 HS geogrid (or equivalent) placed 300 mm above the top of the rock fill.

The geogrid must extend from the outside edge of the NB shoulder fully across the highway platform to the edge of the embankment on the west facing slope. In order to provide good mobilization of the interlock between the geogrid and the granular and to reduce the risk of any on-going loss of material into the rock fill, it is recommended that the existing pavement structure and sand fill be excavated to the top of rock fill, Elevation 292.0 m at BH 11-11 falling to Elevation 290.5 at BH 11-12. Excavation must be limited to the sand fill and the underlying rock fill must not be disturbed. After the sand fill has been removed, place a 300 mm thick layer of Granular “B” Type II. The geogrid must be laid on top of the Granular “B” type II and then be covered with a further 300 mm layer of Granular “B” Type II. From the top of this upper 300mm, the remaining fill to the underside of the design pavement structure may be either Granular “B” Type I or Type II. The geogrid must be rolled out perpendicular to the highway centreline and it is recommended that it be placed in complete lengths across the highway.

This option theoretically would stabilize the slide if the active portion of the embankment acted as a rigid body. However, the resisting force is applied near the top of the embankment and will not be effective in controlling deep-seated, creep movements. For this reason, although it would reinforce the pavement and control future cracking, it is not recommended as the preferred geotechnical solution.

Option 5 (Use of light weight fill)

In Option 5, the factor of safety against global instability is increased by reducing the driving forces in the slope by replacing some of the existing sand fill by EPS 29. The EPS should extend from the highway centreline westward to a point where there will be 0.5m minimum cover over it. The EPS should be placed above the rock fill. Thus, the sand fill must be excavated to the top of rock fill, Elevation 292 m at BH 11-11 falling to Elevation 290.5 at BH 11-12. Excavation must be limited to the sand fill and the underlying rock fill must not be disturbed. After the sand fill has been removed, a nominal 100mm layer of Granular “B”

Type II must be placed over the rock fill. The EPS 29 must be placed on the compacted Granular B Type II following which construction to the underside of the design pavement structure can be completed using Granular “B” type I or Type II.

This option only provides an adequate factor of safety when the shear strength of the EPS is taken into consideration in the analysis. Reliance on the shear strength of EPS blocks under shallow cover is not considered to be a prudent design since it will be difficult to control the placement of the individual blocks of EPS in the field to prevent future damage. This option also involves potential icing problems on the pavement. Furthermore this option is not likely to address a deep-seated movement. Accordingly, this option is not recommended.

8.5 Preferred Course of Action

From a geotechnical perspective, the preferred course of action is to monitor the critical section of the embankment for a period of at least 2 years and to base the decision on remedial work on the results of this monitoring.

If, after monitoring, it is concluded that remedial work is warranted, then a design assignment should be arranged to select an effective option based on the findings of the monitoring program.

9 CLOSURE

Engineering analysis and preparation of the report were carried out by Ms. Luciana Thomasi, M.Sc., Mr. Stephen Peters, E.I.T., Mr. Alastair E. Gorman, P.Eng and Mr Jason Lee, P.Eng.

The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.

Jason P. Lee, P.Eng., M.Sc.
Geotechnical Engineer



Alastair Gorman, P.Eng., M.Sc.
Senior Foundations Engineer



Report reviewed by:
P.K. Chatterji, P.Eng., Ph.D.
Review Principal



Appendix A
Record of Borehole Sheets

RECORD OF BOREHOLE No 11-01

1 OF 1

METRIC

W.P. 19-5161-103 LOCATION N 5 189 174.603 E 282 212.612 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2011.04.06 - 2011.04.06 CHECKED BY JPL

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 (%)
								20 40 60 80 100							
290.2															
0.0															
0.1	PEAT: (100mm)														
	SILT, trace sand, some clay, trace roots and rootlets Loose Brown Moist Occasional grey sand seams		1	SS	10		290								
			2	SS	8		289								
			3	SS	10		288								
			4	SS	10		287								
287.3															
2.9	SAND, trace gravel Compact Brown Wet		5	SS	28		286								
286.6															
3.6	SAND and GRAVEL, some silt and clay Compact Brown Wet														
285.9															
4.3	END OF BOREHOLE AT 4.3m UPON AUGER REFUSAL ON PROBABLE BOULDER OR BEDROCK. WATER LEVEL AT 0.9m UPON COMPLETION. BOREHOLE BACKFILLED WITH HOLEPLUG TO 2.4m, THEN CUTTINGS TO SURFACE.														

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

RECORD OF BOREHOLE No 11-02

1 OF 2

METRIC

W.P. 19-5161-103 LOCATION N 5 189 224.419 E 282 215.261 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2011.04.06 - 2011.04.06 CHECKED BY JPL

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						
290.3								20 40 60 80 100						
0.0	PEAT , wood fibres Soft Dark Brown Wet		1	SS	3		290						137	
289.7														
0.6	SILT , some sand, trace roots and rootlets, mixed with peat Very Loose Grey/Dark Brown Moist		2	SS	1		289							
288.8														
1.5	SILT , trace sand, trace to some clay, occasional sand pockets Loose Brown Moist		3	SS	4		288							
	Becoming grey		4	SS	4		287							
			5	SS	6		286							
							285							
	Sand seams Compact		6	SS	16		284							
							283							
			7	SS	10		282							
	Becoming sandy, trace gravel Very Dense Grey Wet Occasional cobbles		8	SS	52									
281.5														
8.8	END OF BOREHOLE AT 8.8m UPON AUGER REFUSAL ON PROBABLE BOULDER OR BEDROCK. WATER LEVEL AT 1.2m UPON COMPLETION. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.													

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

METRIC

[illegible]

RECORD OF BOREHOLE No 11-03

1 OF 1

METRIC

W.P. 19-5161-103 LOCATION N 5 189 282.596 E 282 219.803 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2011.04.06 - 2011.04.06 CHECKED BY JPL

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										
291.4								20 40 60 80 100										
0.0	ORGANICS: (150mm)							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										
0.2	Clayey SILT, some sand, trace organics		1	SS	2	▽	291											
290.8	Soft						290											
0.6	Brown																	
	SILT, trace sand, trace to some clay, occasional oxide staining		2	SS	8													
	Loose to Compact																	
	Brown																	
	Moist to Wet																	
			3	SS	7													
	Occasional sand seams		4	SS	12			289										
			5	SS	10		288											
							287											
			6	SS	6													
							286											
285.3																		
6.1	Sandy GRAVEL		7	SS	100/													
285.0	Very Dense																	
6.3	Brown				0.100													
	Wet																	
	END OF BOREHOLE AT 6.3m UPON REFUSAL ON BEDROCK. WATER LEVEL AT 2.0m UPON COMPLETION. BOREHOLE BACKFILLED WITH HOLEPLUG TO 3.9m, THEN CUTTINGS TO SURFACE.																	

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

RECORD OF BOREHOLE No 11-04

1 OF 1

METRIC

W.P. 19-5161-103 LOCATION N 5 189 376.732 E 282 227.452 ORIGINATED BY ES
HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2011.04.06 - 2011.04.06 CHECKED BY JPL

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						
293.0								20 40 60 80 100						
0.0	ORGANICS: (50mm) Clayey SILT , trace sand, trace roots and rootlets, occasional oxide staining Firm to Very Stiff Brown/Grey Moist		1	SS	5		293	○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
			2	SS	6		292	20 40 60 80 100						0 2 74 24
	Occasional sand seams		3	SS	12		291	20 40 60 80 100						
			4	SS	18		290	20 40 60 80 100						
			5	SS	11		289	20 40 60 80 100						
289.4								20 40 60 80 100						
3.6	SILT , trace sand, trace clay Firm Grey Moist		1	TW			289	20 40 60 80 100						0 2 94 4 No sample for WC testing
							288	20 40 60 80 100						
287.7								20 40 60 80 100						
5.2	SAND , trace gravel, some silt and clay, occasional cobbles Compact Brown Wet		6	SS	30		287	20 40 60 80 100						4 86 10 (SI+CL)
			7	SS	19		286	20 40 60 80 100						
285.7								20 40 60 80 100						
7.3	END OF BOREHOLE AT 7.3m UPON AUGER REFUSAL ON PROBABLE BOULDER OR BEDROCK. WATER LEVEL AT 2.1m UPON COMPLETION. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Apr. 07/ 11 1.68 291.32 May. 04/ 11 1.71 291.29 May. 05/ 11 1.60 291.4							20 40 60 80 100						

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

RECORD OF BOREHOLE No 11-05

1 OF 1

METRIC

W.P. 19-5161-103 LOCATION N 5 189 432.912 E 282 229.558 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2011.04.06 - 2011.04.06 CHECKED BY JPL

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						
								20 40 60 80 100						
								20 40 60 80 100						
						20 40 60 80 100					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			
						20 40 60 80 100					W P W W L			
						20 40 60 80 100					WATER CONTENT (%)			
						20 40 60 80 100								
						20 40 60 80 100								
						20 40 60 80 100								
						20 40 60 80 100								
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+³, ×³: Numbers refer to
Sensitivity







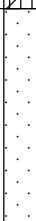
20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 11-06

1 OF 2

METRIC

W.P. 19-5161-103 LOCATION N 5 189 486.807 E 282 241.686 ORIGINATED BY ES
HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2011.04.06 - 2011.04.06 CHECKED BY JPL

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					
								WATER CONTENT (%)							
290.7						20	40	60	80	100	PLASTIC LIMIT W P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W L		
0.0	ICE		1	SS	2		290								
290.1															
0.6	Silty CLAY , some peat Very Soft Grey to Dark Brown Wet		2	SS	2		289							132	
289.3															
1.3	PEAT , amorphous, trace roots Very Soft Dark Brown Wet		3	SS	1		289							128	
			4	SS	1		288							126	
287.4															
3.3	SILT , trace clay, trace sand Very Soft Grey Moist (MI-OI)		5	SS	1		287							131	
			6	SS	2		286								0 2 90 8
			1	TW			286								
285.5															
5.2	Clayey SILT , trace sand Soft Grey Wet		7	SS	3		285								
			8	SS	3		284								0 5 73 22
283.5															
7.2	SAND , trace gravel Compact Grey Wet		9	SS	25		283								
282.0															
8.6	END OF BOREHOLE AT 8.6m UPON AUGER REFUSAL ON PROBABLE BOULDER OR BEDROCK. WATER LEVEL AT SURFACE UPON COMPLETION. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS:														

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 11-06

2 OF 2

METRIC

W.P. 19-5161-103 LOCATION N 5 189 486.807 E 282 241.686 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2011.04.06 - 2011.04.06 CHECKED BY JPL


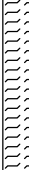


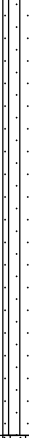

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					W P W W L 20 40 60					
	Continued From Previous Page																
	DATE DEPTH (m) ELEV. (m) Apr. 07, 11 On Surface 290.70 May. 04/ 11 0.12 290.58 May. 05/ 11 0.16 290.54																

RECORD OF BOREHOLE No 11-07

1 OF 2

METRIC

W.P. 19-5161-103 LOCATION N 5 189 517.835 E 282 251.139 ORIGINATED BY ES
HWY 11 BOREHOLE TYPE Tripod/Casing COMPILED BY AN
DATUM Geodetic DATE 2011.04.13 - 2011.04.13 CHECKED BY JPL

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							
290.5								20 40 60 80 100							
0.0	WATER														
289.6															
0.9	ORGANICS , mixed with roots, trace silt Very Soft Dark Brown Wet		1	SS	1									373	
288.4			2	SS	0									88	
2.1	PEAT , amorphous, trace silt, trace roots and rootlets Very Soft to Soft Dark Brown Wet		3	SS	1										
287.2			4	SS	3									102	
3.2	SILT , trace to some clay, trace sand Loose to Compact Grey Wet		5	SS	5										
	Trace black sand seams		6	SS	16										0 9 79 12
			7	SS	18										
	Sandy		8	SS	14										
284.6															
5.8	SILT and SAND , fine grained, trace clay, trace gravel Loose to Compact Grey Wet		9	SS	19										
			10	SS	10										
			11	SS	8										1 42 54 4
			12	SS	14										
			13	SS	29										
281.7															
8.8	Silty SAND , trace gravel, trace clay Compact to Very Dense Grey Wet		14	SS	17										
			15	SS	59										9 58 33 (SI+CL)

Continued Next Page

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

RECORD OF BOREHOLE No 11-07

2 OF 2

METRIC

W.P. 19-5161-103 LOCATION N 5 189 517.835 E 282 251.139 ORIGINATED BY ES
HWY 11 BOREHOLE TYPE Tripod/Casing COMPILED BY AN
DATUM Geodetic DATE 2011.04.13 - 2011.04.13 CHECKED BY JPL

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																
280.2			16	SS	138												
280.0	Gravelly SAND Very Dense Brown Wet																
10.5	END OF BOREHOLE AT 10.5m UPON REFUSAL ON BEDROCK. WATER LEVEL AT SURFACE UPON COMPLETION. BOREHOLE BACKFILLED WITH SAND TO SURFACE.						280										

RECORD OF BOREHOLE No 11-08

1 OF 1

METRIC

W.P. 19-5161-103 LOCATION N 5 189 563.586 E 282 271.908 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Tripod/Casing COMPILED BY AN
 DATUM Geodetic DATE 2011.04.15 - 2011.04.15 CHECKED BY JPL

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									
290.6						▽	290	20	40	60	80	100					
0.0	ICE							20	40	60	80	100					
0.2	WATER																
290.0																	
0.6	PEAT, roots and rootlets Soft Dark Brown Moist		1	SS	2												
289.5							289										33 54 13 (SI+CL)
1.1	SILT, some sand Compact Grey Moist		2	SS	23												
288.9																	
1.7	Gravelly SAND, some silt and clay Loose to Compact Brown Wet Trace bedrock fragments		3	SS	8												
			4	SS	19												
			5	SS	110/ 0.250		288										
287.2																	
3.4	END OF BOREHOLE AT 3.4m UPON REFUSAL ON BEDROCK. WATER LEVEL AT SURFACE UPON COMPLETION. BOREHOLE BACKFILLED WITH SAND TO SURFACE.																

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 11-09

1 OF 1

METRIC

W.P. 19-5161-103 LOCATION N 5 189 622.685 E 282 303.204 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Tripod/Casing COMPILED BY AN
 DATUM Geodetic DATE 2011.04.12 - 2011.04.12 CHECKED BY JPL

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						
290.9								20 40 60 80 100						
0.0	ICE		1	SS	1									
290.4														
0.6	Sandy SILT, trace to some clay Compact Brown Wet		2	SS	17		290							
	occasional burnt wood fibres, occasional organics		3	SS	20									0 29 60 10
288.9														
2.0	PEAT, wood fibres Firm Dark Brown Wet		4	SS	8		289					103		
288.5														
2.4	SAND, trace gravel Loose Brown Wet		5	SS	7		288							
			6	SS	5									
286.9			7	SS	158/ 0.200		287							
4.0	END OF BOREHOLE AT 4.0m UPON REFUSAL ON BEDROCK. WATER LEVEL AT SURFACE UPON COMPLETION. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Apr 12/11 0 290.9													

+³, ×³: Numbers refer to
Sensitivity

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15
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





(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 11-10

1 OF 1

METRIC

W.P. 19-5161-103 LOCATION N 5 189 657.784 E 282 331.873 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE 3rd Weight Hammer COMPILED BY AN
 DATUM Geodetic DATE 2011.04.11 - 2011.04.11 CHECKED BY JPL

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					○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL				
291.3																							
0.0	ORGANICS Dark Brown Frozen		1	SS	6		291									528							
290.8																							
0.5	SAND , some gravel, some silt, trace clay Compact to Dense Brown Wet		2	SS	17													12	73	14			
																			(SI+CL)				
288.8																							
2.5	Clayey SILT , some sand, trace gravel, occasional cobble		5	SS	37													1	16	60	22		
288.3	Hard Brown Wet																						
2.9	Gravelly SAND , some silt, trace clay Compact to Dense Brown Wet		6	SS	14		288																

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 11-11

1 OF 2

METRIC

W.P. 19-5161-103 LOCATION N 5 189 108.414 E 282 188.645 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2011.05.03 - 2011.05.04 CHECKED BY JPL

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 (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				GR	SA	SI	CL	
								20	40	60	80	100	W _P	W		W _L				
294.2																				
0.0																				
0.1	ASPHALT: (100mm)																			
	SAND, some gravel, trace silt, trace clay Compact to Dense Brown Moist (FILL)		1	SS	32							○								
			2	SS	19							○								
	Occasional cobbles		3	SS	37							○								
292.0																				
2.2	ROCKFILL:																			
											</									

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity



20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 11-11

2 OF 2

METRIC

W.P. 19-5161-103 LOCATION N 5 189 108.414 E 282 188.645 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2011.05.03 - 2011.05.04 CHECKED BY JPL

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												
								20 40 60 80 100												
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
Continued From Previous Page						PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W P W W L WATER CONTENT (%) 20 40 60														
283.5	Compact Grey Wet		9	SS	29		284													
10.7	COBBLES: Compact to Dense Blackish Grey Wet		10	SS	23		283													
			11	SS	33															
282.0	GRANITE , bedrock 400mm cobbles at 13.8m Reddish grey, occasional mechanical breaks, strong Sub-vertical fractures (25mm to 50mm) from 14.2m to 14.7m 50mm broken zone at 16.1m Sub-vertical fractures (25mm to 50mm) at 15.3m, 15.4m, 15.7m, 16.1m, 16.7m, 16.8m, 16.9m 50mm sub-vertical fractures at 16.7m and 17.0m 350mm vertical fractures at 16.9m Sub-horizontal fractures at 17.0m and 17.1m		1	RUN		282														
12.2			2	RUN		281														
			3	RUN		280														
			4	RUN		279														
			5	RUN		278														
276.9							277													
17.3	END OF BOREHOLE AT 17.3m. WATER LEVEL AT 2.5m UPON COMPLETION. BOREHOLE BACKFILLED WITH HOLEPLUG TO 0.1m, THEN ASPHALT TO SURFACE.																			

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 11-12

1 OF 2

METRIC

W.P. 19-5161-103 LOCATION N 5 189 176.423 E 282 193.536 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2011.04.26 - 2011.04.26 CHECKED BY JPL

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 (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				GR	SA	SI	CL
292.7								20	40	60	80	100							
0.0	ASPHALT: (113mm)																		
0.1	Sandy GRAVEL, trace silt, occasional cobbles Very Dense Brown Moist (FILL)		1	SS	71									○					
			2	SS	36									○					76 22 2 (SI+CL)
290.5																			
2.2	ROCKFILL:																		
			3	SS	10														

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 11-12

2 OF 2

METRIC

W.P. 19-5161-103 LOCATION N 5 189 176.423 E 282 193.536 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2011.04.26 - 2011.04.26 CHECKED BY JPL

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 (%)
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE						
	Continued From Previous Page						20	40	60	80	100					GR SA SI CL	
281.6	SILT , trace sand to sandy, trace clay Very Dense Grey Wet to Moist		9	SS	111											0 18 78 4	
11.1	BOULDER: (Granite), blackish grey 125mm sub-vertical fracture at 11.4m		1	RUN												RUN #1 TCR=100% SCR=72% RQD=72%	
	Boulders and cobbles		2	RUN												RUN #2 TCR=100% SCR=0% RQD=0%	
279.6																	
13.1	GRANITE , bedrock, blackish grey, strong Sub-vertical fractures at: 225mm at 13.3m 200mm at 13.6m 50mm at 14.1m 75mm highly broken zones at 13.3m and 13.6m Occasional mechanical breaks 50mm soft zone at 14.1m Very strong Sub-vertical fractures at: 250mm at 14.7m 175mm at 15.3m 125mm at 15.7m 250mm vertical fracture at 15.0m Occasional mechanical breaks		3	RUN												RUN #3 TCR=100% SCR=83% RQD=67%	
			4	RUN												RUN #4 TCR=100% SCR=100% RQD=60%	
276.9	75mm highly broken zone at 15.6m																
15.8	END OF BOREHOLE AT 15.8m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.04m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) May. 04/ 11 2.39 290.31																

RECORD OF BOREHOLE No 11-13

1 OF 1

METRIC

W.P. 19-5161-103 LOCATION N 5 189 532.488 E 282 246.147 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers/Casing/NQ COMPILED BY AN
 DATUM Geodetic DATE 2011.05.04 - 2011.05.04 CHECKED BY JPL

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						
								20 40 60 80 100						
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
							WATER CONTENT (%)							
							PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT w _p w w _L							
293.3														
0.0	ASPHALT: (50mm)													
	SAND, some to trace gravel Compact to Very Dense Brown Moist (FILL)		1	GS			293							
			1	SS	29		292							
291.5			2	SS	73/ 0.200									
1.9	ROCKFILL													
							291							
							290							
							289							
288.3														
5.0	SILT, some sand, trace gravel, trace clay Loose to Compact Grey Wet													
			3	SS	15		288							4 12 80 4
			4	SS	9		287							
	Becoming very dense		5	SS	60									2 12 80 5
286.0														
7.4	END OF BOREHOLE AT 7.4m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.													
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) May. 05/ 11 2.50 290.8													

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 11-14

1 OF 1

METRIC

W.P. 19-5161-103 LOCATION N 5 189 542.937 E 282 249.374 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers/Casing/NQ COMPILED BY AN
 DATUM Geodetic DATE 2011.05.04 - 2011.05.04 CHECKED BY JPL

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						
293.6								20 40 60 80 100						
0.0	ASPHALT: (38mm)													
	Gravelly SAND , trace silt, trace clay Loose to Compact Brown Moist (FILL)		1	GS			293							
			1	SS	24									
			2	SS	8		292							
291.3														
2.3	Gravelly SAND , some silt, mixed with peat Compact Dark Brown Wet		3	SS	20		291							21 72 7 (SI+CL)
			4	SS	7									
290.1														
3.5	SAND and SILT , trace clay, occasional oxide staining Loose Grey Wet		5	SS	10		290							0 53 38 9
289.0														
4.6	GRAVEL , some sand Very Loose to Compact Grey Wet		6	SS	6		289							No sample for WC testing.
	Occasional cobble		7	SS	17		288							
			8	SS	10		287							
			9	SS	3									
286.0														
7.6	SAND , coarse grained, some gravel, trace silt, trace clay Loose to Very Dense Brown Wet		10	SS	7		286							11 82 7 (SI+CL)
			11	SS	156/ 0.200		285							
284.9														
8.7	END OF BOREHOLE AT 8.7m. WATER LEVEL AT 2.6m UPON COMPLETION. BOREHOLE BACKFILLED WITH HOLEPLUG TO 0.4m, CUTTINGS TO 0.1m, THEN ASPHALT TO SURFACE.													

ONTMT4S 1103.GPJ 7/20/11

RECORD OF BOREHOLE No 11-15

1 OF 1

METRIC

W.P. 19-5161-103 LOCATION N 5 189 595.685 E 282 271.285 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers/Casing/NQ COMPILED BY AN
 DATUM Geodetic DATE 2011.05.01 - 2011.05.01 CHECKED BY JPL

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						
								20 40 60 80 100						
295.8														
0.0	ASPHALT: (50mm)													
	SAND, some to trace gravel, occasional cobbles Very Dense Brown Moist (FILL)		1	GS			295							
			1	SS	50/ 0.125									
			2	SS	53		294							
293.7														
2.1	SAND and SILT, trace gravel, some clay Compact Brown Moist		3	SS	28		293							4 43 38 14
292.7														
3.0	Gravelly SAND, some silt, trace clay, trace peat, occasional cobbles Very Dense Brown Damp		4	SS	50/ 0.150									31 58 11 (SI+CL)
292.2														
3.6	GRANITE bedrock, blackish grey, strong		1	RUN			292							RUN #1 TCR=100% SCR=100% RQD=88%
290.7	125mm sub-vertical fracture at 4.8m						291							
5.0	END OF BOREHOLE AT 5.0m. WATER LEVEL AT 2.9m UPON COMPLETION. BOREHOLE BACKFILLED WITH HOLEPLUG TO 0.1m, THEN ASPHALT TO SURFACE.													

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 11-16

1 OF 1

METRIC

W.P. 19-5161-103 LOCATION N 5 189 643.922 E 282 297.201 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers/Casing/NQ COMPILED BY AN
 DATUM Geodetic DATE 2011.05.05 - 2011.05.05 CHECKED BY JPL

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					
298.0								20 40 60 80 100					
0.0	ASPHALT: (50mm)						298						
	Gravelly SAND , trace silt, trace clay		1	GS									
	Brown												
	Moist												
	(FILL)												
	Trace gravel, occasional cobbles		1	SS	133/		297						21 70 9
296.8	Very Dense				0.225								(SH+CL)
1.1	END OF BOREHOLE AT 1.1m UPON REFUSAL ON PROBABLE BEDROCK. BOREHOLE BACKFILLED WITH CUTTINGS TO 0.04m, THEN ASPHALT TO SURFACE.												

RECORD OF BOREHOLE No 11-17

1 OF 1

METRIC

W.P. 19-5161-103 LOCATION N 5 189 687.536 E 282 326.447 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers/Casing/NQ COMPILED BY AN
 DATUM Geodetic DATE 2011.05.05 - 2011.05.05 CHECKED BY JPL

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 (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL	
								20	40	60	80	100	W _P	W	W _L						
299.7																					
0.0	ASPHALT: (40mm)																				
	Gravelly SAND , trace silt Very Loose to Dense Dark Brown to Brown Damp to Moist (FILL)		1	GS																	
			1	SS	39														31 65 4 (SI+CL)		
			2	SS	7																
			3	SS	3																
			4	SS	1																
			5	SS	6																
295.3																					
4.4	END OF BOREHOLE AT 4.4m UPON REFUSAL ON PROBABLE BOULDER OR BEDROCK. BOREHOLE DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH CUTTINGS TO 0.04m, THEN ASPHALT TO SURFACE.																				

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No RCC-1

1 OF 2

METRIC

W.P. 19-5161-103 LOCATION N 5 189 534.691 E 282 254.844 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Tripod/Casing COMPILED BY AN
 DATUM Geodetic DATE 2011.04.12 - 2011.04.12 CHECKED BY JPL

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						
								20 40 60 80 100						
290.8														
0.0	WATER													
289.4							290							
1.4	SAND , trace gravel, trace silt Loose Dark Brown Wet		1	SS	7									
289.0							289							
1.8	SILT , some clay, trace sand Loose to Compact Grey Moist		2	SS	4									0 5 80 15
	Black coarse sand seam at 2.8m		3	SS	10		288							
			4	SS	13									
286.8							287							
4.0	Sandy SILT , trace clay Loose to Very Dense Grey Wet		5	SS	9									0 23 72 5
			6	SS	6		286							
			7	SS	7									
			8	SS	10		285							
	Occasional cobbles		9	SS	7									
			10	SS	17		284							
			11	SS	29		283							
			12	SS	31									
	Becoming silty sand, some gravel, trace clay Granite fragments		13	SS	127		282							17 50 29 4
281.6														
9.1	END OF BOREHOLE AT 9.1m UPON REFUSAL ON BEDROCK. WATER LEVEL AT SURFACE UPON COMPLETION. BOREHOLE CAVED TO 5.1m, BACKFILLED WITH SAND TO													

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No RCC-1

2 OF 2

METRIC

W.P. 19-5161-103 LOCATION N 5 189 534.691 E 282 254.844 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Tripod/Casing COMPILED BY AN
 DATUM Geodetic DATE 2011.04.12 - 2011.04.12 CHECKED BY JPL








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 SURFACE.																

RECORD OF BOREHOLE No RCC-2

1 OF 2

METRIC

W.P. 19-5161-103 LOCATION N 5 189 536.616 E 282 260.706 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Tripod/Casing COMPILED BY AN
 DATUM Geodetic DATE 2011.04.13 - 2011.04.13 CHECKED BY JPL

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					
290.8								20 40 60 80 100					
0.0	WATER							20 40 60 80 100					
289.2								20 40 60 80 100					
1.5	PEAT , trace roots and rootlets Very Soft Dark Brown Wet		1	SS	1			20 40 60 80 100				128	
288.7								20 40 60 80 100					
2.1	Clayey SILT , trace sand Soft to Firm Grey Wet		2	SS	2			20 40 60 80 100					0 6 68 27
								20 40 60 80 100					
	Black coarse sand		3	SS	8			20 40 60 80 100					
287.4								20 40 60 80 100					
3.4	Sandy SILT , trace clay Loose to Very Dense Grey Wet		4	SS	14			20 40 60 80 100					
								20 40 60 80 100					
			5	SS	10			20 40 60 80 100					0 24 71 5
								20 40 60 80 100					
			6	SS	9			20 40 60 80 100					
								20 40 60 80 100					
			7	SS	6			20 40 60 80 100					
								20 40 60 80 100					
			8	SS	12			20 40 60 80 100					
								20 40 60 80 100					
			9	SS	10			20 40 60 80 100					
								20 40 60 80 100					
			10	SS	15			20 40 60 80 100					0 32 63 5
								20 40 60 80 100					
	Trace to some gravel		11	SS	24			20 40 60 80 100					
								20 40 60 80 100					
			12	SS	23			20 40 60 80 100					
								20 40 60 80 100					
			13	SS	69			20 40 60 80 100					
281.3								20 40 60 80 100					
9.4	Sandy GRAVEL , some silt to silty, trace clay Very Dense Brown		14	SS	78			20 40 60 80 100					44 24 32 (SI+CL)

Continued Next Page

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

RECORD OF BOREHOLE No RCC-2

2 OF 2

METRIC

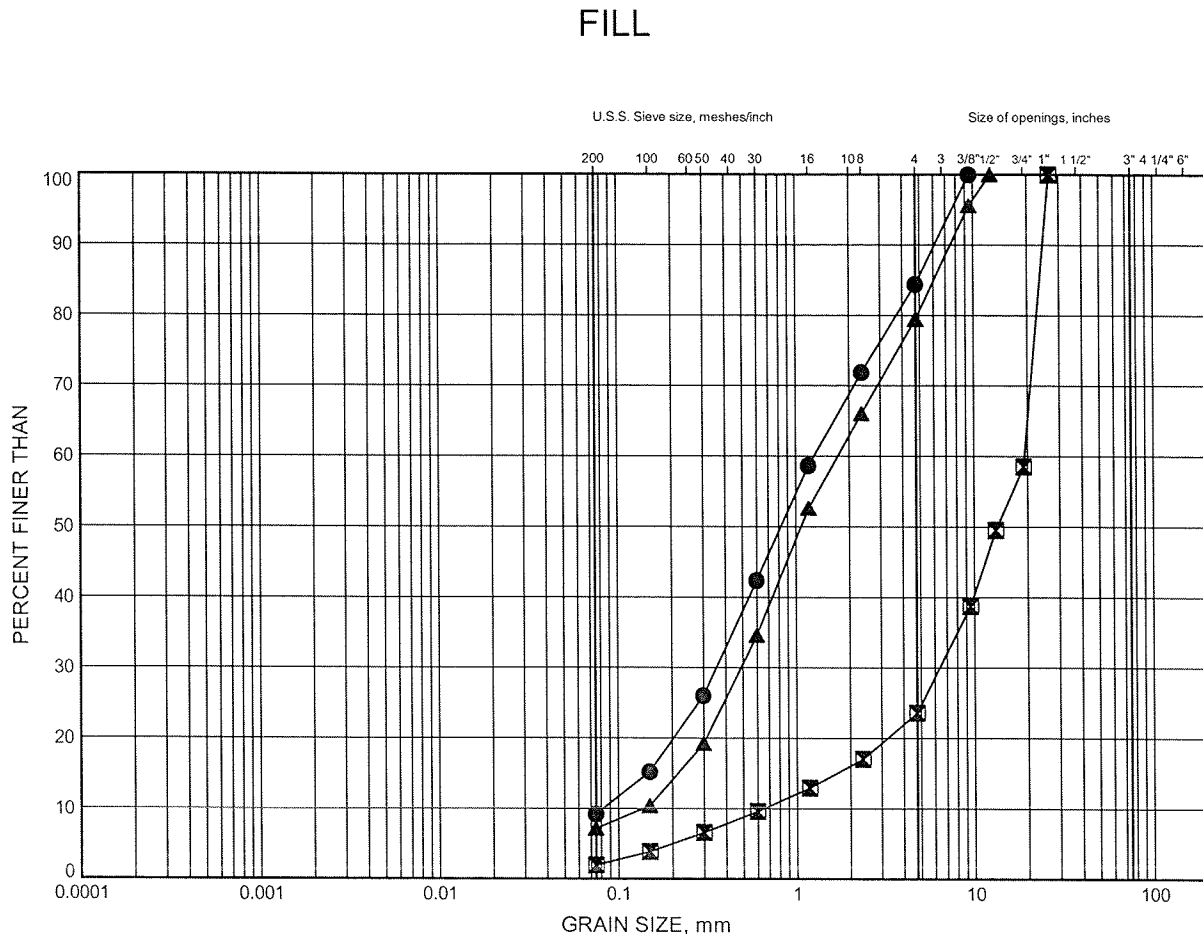
W.P. 19-5161-103 LOCATION N 5 189 536.616 E 282 260.706 ORIGINATED BY ES
HWY 11 BOREHOLE TYPE Tripod/Casing COMPILED BY AN
DATUM Geodetic DATE 2011.04.13 - 2011.04.13 CHECKED BY JPL

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									
280.7	Continued From Previous Page		15	SS	100												
10.1	Wet END OF BOREHOLE AT 10.1m UPON REFUSAL ON BEDROCK. WATER LEVEL AT SURFACE UPON COMPLETION. BOREHOLE BACKFILLED WITH SAND TO SURFACE.				0.025												
							280										

Appendix B
Laboratory Test Results

Hwy 11 Tomiko River GRAIN SIZE DISTRIBUTION

FIGURE B1



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

LEGEND

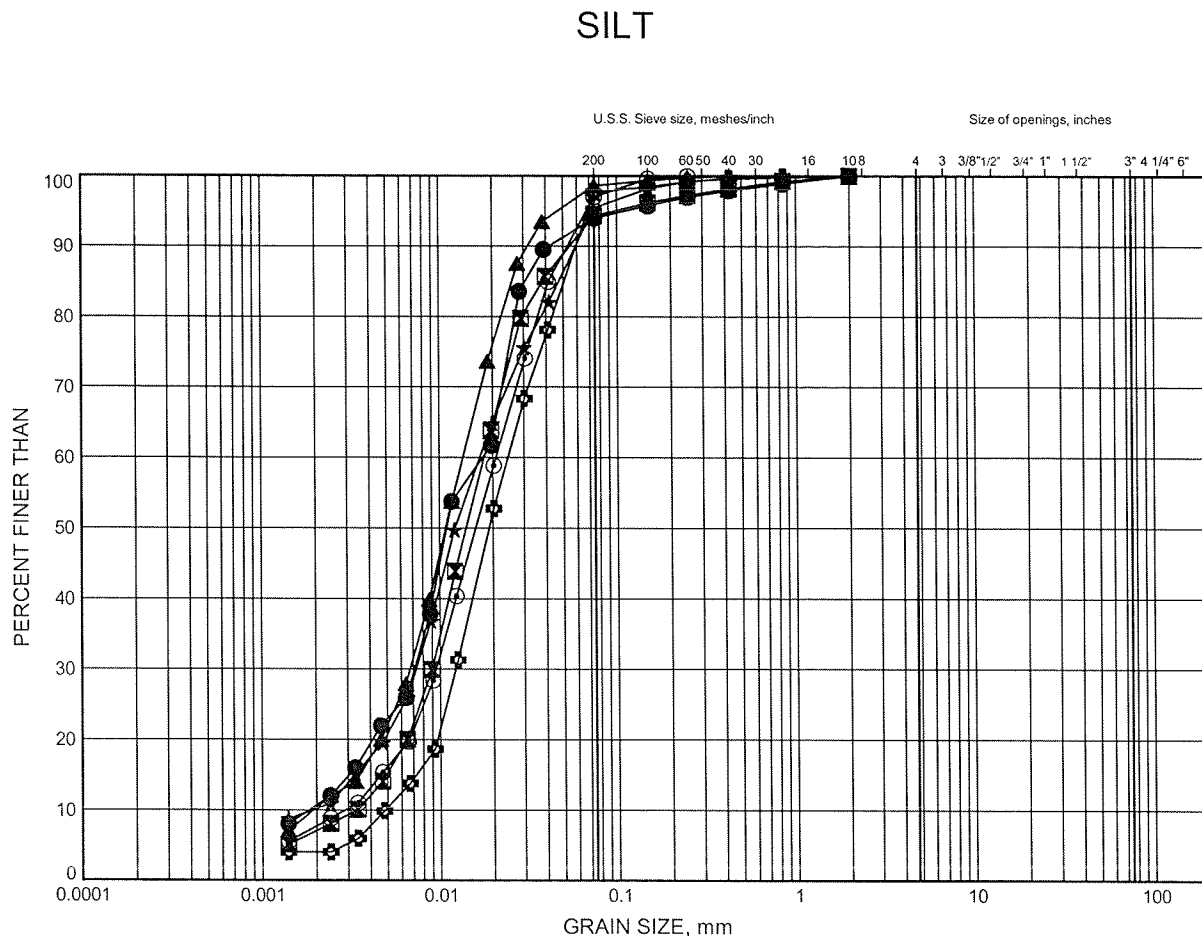
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	11-11	1.83	292.36
⊠	11-12	1.83	290.88
▲	11-14	1.83	291.76



W.P.# 19-5161-103
Prepared By AN
Checked By LT

Hwy 11 Tomiko River GRAIN SIZE DISTRIBUTION

FIGURE B2



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

LEGEND

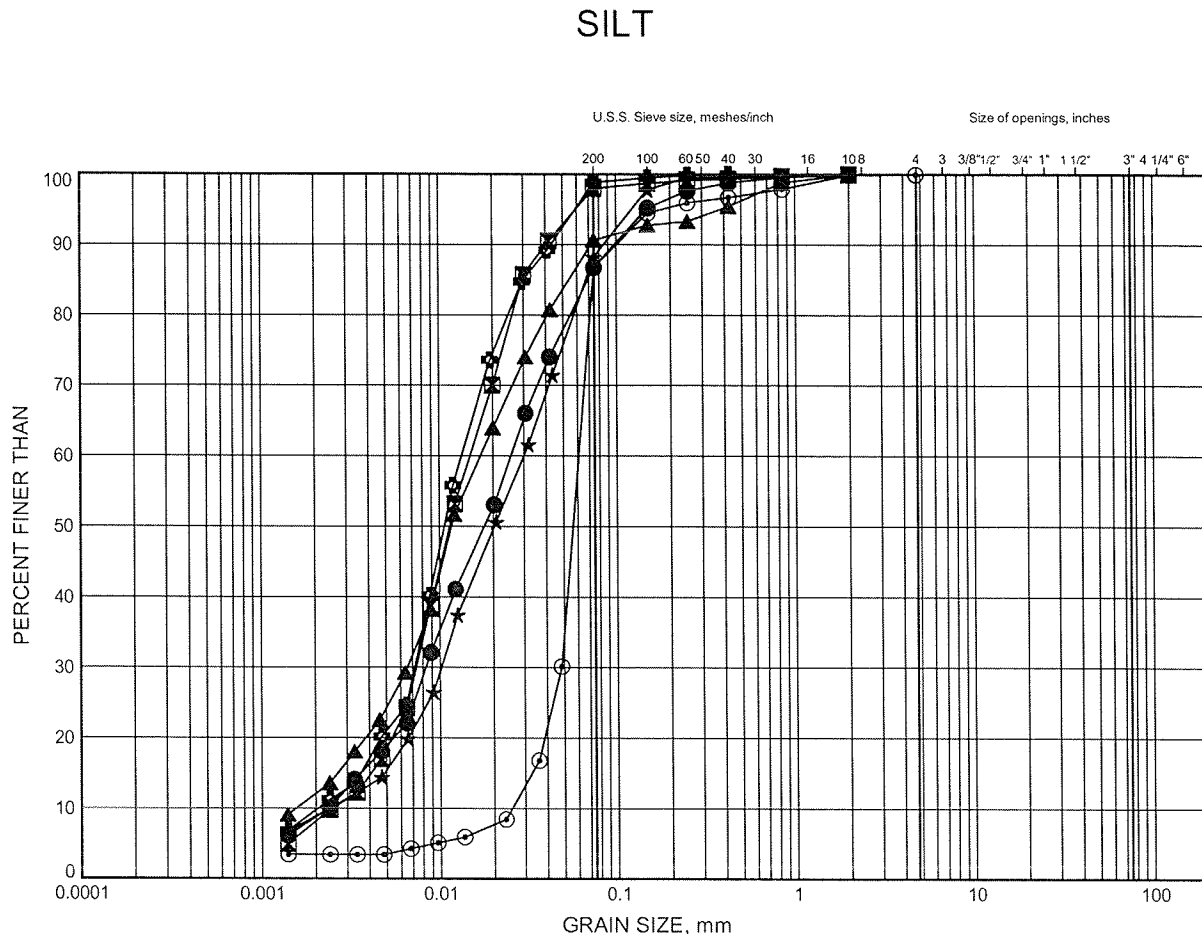
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	11-01	1.83	288.37
⊠	11-02	2.59	287.76
▲	11-02	6.40	283.95
★	11-03	1.07	290.32
⊙	11-03	4.88	286.51
⊕	11-04	4.04	288.92



W.P.# 19-5161-103.....
Prepared By AN.....
Checked By LT.....

Hwy 11 Tomiko River GRAIN SIZE DISTRIBUTION

FIGURE B3



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

LEGEND

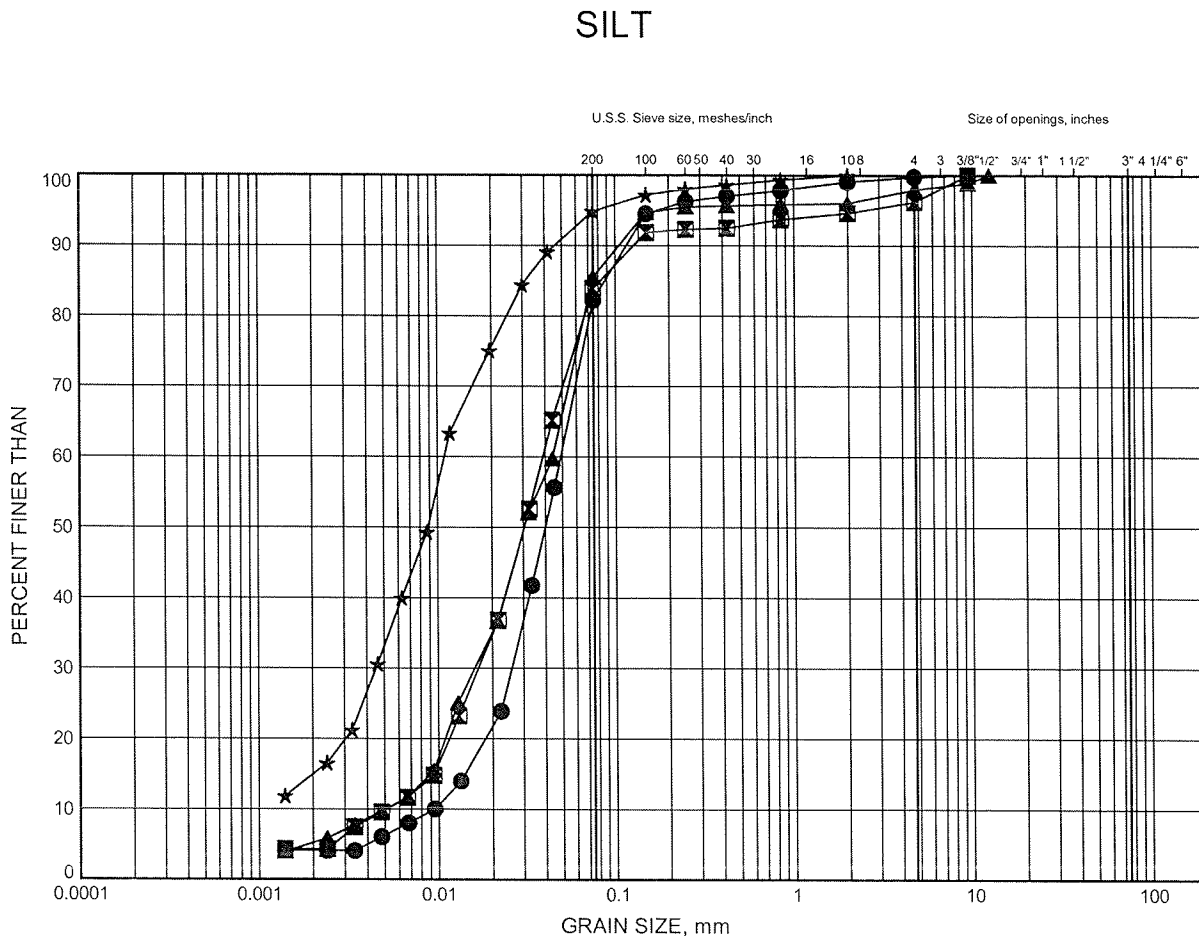
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	11-05	1.83	289.21
⊠	11-06	4.11	286.54
▲	11-07	4.22	286.23
★	11-11	7.16	287.03
⊙	11-11	9.45	284.74
⊕	11-12	7.92	284.78



W.P.# 19-5161-103.....
Prepared By AN.....
Checked By LT.....

Hwy 11 Tomiko River GRAIN SIZE DISTRIBUTION

FIGURE B4



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	11-12	10.90	281.81
■	11-13	5.64	287.69
▲	11-13	7.16	286.17
★	RCC-1	2.29	288.49

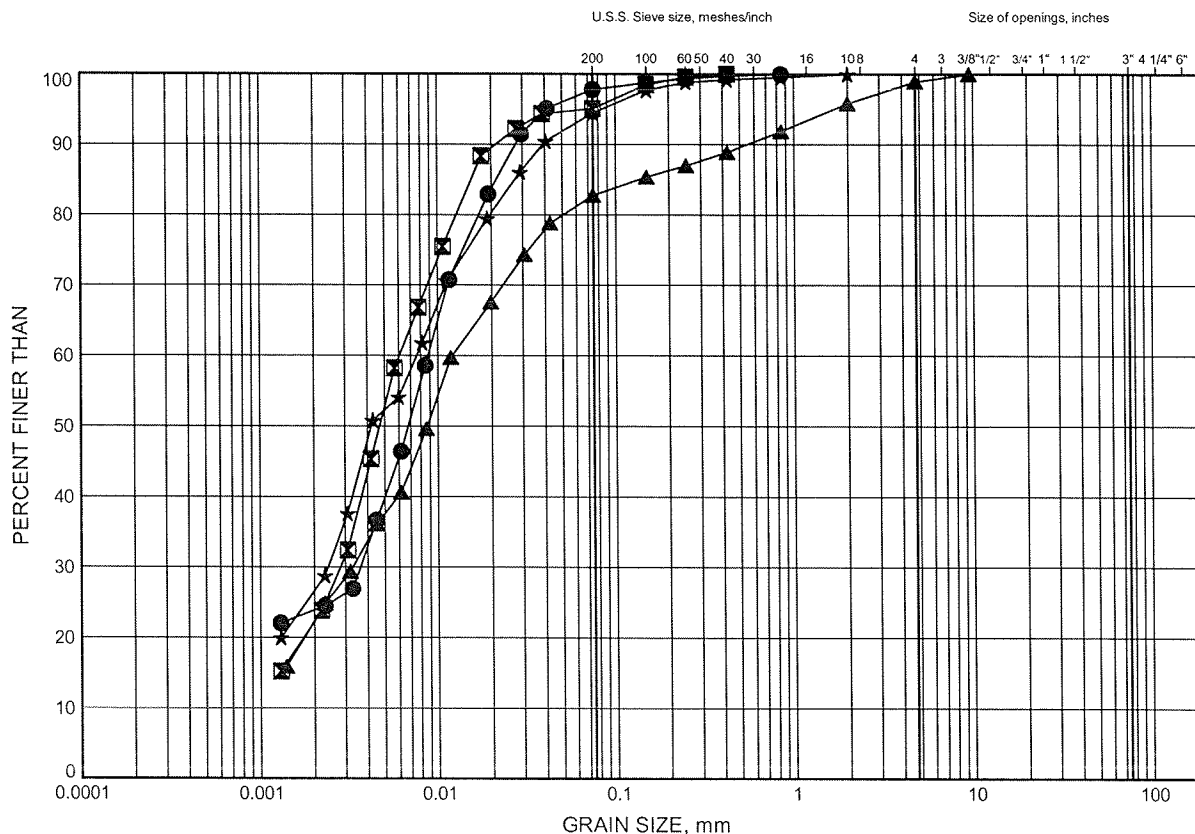


W.P.# 19-5161-103
Prepared By AN
Checked By LT

Hwy 11 Tomiko River GRAIN SIZE DISTRIBUTION

FIGURE B5

SILTY CLAY/CLAYEY SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	11-04	1.07	291.89
⊠	11-06	6.40	284.25
▲	11-10	2.69	288.60
★	RCC-2	2.44	288.33

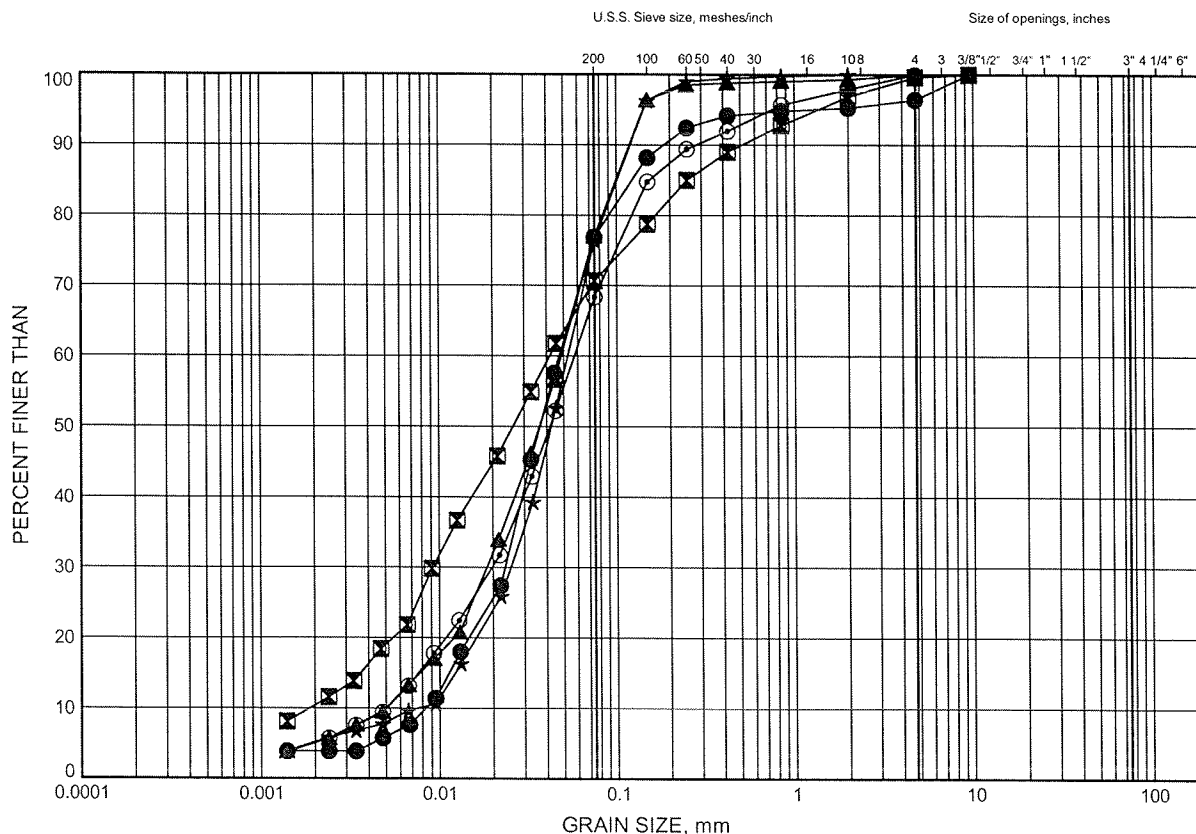


W.P.# 19-5161-103.....
Prepared By .AN.....
Checked By .LT.....

Hwy 11 Tomiko River GRAIN SIZE DISTRIBUTION

FIGURE B6

SANDY SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	11-02	7.92	282.42
⊠	11-09	1.52	289.39
▲	RCC-1	4.42	286.36
★	RCC-2	4.27	286.50
⊙	RCC-2	7.32	283.45

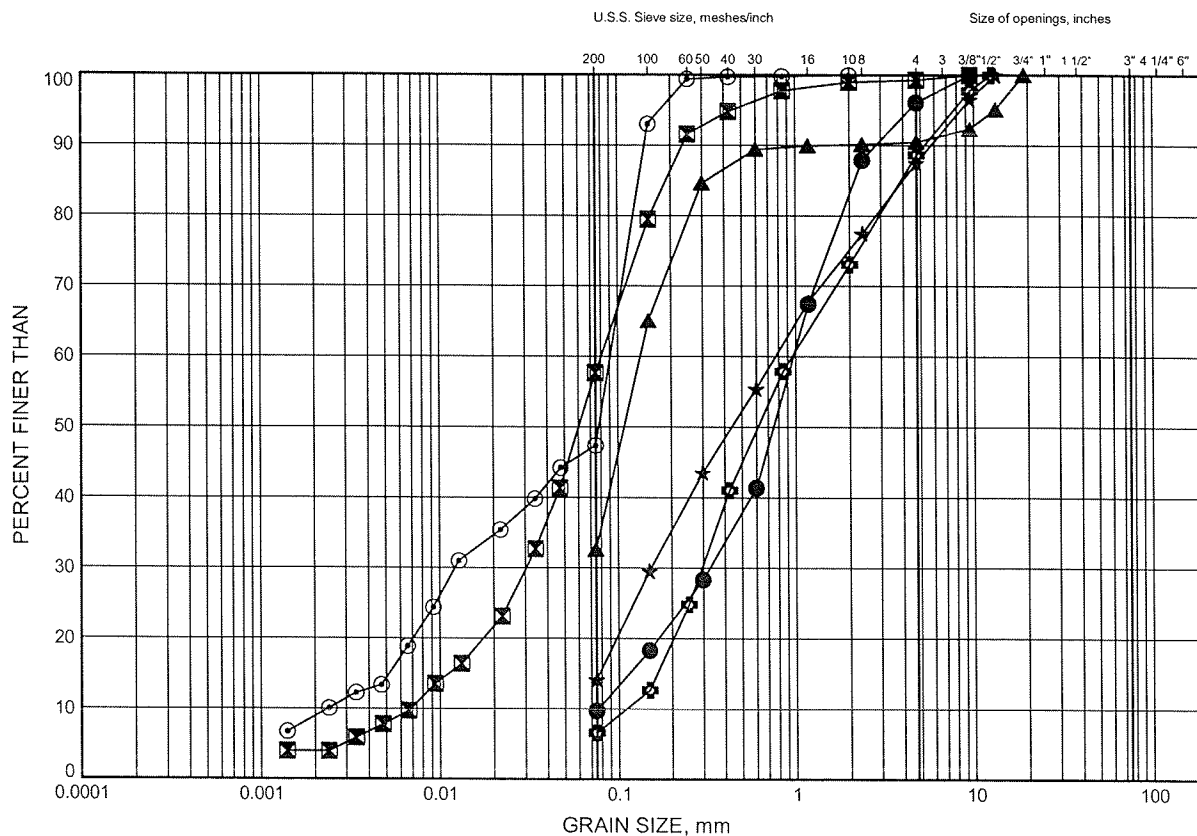


W.P.# 19-5161-103
Prepared By AN
Checked By LT

Hwy 11 Tomiko River GRAIN SIZE DISTRIBUTION

FIGURE B7

SILTY SAND/SILT & SAND/SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	11-04	6.40	286.56
⊠	11-07	7.26	283.19
▲	11-07	9.70	280.75
★	11-10	0.91	290.38
⊙	11-14	4.11	289.47
⊕	11-14	7.92	285.66

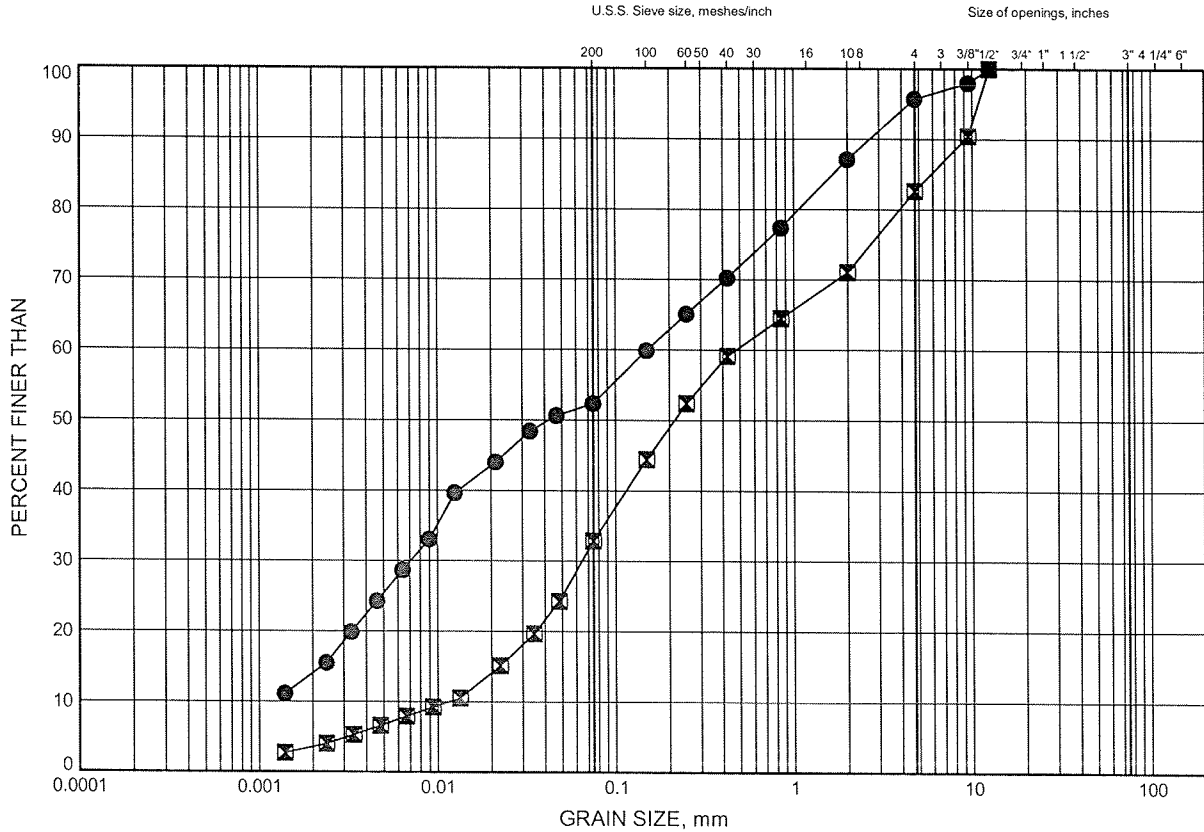


W.P.# 19-5161:103.....
Prepared By AN.....
Checked By LT.....

Hwy 11 Tomiko River GRAIN SIZE DISTRIBUTION

FIGURE B8

SILTY SAND/SILT & SAND/SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	11-15	2.59	293.16
⊠	RCC-1	8.92	281.86

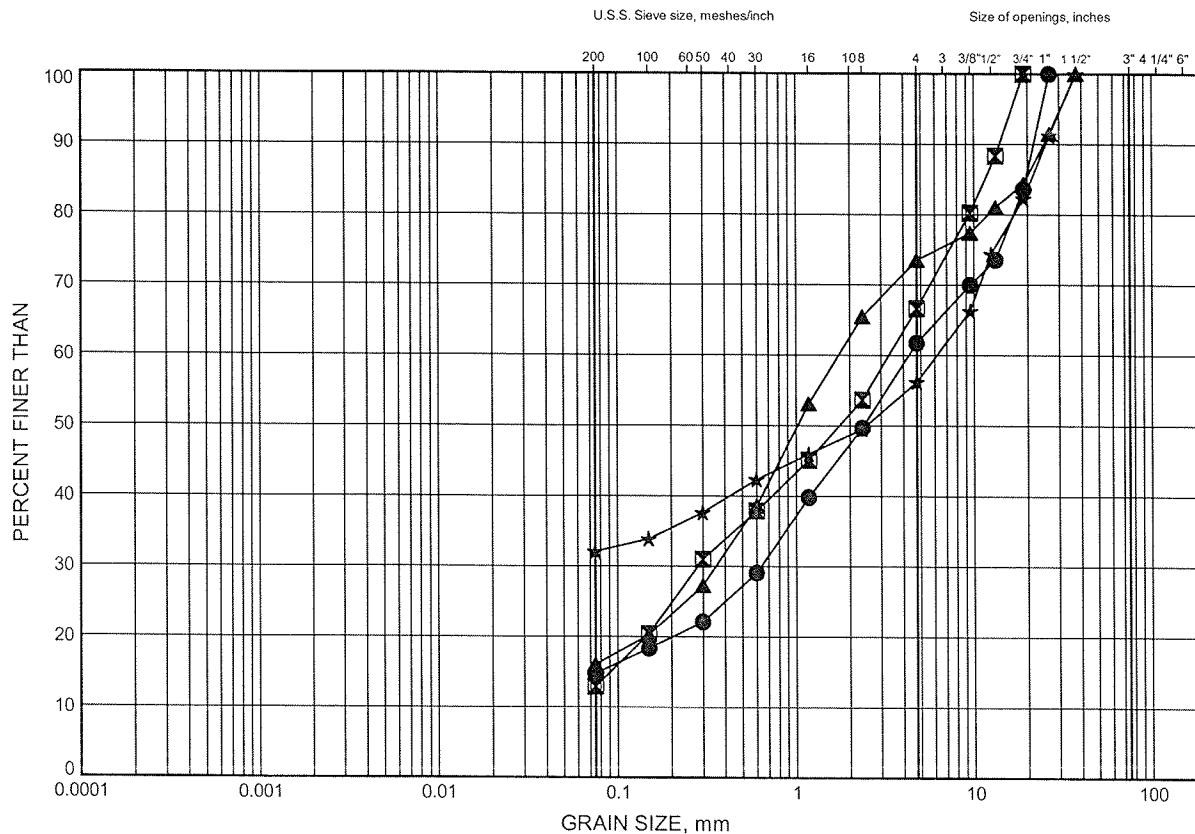


W.P.# 19-5161-103.....
Prepared By AN.....
Checked By LT.....

Hwy 11 Tomiko River GRAIN SIZE DISTRIBUTION

FIGURE B9

SAND & GRAVEL/GRAVELLY SAND/SANDY GRAVEL



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

LEGEND

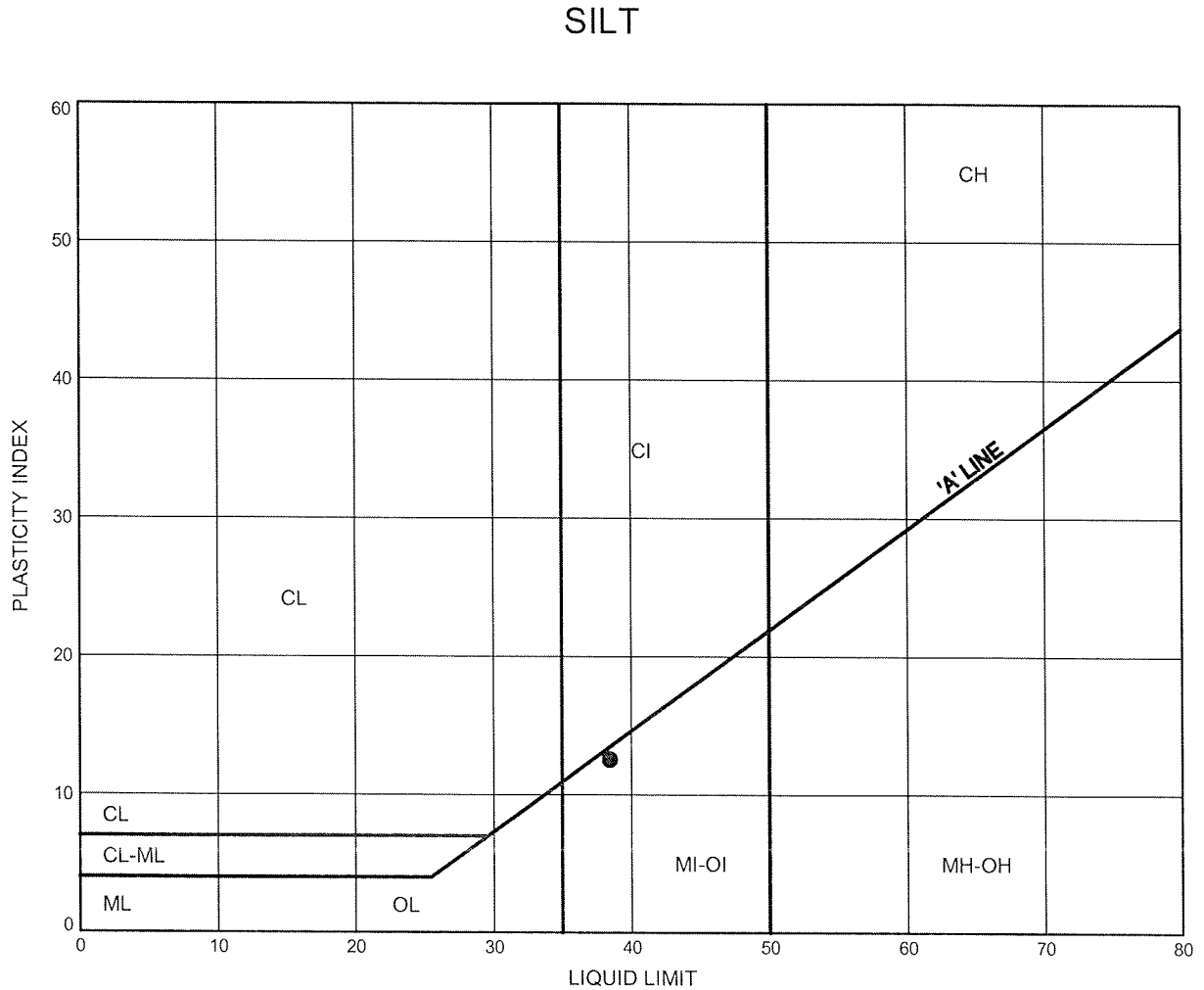
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	11-01	3.61	286.60
⊠	11-08	2.69	287.91
▲	11-10	3.89	287.41
★	RCC-2	9.75	281.02



W.P.# 19-5161-103
Prepared By AN
Checked By LT

Hwy 11 Tomiko River ATTERBERG LIMITS TEST RESULTS

FIGURE B10



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	11-06	4.11	286.54

Date June 2011
Project 19-5161-103



Prep'd AN
Chkd. LT

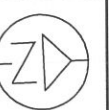
Appendix C

Drawings

NO	ELEVATION	NORTHING	EASTING
11-14	293.6	5 189 542.9	282 249.4
11-15	295.8	5 189 595.7	282 271.3
11-16	298.0	5 189 643.9	282 297.2
11-17	299.7	5 189 687.5	282 326.4
RCC-01	290.8	5 189 534.7	282 254.8
RCC-02	290.8	5 189 536.6	282 260.7
2A (AMEC)	293.8	N.A.	N.A.
4B (AMEC)	289.9	N.A.	N.A.
6B (AMEC)	289.8	N.A.	N.A.
7 (AMEC)	289.9	N.A.	N.A.

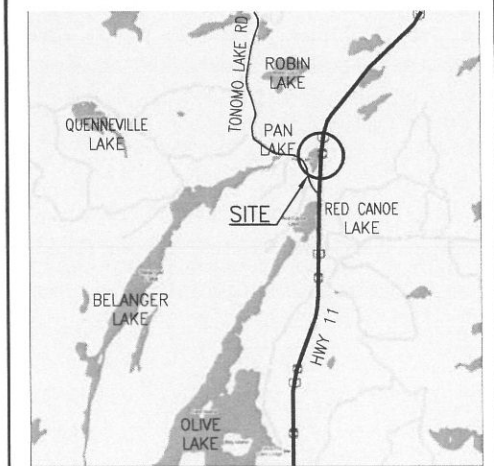
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No 5009-E-0024
WP No 5578-04-00
& 5240-06-00



HIGHWAY 11
AT PAN LAKE
(9.5km NORTH OF HWY 64)
BOREHOLE LOCATIONS

SHEET



KEYPLAN

LEGEND

- Borehole (Thurber)
- ⊕ Borehole (Amec)
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60' Cone, 475J/blow)
- PH Pressure, Hydraulic
- W Water Level
- HA Head Artesian Water
- P Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

NO	ELEVATION	NORTHING	EASTING
11-01	290.2	5 189 174.6	282 212.6
11-02	290.3	5 189 224.4	282 215.3
11-03	291.4	5 189 282.6	282 219.8
11-04	293.0	5 189 379.7	282 227.5
11-05	291.0	5 189 432.9	282 229.6
11-06	290.7	5 189 486.8	282 241.7
11-07	290.5	5 189 517.8	282 251.1
11-08	290.6	5 189 563.6	282 271.9
11-09	290.9	5 189 622.7	282 303.2
11-10	291.3	5 189 657.8	282 331.9
11-11	294.2	5 189 108.4	282 188.6
11-12	292.7	5 189 176.4	282 193.5
11-13	293.3	5 189 532.5	282 246.1

-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. 31L-151

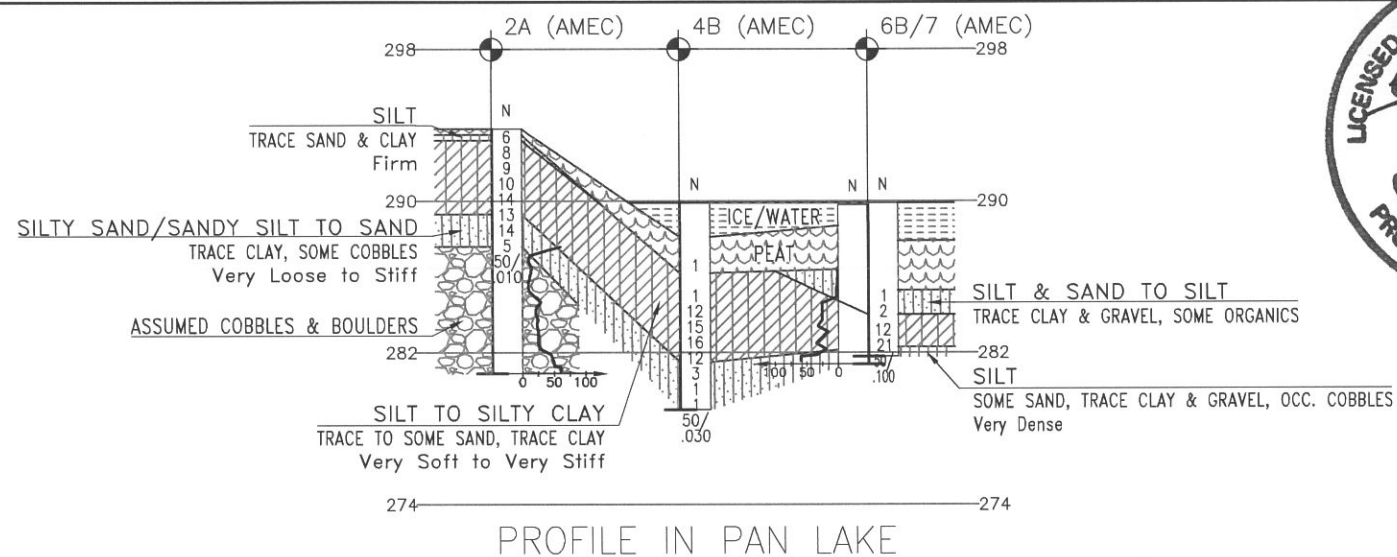
DATE	BY	DESCRIPTION
DESIGN	LT	CHK JPL
DRAWN	MFA	CHK LT
DATE	DEC. 2011	
DWG	1	



PLAN



NO	ELEVATION	NORTHING	EASTING
11-14	293.6	5 189 542.9	282 249.4
11-15	295.8	5 189 595.7	282 271.3
11-16	298.0	5 189 643.9	282 297.2
11-17	299.7	5 189 687.5	282 326.4
RCC-01	290.8	5 189 534.7	282 254.8
RCC-02	290.8	5 189 536.6	282 260.7
2A (AMEC)	293.8	N.A.	N.A.
4B (AMEC)	289.9	N.A.	N.A.
6B (AMEC)	289.8	N.A.	N.A.
7 (AMEC)	289.9	N.A.	N.A.



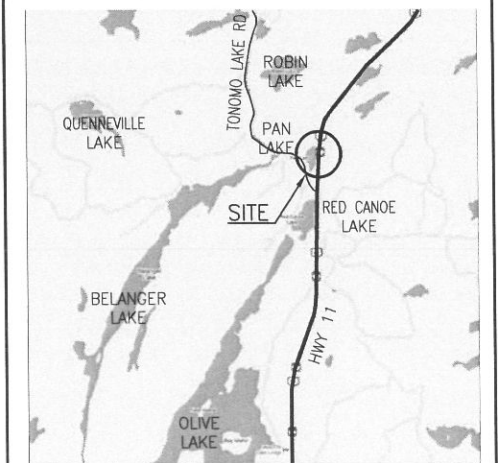
METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWNCONT No 5009-E-0024
WP No 5578-04-00
& 5240-06-00HIGHWAY 11
AT PAN LAKE
(9.5km NORTH OF HWY 64)
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

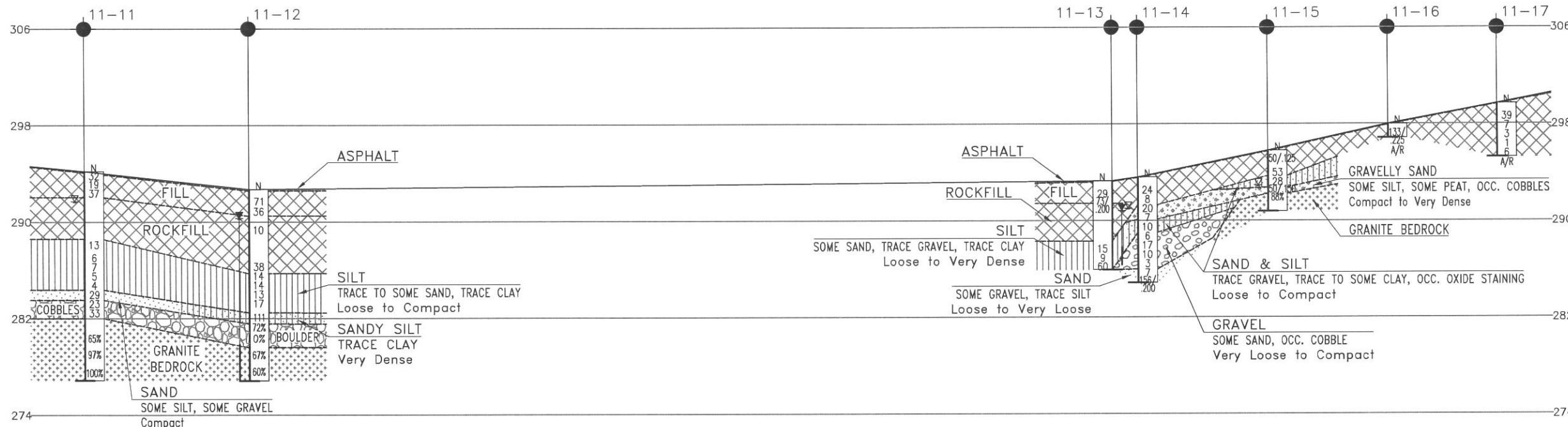
- Borehole (Thurber)
- Borehole (Amec)
- Blows /0.3m (Std Pen Test, 475J/blow)
- Blows /0.3m (60' Cone, 475J/blow)
- CONE
- PH
- Pressure, Hydraulic
- Water Level
- Head Artesian Water
- Piezometer
- 90%
- Rock Quality Designation (RQD)
- A/R
- Auger Refusal

NO	ELEVATION	NORTHING	EASTING
11-01	290.2	5 189 174.6	282 212.6
11-02	290.3	5 189 224.4	282 215.3
11-03	291.4	5 189 282.6	282 219.8
11-04	293.0	5 189 379.7	282 227.5
11-05	291.0	5 189 432.9	282 229.6
11-06	290.7	5 189 486.8	282 241.7
11-07	290.5	5 189 517.8	282 251.1
11-08	290.6	5 189 563.6	282 271.9
11-09	290.9	5 189 622.7	282 303.2
11-10	291.3	5 189 657.8	282 331.9
11-11	294.2	5 189 108.4	282 188.6
11-12	292.7	5 189 176.4	282 193.5
11-13	293.3	5 189 532.5	282 246.1

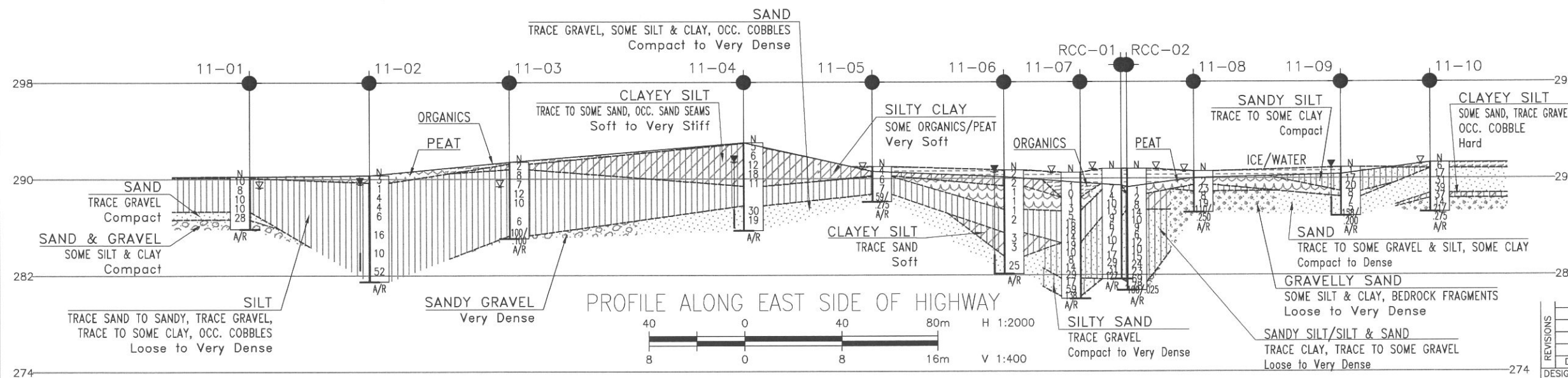
-NOTES-

- 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. 31L-151



PROFILE ALONG SB SHOULDER



PROFILE ALONG NB SHOULDER

PROFILE ALONG EAST SIDE OF HIGHWAY



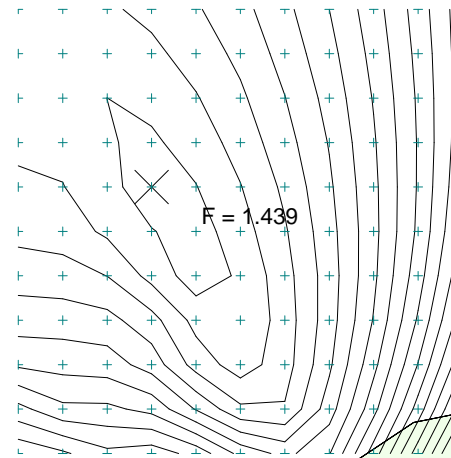
H 1:2000

V 1:400

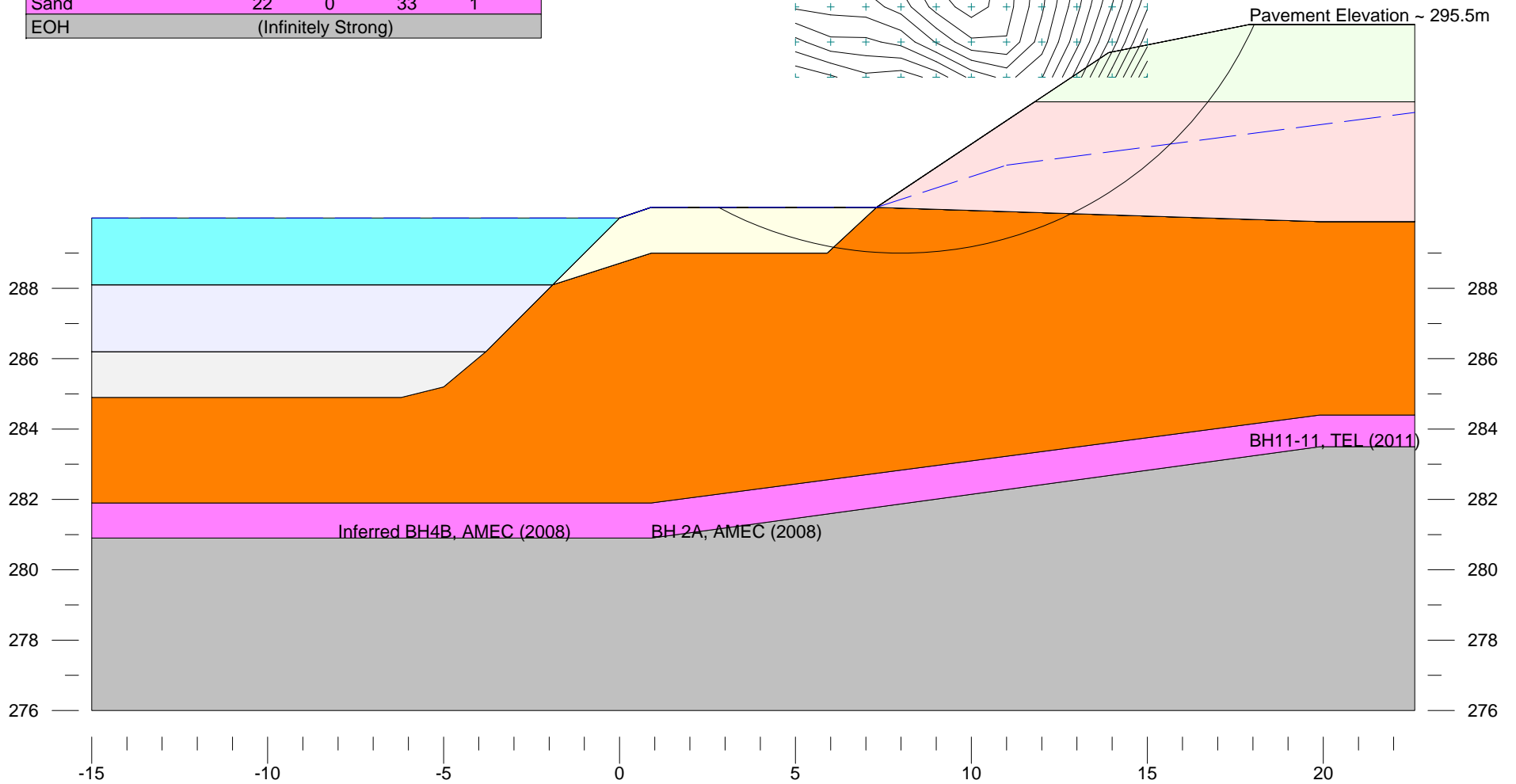
REVISIONS	DATE	BY	DESCRIPTION
DESIGN	LT	CHK JPL	CODE
DRAWN	MFA	CHK LT	SITE
			LOAD
			STRUCT
			DWG 2
			DATE DEC. 2011

Appendix D
Slope Stability Analysis Results

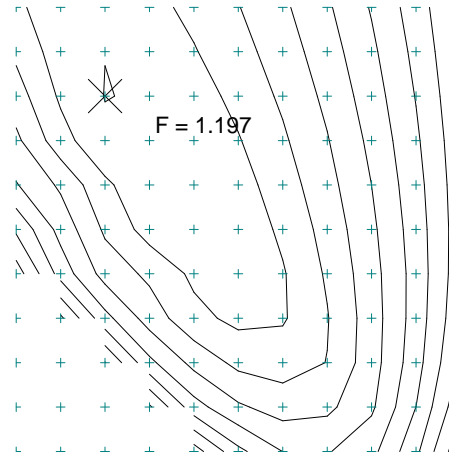
	Gamma kN/m ³	C kPa	Phi deg	Piezo Surf.
Water	9.81	0	0	0
Sand (Fill)	22	0	35	1
Rock (Fill)	19	0	42	1
Peat	14	0	28	1
Silt	20	0	28	1
Clay	18	0	28	1
Silt	20	0	30	1
Sand	22	0	33	1
EOH	(Infinitely Strong)			



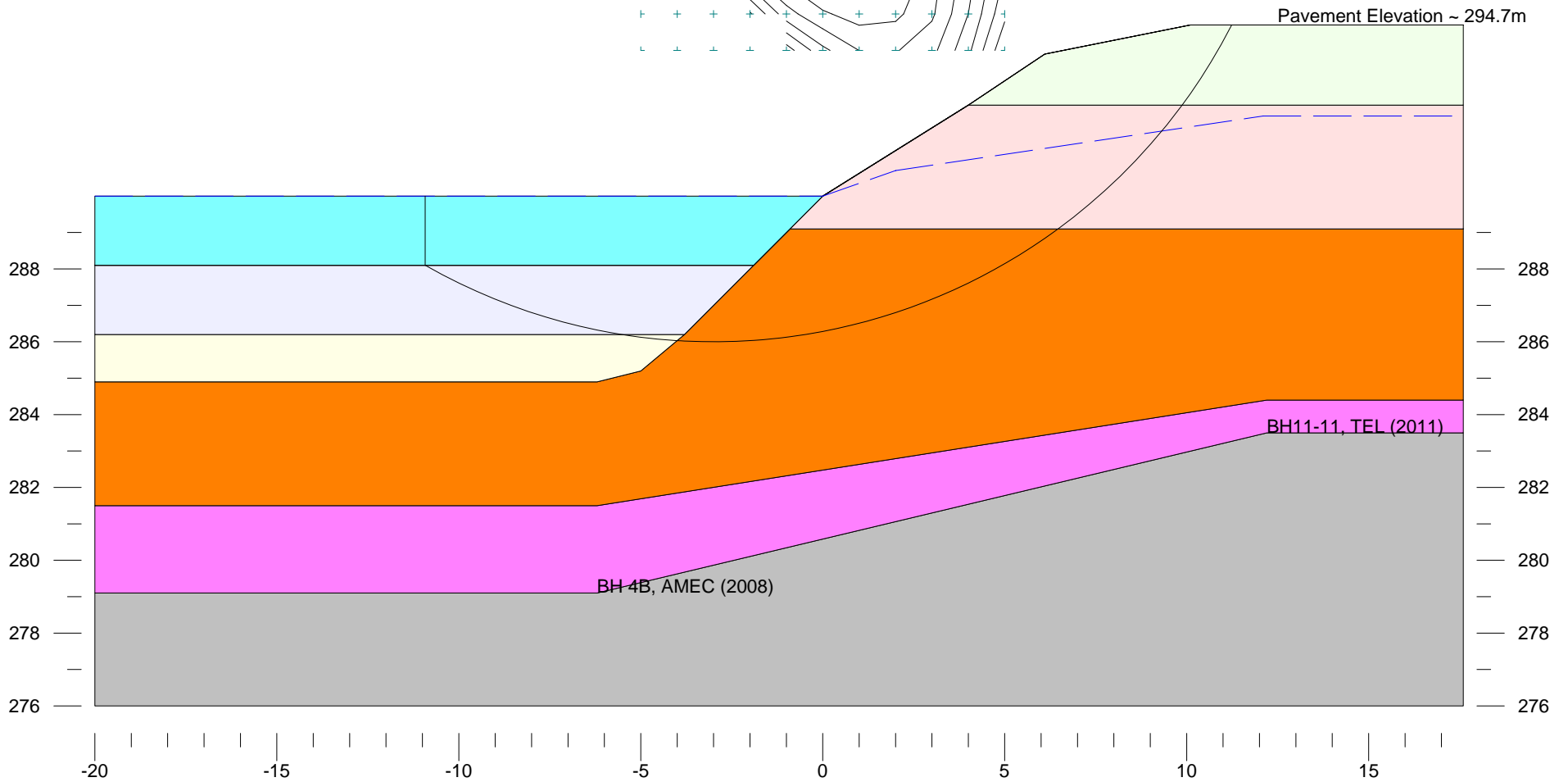
Thurber Engineering Ltd. - Toronto
19-5161-103
Pan Lake - HWY 11 Stability Investigation
July 2011
Sta. 14+564 (previous sta. 14+753)



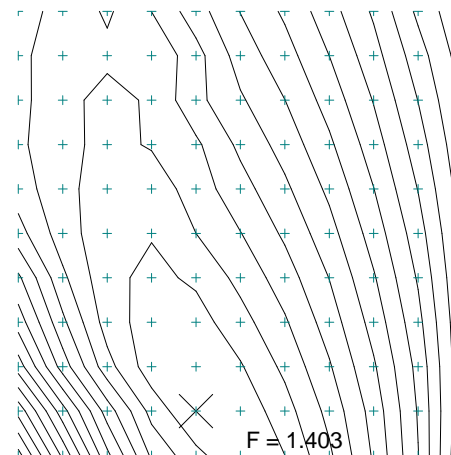
	Gamma kN/m ³	C kPa	Phi deg	Piezo Surf.
Water	9.81	0	0	0
Sand (Fill)	22	0	35	1
Rock (Fill)	19	0	42	1
Peat	14	0	28	1
Clay	18	0	28	1
Silt	20	0	30	1
Sand	22	0	33	1
EOH	(Infinitely Strong)			



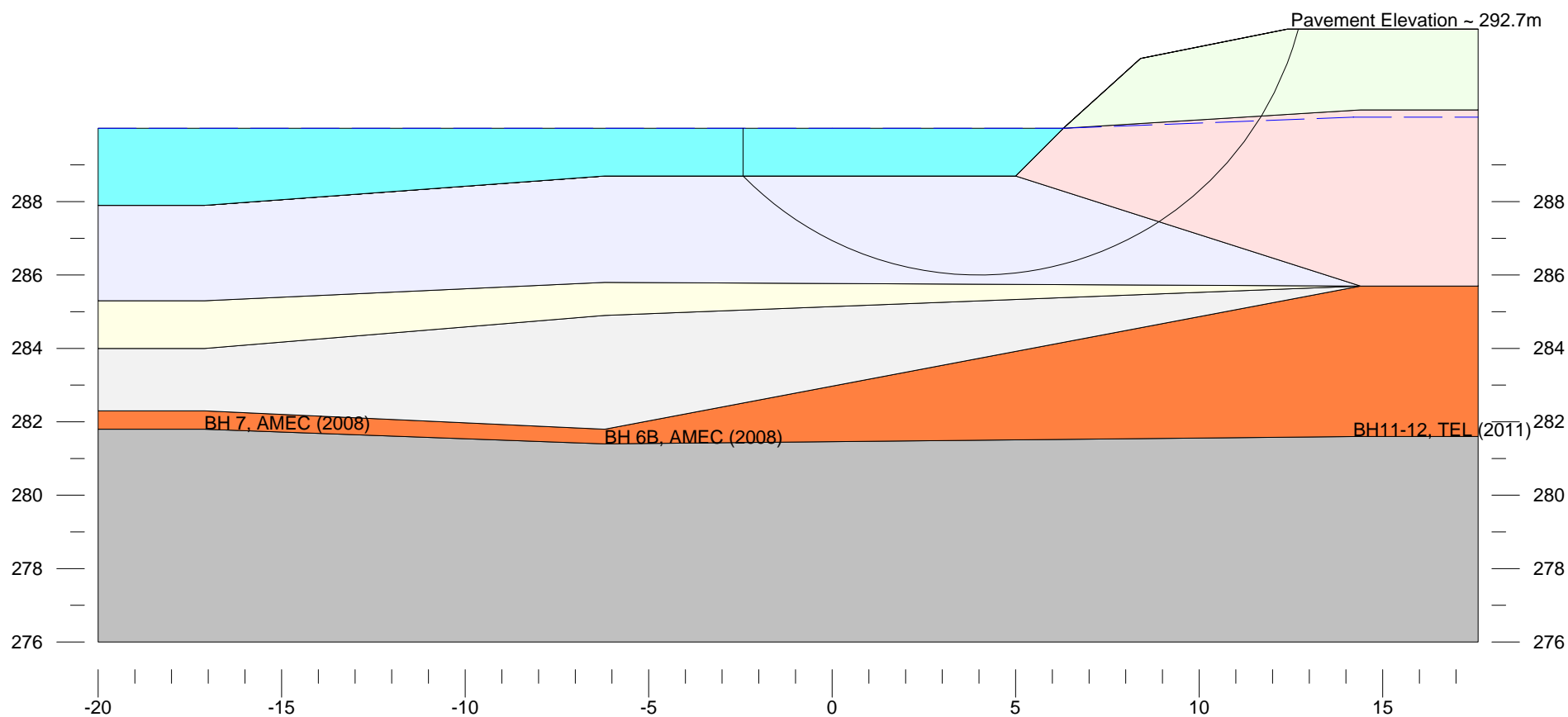
Thurber Engineering Ltd. - Toronto
 19-5161-103
 Pan Lake - HWY 11 Stability Investigation
 July 2011
 Sta. 14+587 (previous sta. 14+776)



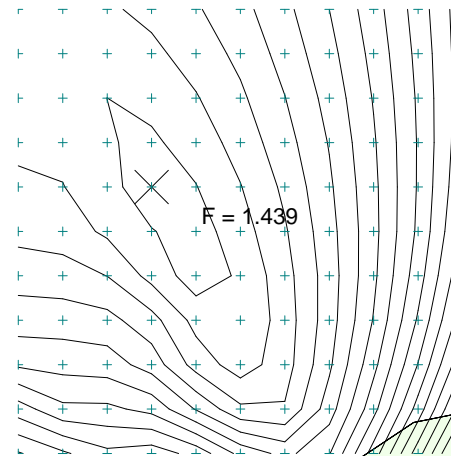
	Gamma kN/m ³	C kPa	Phi deg	Piezo Surf.
Water	9.81	0	0	0
Sand (Fill)	22	0	35	1
Rock (Fill)	19	0	42	1
Peat	14	0	28	1
Silt	19	0	28	1
Clay	18	0	28	1
Silt	20	0	30	1
EOH	(Infinitely Strong)			



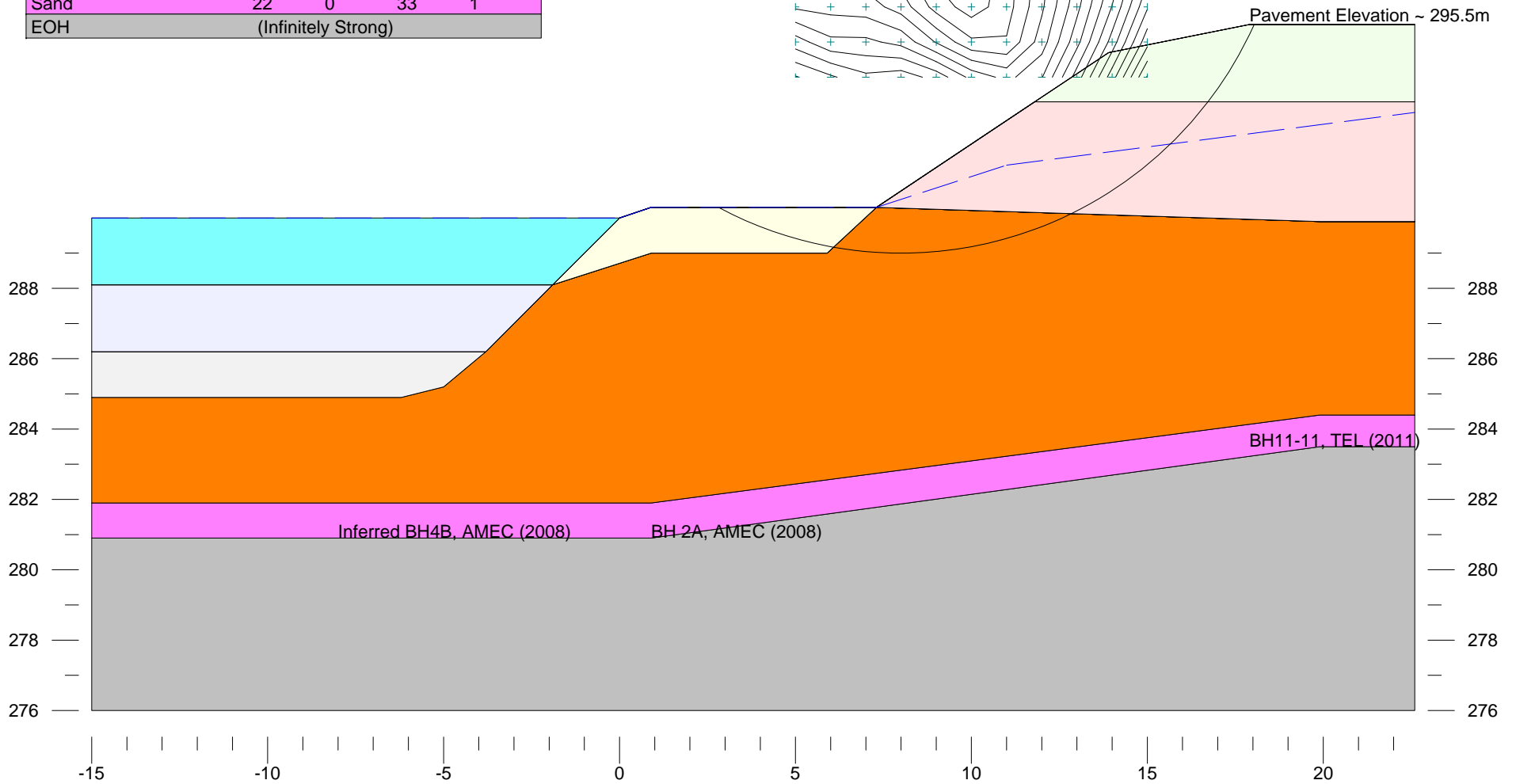
Thurber Engineering Ltd. - Toronto
19-5161-103
Pan Lake - HWY 11 Stability Investigation
July 2011
Sta. 14+670 (previous sta. 14+859)



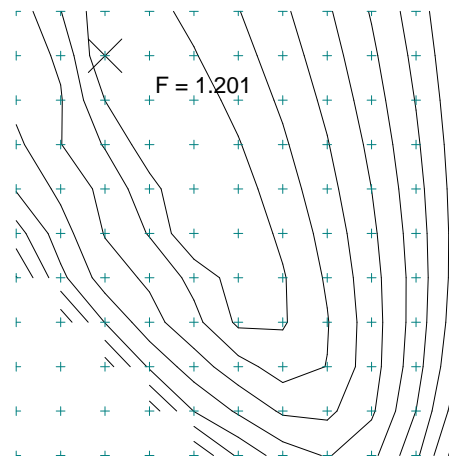
	Gamma kN/m ³	C kPa	Phi deg	Piezo Surf.
Water	9.81	0	0	0
Sand (Fill)	22	0	35	1
Rock (Fill)	19	0	42	1
Peat	14	0	28	1
Silt	20	0	28	1
Clay	18	24	0	1
Silt	20	0	30	1
Sand	22	0	33	1
EOH	(Infinitely Strong)			



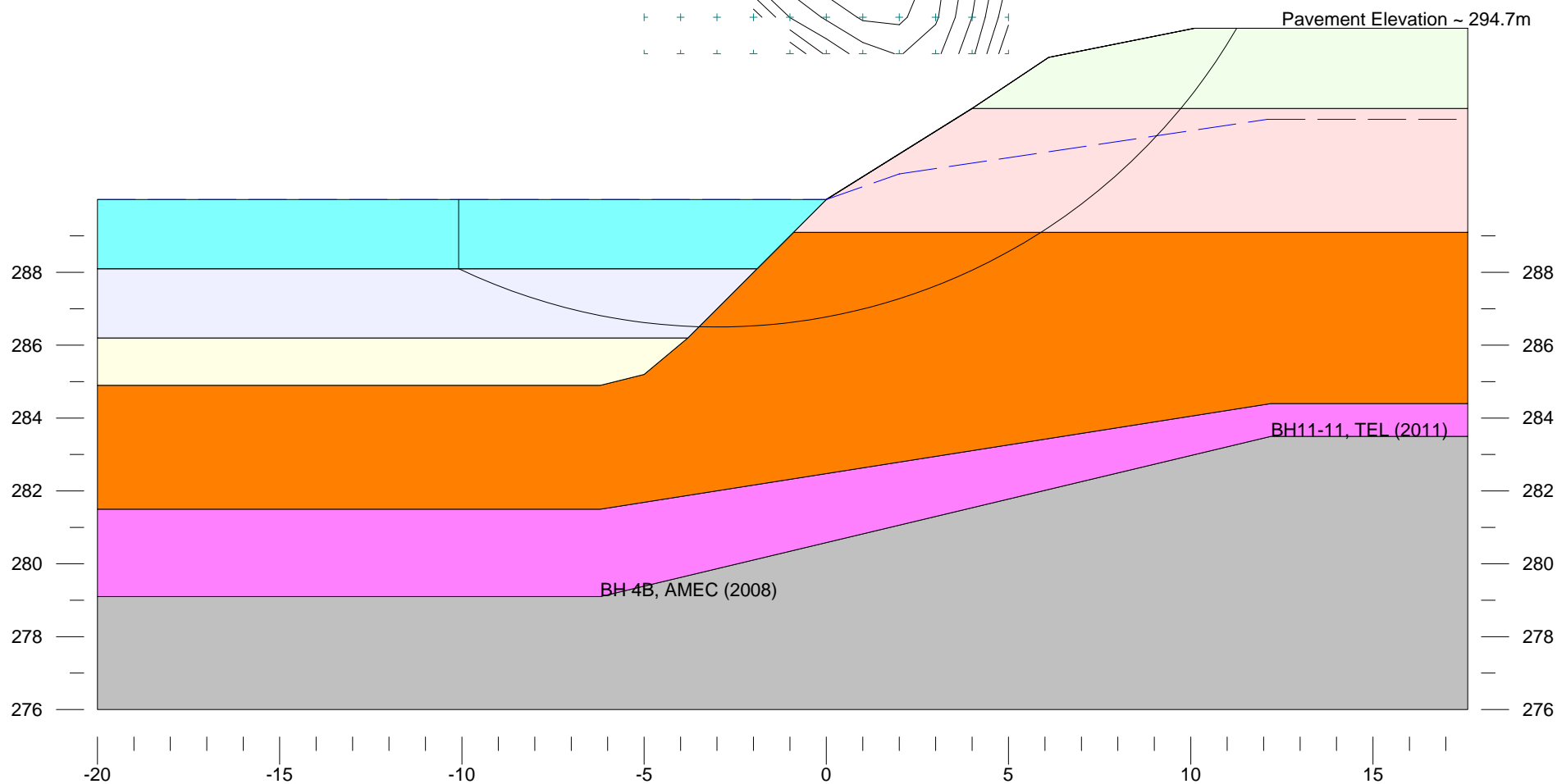
Thurber Engineering Ltd. - Toronto
19-5161-103
Pan Lake - HWY 11 Stability Investigation
July 2011
Sta. 14+564 (previous sta. 14+753)



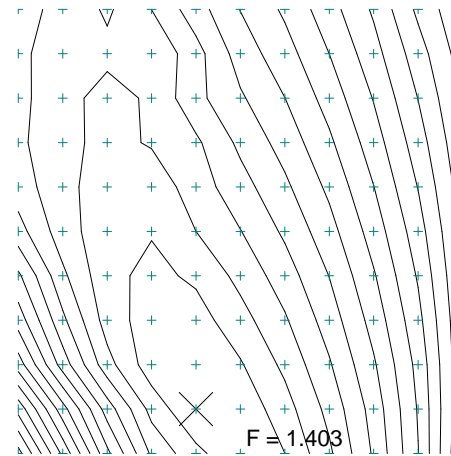
	Gamma kN/m ³	C kPa	Phi deg	Piezo Surf.
Water	9.81	0	0	0
Sand (Fill)	22	0	35	1
Rock (Fill)	19	0	42	1
Peat	14	0	28	1
Clay	18	24	0	1
Silt	20	0	30	1
Sand	22	0	33	1
EOH	(Infinitely Strong)			



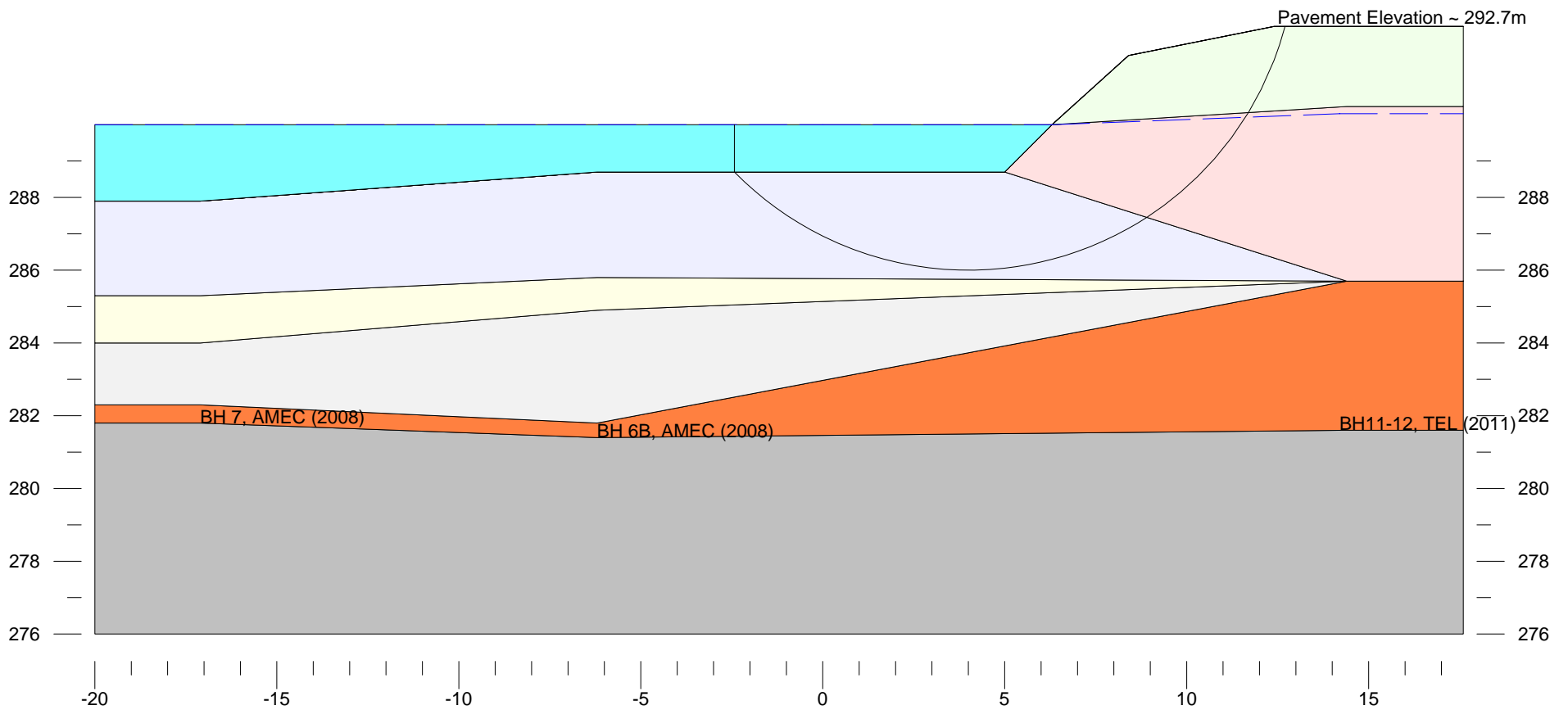
Thurber Engineering Ltd. - Toronto
19-5161-103
Pan Lake - HWY 11 Stability Investigation
July 2011
Sta. 14+587 (previous sta. 14+776)



	Gamma kN/m ³	C kPa	Phi deg	Piezo Surf.
Water	9.81	0	0	0
Sand (Fill)	22	0	35	1
Rock (Fill)	19	0	42	1
Peat	14	0	28	1
Silt	19	0	28	1
Clay	18	0	28	1
Silt	20	0	30	1
EOH	(Infinitely Strong)			



Thurber Engineering Ltd. - Toronto
19-5161-103
Pan Lake - HWY 11 Stability Investigation
July 2011
Sta. 14+670 (previous sta. 14+859)



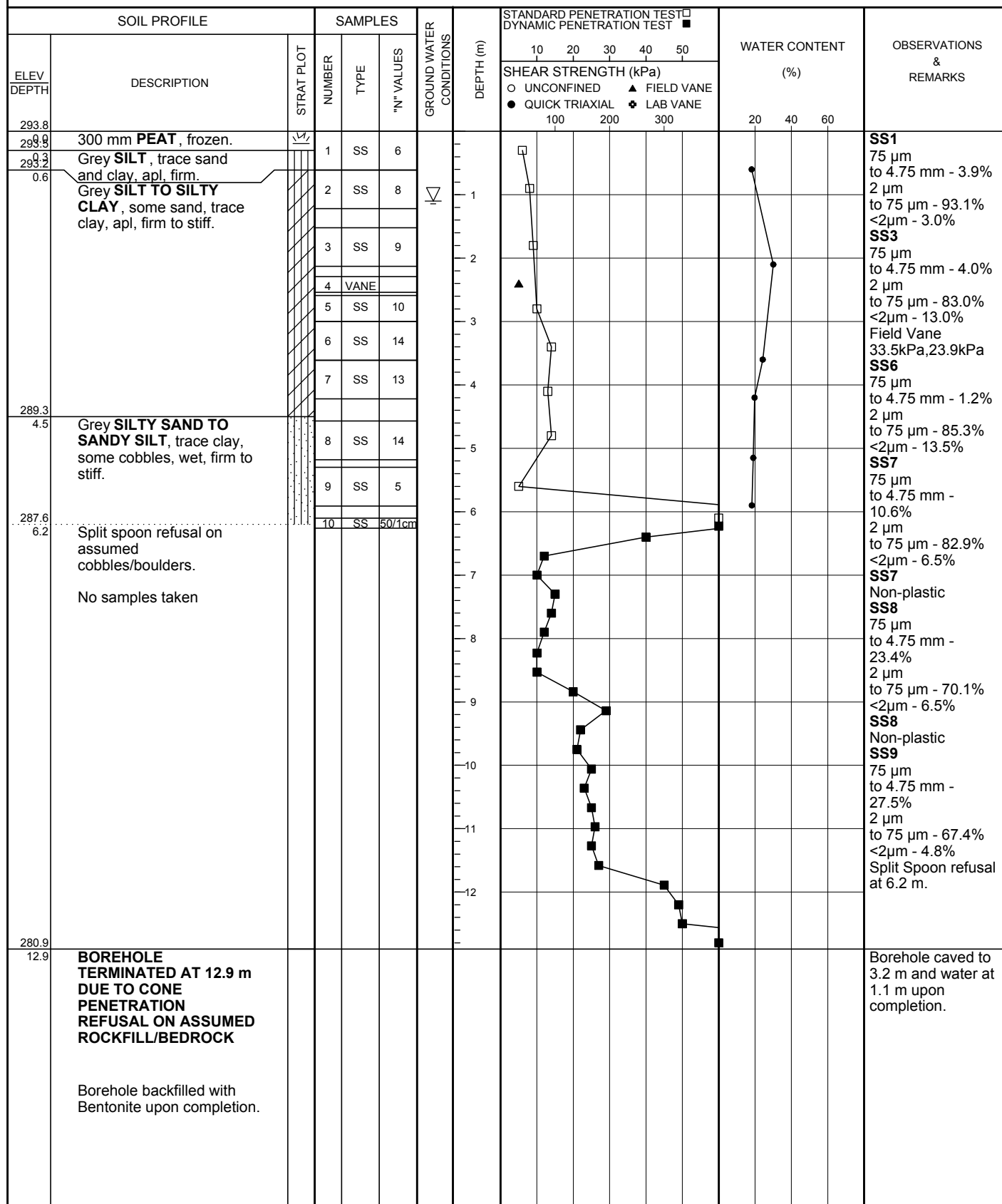
Appendix E

Select Record of Borehole Sheets from GEOCREG No. 31L-123

RECORD OF BOREHOLE No 2A

1 OF 1

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



RECORD OF BOREHOLE No 4B

1 OF 1

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

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH (m)	STANDARD PENETRATION TEST <input type="checkbox"/> DYNAMIC PENETRATION TEST <input checked="" type="checkbox"/>					WATER CONTENT			OBSERVATIONS & REMARKS
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)					(%)			
								10	20	30	40	50	20	40	60	
289.9 0.0	ICE															
289.3 0.6	WATER						1									
288.1 1.8	Brown PEAT , some silt.		1	AUGER			2									
286.2 3.7	Grey SILTY CLAY TO SILT , trace sand, apl, very soft to very stiff.		2	SS	1		3									
			3	VANE			4									
			4	VANE			5									
			5	SS	1		6									
			6	SS	12		7									
			7	SS	15		8									
			8	SS	16		9									
281.5 8.4	SANDY SILT/SILTY SAND to SAND, trace clay, wet, very loose.		9	SS	12		10									
			10	SS	3		11									
			11	SS	1		12									
			12	SS	1		13									
279.1 10.9	BOREHOLE TERMINATED DUE TO SPLIT SPOON REFUSAL ON ASSUMED ROCKFILL/BEDROCK Borehole backfilled with Bentonite upon completion.															

Field Vane
23.9kPa, 19.2kPa

Field Vane
23.9kPa, 19.2kPa

SS5
75 µm
to 4.75 mm - 1.1%
2 µm
to 75 µm - 86.9%
<2µm - 12.0%

SS5
LL-20%, PL-18%, PI-2%

SS7
75 µm
to 4.75 mm - 3.6%
2 µm
to 75 µm - 87.4%
<2µm - 9.0%

SS7
Non-plastic

SS8
75 µm
to 4.75 mm - 4.0%
2 µm
to 75 µm - 86.5%
<2µm - 9.5%

Borehole caved to 4.7 m and water at surface upon completion.

SS10
75 µm
to 4.75 mm - 30.3%
2 µm
to 75 µm - 64.76%
<2µm - 5.0%






SS11
75 µm
to 4.75 mm - 64.5%
2 µm
to 75 µm - 32.0%
<2µm - 3.5%

SS13
75 µm to 4.75 mm - 80.4%
2 µm to 75 µm - 16.1%
<2µm - 3.5%

RECORD OF BOREHOLE No 6B

1 OF 1

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

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

Appendix F

Site Photos



Photo 1: Highway 11 East Ditch (looking south)



Photo 2: Highway 11 West Embankment Slope, Pan Lake (looking north)



Photo 3: Drilling at Robin Creek Culvert (looking south)



Photo 4: Highway 11 East Embankment Slope north of Robin Creek Culvert (looking northeast at Swamp)

Appendix G
Comparison of Remedial Options

TABLE G1: COMPARISON OF REMEDIAL OPTIONS

Flattening of the embankment slope below the highway to 2H:1V	Berm construction at the highway embankment toe	Installation of retaining structure	Use of geosynthetic reinforcement	Use of light weight fill
<p>Advantages:</p> <ul style="list-style-type: none"> i. Effectively increase resisting force to the potential “deep seated” sliding mass. ii. Ease of construction. iii. One lane of traffic can be maintained iv. Lower cost than retaining structure. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Construction encroaches into Pan Lake <p>FEASIBLE IF ENCROACHMENT INTO PAN LAKE IS ALLOWED</p>	<p>Advantages:</p> <ul style="list-style-type: none"> i. Effectively increase resisting force to the potential “deep seated” sliding mass. ii. Ease of construction. iii. One lane of traffic can be maintained iv. Lower cost than retaining structure. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Construction encroaches into Pan Lake <p>FEASIBLE IF ENCROACHMENT INTO PAN LAKE IS ALLOWED</p>	<p>Advantages:</p> <ul style="list-style-type: none"> i. Effectively increase resistance to the potential “deep seated” sliding mass. ii. Construction does not encroach into Pan Lake <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Cost of constructing retaining structure ii. Greater disruption to road traffic, though one lane can be maintained iii. Pile installation through rockfill will be required <p>RECOMMENDED</p>	<p>Advantages:</p> <ul style="list-style-type: none"> i. Reduce potential for pavement distress ii. Geogrid reinforcement can be readily installed. iii. Low cost of geosynthetic materials <p>Disadvantages:</p> <ul style="list-style-type: none"> i. It does not effectively increase resistance to the potential “deep seated” sliding mass ii. Disruption to road traffic. Detour will be required <p>NOT RECOMMENDED</p>	<p>Advantages:</p> <ul style="list-style-type: none"> i. Reduce driving force to the foundation with a lighter embankment. ii. Ease of construction. Light weight fill (EPS) blocks can be readily installed <p>Disadvantages:</p> <ul style="list-style-type: none"> i. It does not increase resistance to the potential “deep seated” sliding mass ii. Cost of lightweight fill (EPS) is high. iii. Disruption to road traffic. Detour will be required <p>NOT RECOMMENDED</p>