

**FOUNDATION INVESTIGATION REPORT  
CULVERTS, SUPPLEMENTARY EMBANKMENTS AND CUT SLOPES  
HIGHWAY 11/17 RED ROCK TO NIPIGON  
FROM 4.8 KM WEST OF HWY 628 TO 1.5KM WEST OF HWY 585  
G.W.P. 647-89-00**

**Geocres Number: 52A-184  
VOLUME 1 / 3**

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October 3, 2014  
File: 19-1351-237

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Appendices B to AP include:

- Record of Borehole Sheets
- Laboratory Test Results
- Borehole Locations and Soil Strata Drawings

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CULVERTS, ADDITIONAL EMBANKMENTS AND CUT SLOPES  
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Geocres Number: 52A-184

## **1 INTRODUCTION**

This report presents the factual findings obtained from a foundation investigation conducted for the proposed culverts and additional fill embankments and cuts required for the Highway 11/17 four-laning project extending from 4.8 km west of Highway 628 to 1.5 km west of Highway 585 between Red Rock and Nipigon.

The purpose of the investigation was to explore the subsurface conditions at sites where fill embankments and cuts have been identified along the proposed alignment and, based on the data obtained, to provide record of borehole sheets, borehole location plans, stratigraphic profiles, laboratory test results, and a generalized description of the subsurface conditions at each location. This information provides a model of the anticipated geotechnical conditions influencing design and construction of the fill embankments and cuts within the investigated sections.

Thurber Engineering Ltd. (Thurber) carried out the investigation as a sub-consultant to MMM Group Limited (MMM) under the Ministry of Transportation Ontario (MTO) Agreement Number 6009-E-0019.

## **2 SITE DESCRIPTION**

The existing Highway 11/17 comprises a two lane undivided highway. The alignment of the proposed four lane divided highway runs in an approximate north-south direction and typically follows the existing highway alignment except at Sta. 13+500 to 16+450 and Sta. 18+500 to 19+100 where the proposed alignment runs west of the existing alignment and at Sta. 11+800 to 12+700 and Sta. 16+450 to 17+300 where the proposed alignment runs east of the existing alignment.

The site topography along the roadway corridor typically comprises relatively heavily treed rolling hills separated by low-lying soft ground and streams. Frequent bedrock outcrops are present along the alignment.

The site is overlain by intermittent lacustrine deposits comprising varved or massive clay and silt, silty to sandy till and bare bedrock outcrops (ref: Surficial Geological Map of the Ontario Department of Lands and Forest). Layers of recent organic deposits of peat occur in low lying areas. The area is underlain by Precambrian felsic igneous and metamorphic rocks, as well as sedimentary rocks of the Sibley Group (OGS Map No. 2232).

The existing conditions at the culverts, additional embankments and cut slopes investigated during the current study generally consist of either partially treed areas with intermittent bedrock outcrops, flat areas covered with shrubs and trees or low lying swamp areas bounded by bedrock outcrops. The embankment fill heights for each section are presented in Table A1.

### **3 SITE INVESTIGATION AND FIELD TESTING**

Thurber carried out the site investigation and field testing at each fill embankment and cut location as identified in the Proposal for Foundation Investigation, dated June 20, 2013 and November 4, 2013. The site investigation was carried out during the period of November 12 to 14, 2013 and February 4 to March 29, 2014 and consisted of advancing 133 boreholes. Boreholes and DCPTs were advanced to refusal or to a maximum depth of investigation of 21.2 m.

The boreholes were generally positioned along the centrelines of the proposed embankments with additional boreholes conducted at the embankment toe or within the cut slopes when required.

A summary of the locations and depths of the boreholes carried out during this study is provided in Table A1 in Appendix A. The boreholes are identified by the station and offset distance from the median centerline. The approximate locations of the boreholes and depths are shown on the Borehole Locations and Soil Strata Drawings included in Appendices B to AP.

The investigated locations were chosen by Thurber with reference to the centerline established by MMM. The borehole locations were laid out by Thunder Bay Testing and Engineering (TBTE) personnel. The approximate ground surface elevations at the borehole locations were interpreted by MMM based on topographic survey data.

The advancement of the boreholes was carried out using either a CME 55 drill rig or a track-mounted Acker drill rig in conjunction with hollow stem augers (HSA) supplied and operated by TBTE. Prior to commencement of drilling, utility clearances were obtained for all investigated locations. A member of Thurber's technical field staff supervised the drilling and sampling operations on a full time basis. The onsite supervisor logged the boreholes and processed the recovered soil samples for transport to TBTE's geotechnical laboratory in Thunder Bay, Ontario for further examination and testing.

Soil samples were obtained using a split spoon sampler in conjunction with Standard Penetration Tests (SPT). In situ vane shear testing was carried out to assess the undrained shear strength of the cohesive deposits. Sampling of the underlying rock was not included in the scope of this project.

Groundwater conditions in the open boreholes were observed upon completion of the drilling operations. Standpipe piezometers were installed in selected boreholes to monitor groundwater levels after drilling. Completion of the boreholes and standpipe piezometers was carried out in general accordance with the requirement of O.Reg 903 (as amended by O. Reg. 372/07). Following the final water level readings, the piezometers were decommissioned by TBTE in general accordance with MOE Regulation 903.

### **4 LABORATORY**

Recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to gradation analysis (hydrometer and/or sieve)

and Atterberg Limits testing, where appropriate. The results of this testing is shown on the Record of Borehole sheets and Figures included in their respective appendices. All laboratory testing was completed in TBTE's geotechnical laboratory.

## **5 DESCRIPTION OF SUBSURFACE CONDITIONS**

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets and the Borehole Locations and Soil Strata Drawings included in Appendices B to AP. The specific conditions encountered at individual sites vary. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following sections. However, the factual data presented in the borehole logs shall take precedence over these general descriptions and interpretations of the site conditions. It must be recognized that the soil conditions may vary between and beyond the investigated borehole locations.

The water level readings provided below are short-term readings and seasonal fluctuations of the groundwater level are to be expected, particularly after the spring snowmelt or after periods of significant and/or prolonged precipitation.

### **5.1 Highway 11/17 EBL, Sta. 10+500 to 10+600 (Appendix B)**

#### **5.1.1 General**

One borehole was advanced within Sta. 10+500 to 10+600. Existing embankment fill was encountered with sand, trace to some gravel and trace silt underlain by a deposit of native sand with some silt to silty, trace gravel and trace clay which was further underlain by silt with trace to some sand and trace clay.

#### **5.1.2 Sand Fill**

A 1.4 m thick layer of sand fill with trace to some gravel and trace silt was encountered at the surface of Borehole 10+580 05R with an underside elevation of Elev. 232.3 m. At the time of the field investigation, the fill was generally frozen, or covered with ice.

A single SPT N-value of 88 blows per 0.3 m of penetration was recorded; however the N-value likely reflects the frozen nature of the soil at the time of investigation. The moisture content ranged from 7 to 28%.

#### **5.1.3 Sand**

A 7.7 m thick layer of native sand with some silt to silty, trace gravel and trace clay was encountered below the surficial layer of sand fill. The sand layer had a lower boundary at a depth of 9.1 m (Elev. 224.5 m).

SPT N-values typically ranged between 6 and 12 blows per 0.3 m of penetration with a single SPT N-value of 27 blows per 0.3 m of penetration within the frozen soil, indicating loose to compact relative density. The moisture content varied from 18 to 24%.

A grain size distribution test was carried out on a sample of sand. The results of the test are presented on the Record of Borehole Sheet included in Appendix B. The grain size distribution curve for the sample is plotted on Figure B1 of Appendix B. The results of the laboratory test are summarized as follows:

Gravel %	0
Sand %	65
Silt & Clay %	35

#### 5.1.4 Silt

A deposit of silt with trace to some sand and trace clay was encountered below the sand layer. The borehole was terminated within the silt at a depth of 14.3 m (Elev. 219.3 m).

SPT N-values were recorded in the silt between 9 and 15 blows per 0.3 m of penetration, indicating a loose to compact relative density. The moisture content of the silt ranged from 21 to 26%.

A grain size distribution test was carried out on a sample of the silt. The result of the testing is presented on the Record of Borehole Sheet included in Appendix B. The grain size distribution curve for the sample is plotted on Figure B2 in Appendix B. The results of the laboratory test are summarized as follows:

Gravel %	0
Sand %	8
Silt %	88
Clay %	4

#### 5.1.5 Groundwater Conditions

The water level observed in the open borehole upon completion of drilling is summarized in Table 5-1.

**Table 5-1 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
10+580 05R	Mar. 15, 2014	5.6	228.1	Open borehole

## 5.2 Highway 11/17 EBL and WBL, Sta. 10+600 to 10+940 (Appendix C)

### 5.2.1 General

Three boreholes were advanced within Sta. 10+600 to 10+900. The site stratigraphy encountered generally consists of a surficial layer of organic soils underlain by silty sand to sandy silt with trace clay.

### 5.2.2 Organic Soils

A 100 mm thick surficial layer of topsoil was encountered at Borehole 10+805 22L. A layer of organic soils ranging from 1.1 to 1.2 m thick was encountered at the surface of Boreholes

10+750 19R and 10+850 13R with an underside elevation varying from Elev. 232.5 to 232.9 m. At the time of the field investigation, the organic material was generally frozen, or covered with ice.

SPT N-values of 7 to 17 blows per 0.3 m of penetration were recorded in the organic soils; however the N-values likely reflect the frozen nature of the soil at the time of investigation. The moisture content of the organic material ranged from 134 to 300%.

### 5.2.3 Clayey Silt

A localized deposit of clayey silt with trace sand was encountered below the topsoil layer in Borehole 10+805 22L. The clayey silt layer was 0.7 m thick with the lower boundary at a depth of 0.8 m (Elev. 233.6 m).

The clayey silt deposit was firm, based on an SPT N-value of 4 blows per 0.3 m of penetration. The moisture content of the clayey silt was measured as 101%.

### 5.2.4 Silt to Silty Sand to Sandy Silt

A layer ranging in composition from silt with trace sand to sandy and trace clay to silty sand to sandy silt with trace clay was encountered below the organic soils and clayey silt. Borehole 10+750 19R was terminated within the sand at a depth of 14.3 m (Elev. 219.3 m). Boreholes 10+805 22L and 10+850 13R were terminated at the base of the sand upon auger refusal on probable bedrock or boulder occurring at depths ranging from 10.7 to 11.3 m (Elev. 222.8 to 223.7 m).

SPT N-values recorded in this layer ranged from 5 to 45 blows per 0.3 m of penetration, indicating a loose to dense relative density. The moisture contents ranged from 18 to 27%.

Grain size distribution testing was carried out on three samples. The results of the testing are presented on the Record of Borehole Sheets included in Appendix C. The grain size distribution curves for the samples are plotted on Figure C1 of Appendix C. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	3 to 49
Silt %	48 to 89
Clay %	3 to 8

### 5.2.5 Groundwater conditions

The water levels observed in open boreholes upon completion of drilling are summarized in Table 5-2.

**Table 5-2 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
10+750 19R	Feb. 4, 2014	1.4	232.3	Open borehole
10+805 22L	Feb. 4, 2014	1.8	232.5	Open borehole
10+850 13R	Feb. 4, 2014	1.2	232.8	Open borehole

### 5.3 Highway 11/17 EBL and WBL, Sta. 10+940 to 10+950 (Appendix D)

#### 5.3.1 General

Five boreholes were advanced along the proposed culvert alignment for Culvert 2 A/B. The site stratigraphy encountered generally consists of surficial layers of peat along the proposed culvert alignment or existing embankment fill underlain by a deposit of silty clay with trace sand, which was further underlain by sand with trace silt to silty and trace clay. Below the above deposits was a lower layer varying from silt with trace to some sand and trace clay to sandy silt.

#### 5.3.2 Peat

A deposit of peat ranging from 0.8 to 1.4 m thick was encountered at the surface of Boreholes 10+945 27L, 10+945 07R, 10+945 15R and 10+945 27R. The peat contained roots, rootlets and occasional wood fibres. The underside elevation of the peat varied from Elev. 232.4 to 233.2 m. At the time of the field investigation, the organic material was generally frozen, or covered with ice.

SPT N-values of 4 to 27 blows per 0.3 m of penetration were recorded in the peat; however the N-values likely reflect the frozen nature of the soil at the time of investigation. The moisture contents varied from 149 to 933%.

#### 5.3.3 Sand Fill

Sand fill with trace to some gravel was encountered at the surface of Borehole 10+945 18L which was drilled on the existing Highway 11/17 embankment. The thickness of the sand fill was 2.7 m with a corresponding underside elevation of Elev. 232.6 m. At the time of the field investigation, the sand fill was frozen to approximately 1.5 m.

SPT N-values of 8 blows per 0.3 m of penetration to 50 blows per 0.025 m of penetration were recorded; however the N-values likely reflect the frozen nature of the soil at the time of investigation. The moisture contents varied from 3 to 10%.

#### 5.3.4 Silt

A 1.5 m thick layer of native silt with trace sand and trace rootlets was encountered below the surficial peat in Borehole 10+945 27L. The encountered silt layer had a lower boundary at a depth of 2.3 m, with an underside elevation of Elev. 231.7 m.

SPT N-values of 7 and 12 blows per 0.3 m of penetration were recorded, indicating a loose to compact relative density. A representative moisture content of 25% was recorded.

### 5.3.5 Silty Clay

A silty clay deposit with trace sand and occasional silt and sand seams was encountered beneath the deposits noted above in all boreholes. The thickness of this layer ranged from 1.4 to 3.2 m with the lower boundary encountered at depths from 3.7 to 5.9 m (Elev. 229.4 to 230.3 m).

SPT N-values were recorded in the silty clay ranging between 0 and 6 blows per 0.3 m of penetration. In situ field vane testing measured undrained shear strengths typically ranging from 65 to 77 kPa, with a measured sensitivity from 5 to 11, based on remolded field vane testing. The SPT N-values and vane testing results indicate that the silty clay is typically soft to stiff, with medium to extra sensitivity. The moisture content ranged from 26 to 34%.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silty clay. The results of the testing are presented on the Record of Borehole Sheets included in Appendix D. The grain size distribution curves for two samples are plotted on Figure D1 and five Atterberg Limits test results are plotted on Figure D4 of Appendix D. The results of the laboratory tests are summarized as follows:

Gravel %	0 to 1
Sand %	1 to 6
Silt %	47 to 62
Clay %	37 to 46
Liquid Limit %	27 to 32
Plastic Limit %	17 to 19

The results of the Atterberg Limit tests indicate that the tested samples of silty clay have low plasticity with group symbol CL.

### 5.3.6 Sand

A sand layer with trace silt to silty and trace clay was encountered beneath the silty clay in all of the boreholes. Boreholes 10+945 07R and 10+945 15R were terminated within the sand at a depth of 14.3 m (Elev. 219.5 to 219.6 m). Where fully penetrated, the thickness ranged from 2.1 to 7.4 m, and the base of the sand layer was encountered at depths of 5.8 to 13.3 m, with underside elevations from Elev. 222.0 to 228.2 m in Boreholes 10+945 27L, 10+945 18L and 10+945 27R.

SPT N-values recorded in the sand ranged from 1 to 49 blows per 0.3 m of penetration but typically ranged from 7 to 16 blows per 0.3 m of penetration, indicating a variable relative density of very loose to dense. The moisture content ranged from 18 to 27%.

The results of grain size distribution tests conducted on three samples of sand are presented on the Record of Borehole sheets in Appendix D and are plotted on Figure D2 of Appendix D. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	64 to 85
Silt %	12 to 31
Clay %	3 to 5
Silt & Clay %	19

### 5.3.7 Lower Silt

A layer of silt with trace to some sand and trace clay was encountered below the sand in Boreholes 10+945 27L and 10+945 18L. Borehole 10+945 27L was terminated at the base of the silt upon auger refusal on probable bedrock or boulder at a depth of 6.7 m (Elev. 227.3 m). Borehole 10+945 18L was terminated within the silt layer at a depth of 14.3 m (Elev. 221.0 m).

SPT N-values of 16 to 32 blows per 0.3 m of penetration were recorded, indicating a compact to dense relative density. Moisture contents ranging from 21 to 23% were recorded.

A grain size distribution test was conducted on a sample of the silt and the result is presented on the Record of Borehole sheet in Appendix D and the grain size distribution curve plotted on Figure D3 of Appendix D. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	9
Silt %	85
Clay %	6

### 5.3.8 Sandy Silt

A layer of sandy silt with trace clay was encountered directly below the sand layer within Borehole 10+945 27R. The sandy silt layer had an underside depth of 14.3 m (Elev. 219.5 m). A DCPT was conducted at the bottom of the borehole which encountered refusal at a depth of 21.2 m (Elev. 212.5 m).

SPT N-values ranging from 15 to 16 blows per 0.3 m of penetration were recorded, indicating a compact relative density. Corresponding moisture contents from 22 to 24% were measured.

A grain size distribution test was conducted on one sample of the sandy silt and the results are presented on the Record of Borehole sheets in Appendix D and the grain size distribution curve plotted on Figure D3 of Appendix D. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	32
Silt %	62
Clay %	6

### 5.3.9 Groundwater Conditions

A standpipe piezometer was installed in one borehole to monitor water levels after completion of drilling. The water levels observed in open boreholes and measured in the piezometer are summarized in Table 5-3.

**Table 5-3 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
10+945 07R	Feb. 5, 2014	1.3	232.6	Open Borehole
10+945 15R	Feb. 5, 2014	1.4	232.4	Open Borehole
10+945 18L	Mar. 16, 2014	3.9	231.4	Open Borehole
10+945 27L	Feb. 4, 2014	1.6	232.4	Open Borehole
10+945 27R	Mar. 27, 2014	1.0	232.8	Piezometer

## 5.4 Off Highway 11/17, Sta. 10+965 Red Rock Road #9 (Appendix E)

### 5.4.1 General

One borehole was advanced at Sta. 10+965 on Red Rock Road #9. The site stratigraphy encountered within this borehole generally consists of existing embankment fill underlain by a layer of organic soils, which was further underlain by silty sand with trace gravel and trace clay with an interlayer of silty clay.

### 5.4.2 Sand Fill

A 0.4 m thick layer of sand fill with some gravel was encountered at the surface of Borehole 10+020 CL (RR9) with an underside elevation of Elev. 231.8 m.

### 5.4.3 Organic Soils

A deposit of organic soils containing peat was encountered below the sand fill. The organics had a thickness of 0.2 m with a lower boundary at a depth of 0.6 m (Elev. 231.5 m).

A moisture content of 135% was measured in the organic soils.

### 5.4.4 Silty Sand

Below the organic soils, a deposit of silty sand with trace gravel and trace clay was encountered. The borehole was terminated in the sand at a depth of 14.3 m (Elev. 217.8 m).

SPT N-values typically ranged from 4 to 36 blows per 0.3 m of penetration, indicating a relative density of loose to dense. The measured moisture content of the sand varied from 16 to 26%.

Grain size distribution testing was carried out on two samples of the sand. The results of the testing are presented on the Record of Borehole Sheets included in Appendix E. The grain size distribution curves for the two samples are plotted on Figure E1 of Appendix E. The results of the laboratory tests are summarized as follows:

Gravel %	0 to 5
Sand %	51 to 77
Silt %	39
Clay %	5
Silt & Clay	23

#### 5.4.5 Silty Clay

A layer of silty clay with trace sand was encountered at a depth of 3.0 m within the silty sand deposit. The thickness of the silty clay layer was 2.5 m with a lower boundary depth at 5.5 m (Elev. 226.6 m).

SPT N-values of 1 and 2 blows per 0.3 m of penetration were recorded. An in situ field vane test measured an undrained shear strength of 62 kPa, indicating that the deposit is typically soft to firm. The measured sensitivity of 6, from remolded field vane testing, indicates that the silty clay is sensitive. The moisture content measurements ranged between 31 and 33%.

Grain size distribution and Atterberg Limits testing were carried out on a sample of the silty clay. The results of the testing are presented on the Record of Borehole Sheets included in Appendix E. The grain size distribution curve is plotted on Figure E2 and the Atterberg Limits test is plotted on Figure E3 of Appendix E. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	1
Silt %	58
Clay %	41
Liquid Limit %	29
Plastic Limit %	18

The results of the Atterberg Limit tests indicate that the tested sample of silty clay has low plasticity with group symbol CL.

#### 5.4.6 Groundwater Conditions

The water level observed in the open borehole upon completion of drilling is summarized in Table 5-4.

**Table 5-4 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
10+020 CL (RR9)	Mar. 14, 2014	3.3	228.8	Open borehole

## 5.5 Highway 11/17 EBL and WBL, Sta. 10+950 to 11+160 (Appendix F)

### 5.5.1 General

Two boreholes were advanced within Sta. 11+000 to 11+100. The site stratigraphy encountered generally consists of surficial layers of organics or sand with trace silt, underlain by a silty clay deposit with trace sand, which was further underlain by a deposit of silty sand to sand with trace clay and occasional silt seams.

### 5.5.2 Organic Soils

A 1.6 m thick layer of organic soils was encountered at the ground surface at Borehole 11+050 17R with an underside elevation of Elev. 232.6 m. At the time of the field investigation, the organic material was generally frozen, or covered with ice.

SPT N-values of 5 and 7 blows were recorded in the organics per 0.3 m of penetration; however the N-values likely reflect the frozen nature of the soil at the time of investigation. The moisture content ranged from 487 to 500%.

### 5.5.3 Sand

A layer of sand with trace silt and occasional rootlets was encountered at the ground surface in Borehole 11+050 28L. The sand layer was 0.6 m thick with an underside elevation of 234.3 m. At the time of the field investigation, the sand was generally frozen, or covered with ice.

A single SPT N-value of 28 blows per 0.3 m of penetration was recorded in the sand, indicating a compact relative density; however the N-value is likely related to the frozen nature of the surficial soils at the time of the investigation. A corresponding moisture content of 25% was measured.

### 5.5.4 Silty Clay

A silty clay deposit with trace sand was encountered beneath the organics and surficial sand layer. The thickness of this layer ranged from 1.7 to 2.7 m with the lower boundary encountered at depths from 2.3 to 4.3 m (Elev. 230.0 to 232.7 m).

SPT N-values were recorded in the silty clay ranging between 0 and 18 blows per 0.3 m of penetration. In situ field vane testing measured undrained shear strengths ranging from 62 to 70 kPa, with a measured sensitivity of 6, based on a remolded field vane test. The field vane test results indicate that the silty clay layer is stiff and classified as sensitive. The moisture content of the silty clay ranged from 23 to 35%.

Atterberg Limits testing was carried out on two samples of the silty clay. The results of the testing are presented on the Record of Borehole Sheets included in Appendix F. The Atterberg Limits test results are plotted on Figure F2 of Appendix F. The results of the laboratory tests are summarized as follows:

Liquid Limit %	30 to 37
Plastic Limit %	18 to 19

The results of the Atterberg Limit tests indicate that the tested sample of the silty clay ranges from low to intermediate plasticity with a group symbol of CL to CI.

### 5.5.5 Silty Sand to Sand

A sand layer ranging in composition from silty sand to sand with trace clay and occasional silt seams was encountered below the silty clay deposit. Both boreholes were terminated in the sand at depths ranging from 8.5 to 14.3 m (Elev. 219.9 to 226.4 m).

SPT N-values recorded within the sand deposit ranged from 3 to 35 blows per 0.3 m of penetration, indicating a very loose to dense relative density. The moisture content of the deposit ranged from 21 to 29%.

The results of a grain size distribution test conducted on one sample of the sand deposit is presented on the Record of Borehole sheet in Appendix F and the grain size distribution curve plotted on Figure F1 of Appendix F. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	85
Silt %	13
Clay %	2

### 5.5.6 Groundwater Conditions

The water levels observed in open boreholes upon completion of drilling is summarized in Table 5-5.

**Table 5-5 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
11+050 17R	Feb. 7, 2014	1.6	232.7	Open borehole
11+050 28L	Feb. 5, 2014	1.5	233.5	Open borehole

## 5.6 Highway 11/17 EBL and WBL, Sta. 11+160 to 11+170 (Appendix G)

### 5.6.1 General

Five boreholes were advanced along the proposed culvert alignment for Culvert 3 A/B. The site stratigraphy encountered generally consists of peat or existing embankment fill, underlain by sand and silt with trace clay, which was further underlain by silty clay with occasional sand seams. Below the above deposits was a layer of sand and silt with trace clay to silty sand.

### 5.6.2 Peat

A deposit of peat ranging from 0.6 to 1.0 m thick was encountered at the surface of Boreholes 11+165 31L, 11+165 05R, 11+165 19R, 11+165 31R. The peat contained roots, rootlets and occasional wood fibres. At the time of the field investigation, the peat was generally frozen, or covered with ice.

SPT N-values of 4 to 20 blows per 0.3 m of penetration were recorded in the peat; however the N-values likely reflect the frozen nature of the soil at the time of investigation. The moisture content varied from 115 to 289%.

### 5.6.3 Sand Fill

Sand fill with trace to some gravel and occasional cobbles was encountered at the surface of Borehole 11+165 14L which was drilled on the existing Highway 11/17 embankment. The thickness of the sand fill was 2.2 m with a corresponding underside elevation of Elev. 233.8 m. At the time of the field investigation, the sand fill was frozen to approximately 2.0 m.

SPT N-values of 28 blows per 0.3 m of penetration to 50 blows per 0.05 m of penetration were recorded in the frozen fill, indicating a compact to very dense relative density. The moisture content varied from 3 to 10%.

### 5.6.4 Sand and Silt

A layer of sand and silt with trace clay was encountered below the peat and sand fill in Boreholes 11+165 14L, 11+165 05R, 11+165 19R and 11+165 31R. The thickness of this layer ranged from 1.8 to 2.2 m, with the lower boundary encountered at depths varying from 2.8 to 4.1 m (Elev. 229.9 to 232.0 m).

SPT N-values recorded in the sand and silt ranged from 5 to 16 blows for 0.3 m penetration, indicating a loose to compact relative density. The moisture content ranged from 22 to 32%.

The results of grain size distribution testing conducted on two samples of the sand and silt layer are presented on the Record of Borehole sheets in Appendix G. The grain size distribution curves are plotted on Figure G1 of Appendix G. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	54 to 59
Silt %	39 to 41
Clay %	2 to 5

### 5.6.5 Silty Clay

A silty clay to clayey silt deposit with occasional sand seams was encountered below the sand and silt or peat layers. The investigated thickness of this layer ranged from 2.0 to 3.7 m with the lower boundary encountered at depths from 3.4 to 6.5 m (Elev. 226.3 to 231.2 m).

SPT N-values were recorded between 0 and 10 blows per 0.3 m of penetration. In situ field vane testing measured undrained shear strengths in the order of 14 to 74 kPa. The vane testing results indicate that the clay layer is soft to stiff. The measured sensitivity, from remolded field vane testing, ranged from 3 to 10 indicating the clay is classified as medium to extra sensitive. The moisture content typically ranged from 26 to 38%.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the deposit. The results of the testing are presented on the Record of Borehole Sheets included in Appendix G. The grain size distribution curve for a sample is plotted on Figure G2 and the four Atterberg Limits test results are plotted on Figure G3 of Appendix G. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	2
Silt %	65
Clay %	33
Liquid Limit %	27 to 33
Plastic Limit %	17 to 19

The results of the Atterberg Limit tests indicate that the tested samples of clay have low plasticity with group symbol CL.

### 5.6.6 Lower Sand and Silt

A deposit of sand and silt with trace clay was encountered below the silty clay layer in all five boreholes. A DCPT was conducted at the bottom of Borehole 11+165 05R, which encountered refusal at a depth of 21.0 m (Elev. 213.3 m). The remaining four boreholes were terminated within this layer at a depth of 14.3 m (Elev. 218.4 to 221.8 m)

SPT N-values recorded within the deposit typically ranged from 6 to 53 blows for 0.3 m penetration, indicating a widely variable relative density of very loose to very dense. Moisture contents ranged from 15% to 31%.

The results of grain size distribution testing conducted on four samples from the layer are presented on the Record of Borehole sheets in Appendix G. Four grain size distribution curves are plotted on Figure G1 of Appendix G. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	40 to 68
Silt %	43 to 57
Clay %	2 to 3
Silt & Clay %	32

### 5.6.7 Groundwater Conditions

A standpipe piezometer was installed in one borehole to monitor water levels after completion of drilling. The water levels observed in open boreholes and measured in the piezometer are summarized in Table 5-6.

**Table 5-6 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
11+165 19R	Mar. 27, 2014	2.4	231.8	Piezometer
11+165 05R	Feb. 9, 2014	1.9	232.4	Open Borehole
11+165 14L	Mar. 24, 2014	4.7	231.4	Open Borehole
11+165 31L	Feb 5, 2014	1.8	232.8	Open Borehole
11+165 31R	Feb. 7, 2014	1.8	231.0	Open Borehole

## 5.7 Highway 11/17 EBL, Sta. 11+170 to 11+770 (Appendix H)

### 5.7.1 General

Five boreholes were advanced within Sta. 11+200 to 11+700. The site stratigraphy encountered generally consists of a surficial layer of organics underlain by a deposit of silty sand to sandy silt with trace clay which was further underlain by a deposit of silty clay with trace to some sand and occasional silt seams. Below the above deposits was a layer of sand and silt to sandy silt with trace clay.

### 5.7.2 Organic Soils

A 0.1 to 0.3 m thick layer of organic soils containing roots and rootlets was encountered at the surface of all five boreholes. At the time of the field investigation, the organic material was generally frozen, or covered with ice.

The moisture content ranged from 36 to 43%.

### 5.7.3 Silty Sand to Sandy Silt

A silty sand to sandy silt deposit with trace clay and trace roots and rootlets was encountered beneath the surficial layer of organics in all five boreholes. The thickness of this layer ranged from 4.0 to 6.0 m, with the lower boundary encountered at depths from 4.3 to 6.1 m (Elev. 227.5 to 230.2 m).

SPT N-values were recorded between 2 to 30 blows per 0.3 m of penetration, indicating a very loose to compact relative density. Moisture contents ranged from 11% to 42%.

Grain size distribution testing was carried out on four samples of the silty sand to sandy silt. The results of the testing are presented on the Record of Borehole Sheets included in Appendix H. The grain size distribution curves for the samples are plotted on Figure H1 of Appendix H. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	38 to 73
Silt %	25 to 59
Clay %	2 to 3

### 5.7.4 Silty Clay

Below the silty sand to sandy silt deposit, a layer of silty clay with trace to some sand and occasional silt seams was encountered in all five boreholes. The investigated thickness ranged from 2.8 to 5.3 m, with the lower boundary encountered at depths from 7.5 to 10.4 m (Elev. 222.6 to 227.5 m).

SPT N-values were recorded in the silty clay deposit between 0 and 7 blows per 0.3 m of penetration. In situ field vane testing measured undrained shear strengths of 47 kPa or greater, with measured sensitivities ranging from 4 to 14, based on remolded field vane tests. The vane testing indicate that the silty clay is typically stiff to very stiff and classified as sensitive to extra-sensitive. The measured moisture contents ranged from 26 to 41%.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silty clay. The results of the testing are presented on the Record of Borehole Sheets included in Appendix H. The grain size distribution curve for one sample is plotted on Figure H2 and five Atterberg Limits test results are plotted on Figure H4 of Appendix H. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	1
Silt %	53
Clay %	46
Liquid Limit %	30 to 40
Plastic Limit %	17 to 18

The results of the Atterberg Limit tests indicate that the tested samples of silty clay have low to intermediate plasticity with a group symbol of CL to CI.

### 5.7.5 Sand and Silt to Sandy Silt

Below the silty clay deposit, a layer of sand and silt to sandy silt with trace clay was encountered in all five boreholes. All five boreholes were terminated in this deposit at depths varying from 14.0 to 14.3 m (Elev. 217.8 to 221.0 m).

SPT N-values were typically recorded between 2 and 29 blows per 0.3 m of penetration, indicating a relative density of very loose to compact. Localized SPT N-values as high as 50 blows per 0.125 m were obtained near the bottom of Borehole 11+700 19R. The measured moisture content of the sand ranged between 17 and 26%.

The results of grain size distribution testing conducted on two samples are presented on the corresponding Record of Borehole sheets. The grain size distribution curves for the two samples are plotted on Figure H3 of Appendix H. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	6 to 54
Silt %	42 to 86
Clay %	4 to 8

### 5.7.6 Groundwater Conditions

The water levels observed in open boreholes upon completion of drilling are provided below in Table 5-7.

**Table 5-7 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
11+250 19R	Feb. 10, 2014	2.3	232.6	Open borehole
11+405 19R	Feb. 10, 2014	2.4	232.9	Open borehole
11+450 22R	Feb. 13, 2014	2.3	231.1	Open borehole
11+550 24R	Feb. 14, 2014	4.1	228.8	Open borehole
11+700 19R	Feb. 15, 2014	1.4	230.4	Open borehole

## 5.8 Off Highway 11/17, Sta. 11+410 Landfill Road (Appendix I)

### 5.8.1 General

Two boreholes were advanced at Sta. 11+410 for Landfill Road. The site stratigraphy encountered generally consists of a surficial layer of organic soils underlain by a deposit of

silty sand to sandy silt with trace clay and occasional silt seams which was interrupted by a layer of silty clay with occasional sand seams.

### 5.8.2 Organic Soils

A layer of organic soils with a thickness of 0.1 to 0.2 m was encountered at the surface of both boreholes.

### 5.8.3 Silty Sand to Sandy Silt

A deposit ranging in composition from silty sand to sandy silt with trace clay was encountered below the organics. Both boreholes were terminated in the sand deposit at the maximum investigation depth of 14.3 m (Elev. 220.2 to 221.1 m).

SPT N-values were recorded between 3 and 22 blows per 0.3 m of penetration, indicating a relative density of very loose to compact. The moisture content in the sand varied between 18 and 29%.

Grain size distribution tests were carried out on two samples of the sand deposit. The results of the testing are presented on the Record of Borehole Sheets included in Appendix I. The grain size distribution curves are plotted on Figure I1 of Appendix I. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	32 to 35
Silt %	58 to 65
Clay %	3 to 7

### 5.8.4 Silty Clay

An interlayer of silty clay with occasional sand seams was encountered within the sand deposit. The thickness of the silty clay ranged from 2.6 to 3.6 m with an underside depth between 7.5 and 9.7 m (Elev. 224.8 to 227.9 m).

SPT N-values were recorded between 3 and 13 blows per 0.3 m of penetration. An in situ field vane test conducted at the base of the silty clay measured an undrained shear strength of 72 kPa indicating that the silty clay deposit is typically stiff. The moisture content varied between 25 and 36%.

Atterberg Limits testing was carried out on select samples of the silty clay. The results of the testing are presented on the Record of Borehole Sheets included in Appendix I. Three Atterberg Limits test results are plotted on Figure I2 of Appendix I. The results of the laboratory tests are summarized as follows:

Liquid Limit %	31 to 36
Plastic Limit %	17

The results of the Atterberg Limit tests indicate that the tested samples of silty clay range from low to intermediate plasticity with group symbol CL to CI.

### 5.8.5 Groundwater Conditions

The water levels observed in open boreholes upon completion of drilling are summarized in Table 5-8.

**Table 5-8 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
9+965 CL (LFR)	Feb. 14, 2014	4.0	231.4	Open borehole
10+010 CL (LFR)	Feb. 13, 2014	2.5	232.0	Open borehole

## 5.9 Highway 11/17 EBL and WBL, Sta. 11+770 to 11+800 (Appendix J)

### 5.9.1 General

Five boreholes were advanced along the proposed culvert alignment for Culvert 4 A/B. The site stratigraphy encountered generally consists of existing embankment fill or peat, underlain by a deposit of silty clay with trace sand and occasional silt seams, which was further underlain by silt with trace to some sand and trace clay.

### 5.9.2 Peat

A layer of peat containing rootlets ranging from 0.7 to 1.4 m thick was encountered at the surface of Boreholes 11+775 35L, 11+785 08R, 11+790 20R, 11+795 35R and buried beneath sand fill in Borehole 11+780 17L. The underside elevation of the peat varied from Elev. 228.2 to 230.8 m. At the time of the field investigation, the peat was generally frozen, or covered with ice.

SPT N-values recorded in the frozen peat ranged from 4 to 20 blows per 0.3 m of penetration. The moisture content ranged from 59 to 246%.

### 5.9.3 Sand Fill

Borehole 11+780 17L was drilled on the existing Highway 11/17 embankment and encountered sand fill with trace to some gravel and trace to some silt. The thickness of the sand fill was 2.9 m with a corresponding underside elevation of Elev. 231.0 m. At the time of the field investigation, the sand fill was frozen to approximately 2.0 m.

SPT N-values of 4 to 16 blows per 0.3 m of penetration to 50 blows per 0.075 m of penetration were recorded in the sand fill. The moisture content generally increased in depth from 6 to 33%.

#### 5.9.4 Silty Clay

A silty clay deposit with trace sand and occasional silt seams was encountered beneath the peat layer in all boreholes. The thickness of this layer ranged from 1.6 to 5.3 m with the lower boundary encountered at depths from 3.0 to 7.3 m (Elev. 222.8 to 229.1 m).

SPT N-values were recorded between 2 and 16 blows per 0.3 m of penetration. In situ field vane testing measured undrained shear strengths of 65 kPa or greater. The field vane testing indicates that the silty clay layer is stiff to very stiff. The measured sensitivity, from remolded field vane testing, ranged from 2 to 6, indicating that the silty clay ranges from medium sensitivity to sensitive.

The moisture content of the silty clay deposit ranged from 27 to 46%.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silty clay. The results of the testing are presented on the Record of Borehole Sheets included in Appendix J. The grain size distribution curve for one sample is plotted on Figure J1 and five Atterberg Limits test results are plotted on Figure J3 of Appendix J. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	0
Silt %	61
Clay %	39
Liquid Limit %	30 to 41
Plastic Limit %	18

The results of the Atterberg Limit tests indicate that the tested samples of silty clay have low to intermediate plasticity with group symbols of CL to CI.

#### 5.9.5 Silt

Below the silty clay deposit, a layer of silt with trace to some sand and trace clay was encountered in all five boreholes. The investigated thickness ranged from 6.1 to 9.1 m with a lower boundary depth varying from 12.1 to 13.6 m (Elev. 216.7 to 220.1 m) in Borehole 11+795 35R as well as Boreholes 11+775 35L and 11+785 08R which were terminated at the base of the silt upon auger refusal on probable bedrock or boulder. Borehole 11+780 17L was terminated within this layer at a depth of 14.0 m (Elev. 219.9 m). A DCPT was conducted in Borehole 11+790 20R at the bottom of the borehole to refusal at a depth of 15.2 m (Elev. 214.0 m).

SPT N-values generally increased with depth and were recorded between 7 to 120 blows per 0.3 m of penetration to as high as 100 blows per 0.250 m of penetration indicating a relative density increasing from loose to very dense. The measured moisture content of the silt ranged between 17 and 26%.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silt. The results of the testing are presented on the Record of Borehole Sheets included in Appendix J. The grain size distribution curves for six samples are plotted on Figure J2 of Appendix J. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	4 to 12
Silt %	78 to 92
Clay %	4 to 10

### 5.9.6 Clayey Silt

A 2.1 m thick layer of clayey silt was encountered below the silt layer in Borehole 11+795 35R. The borehole was terminated within this layer at the maximum investigation depth of 14.3 m (Elev. 214.6 m).

SPT N-values ranging of 55 and 60 blows per 0.3 m of penetration were recorded, indicating a hard consistency. Moisture contents between 20 and 23% were recorded.

### 5.9.7 Groundwater Conditions

A standpipe piezometer was installed in one borehole to monitor water levels after completion of drilling. The water levels observed in open boreholes and measured in the piezometer are summarized in Table 5-9.

**Table 5-9 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
11+775 35L	Feb. 6, 2014	2.7	229.5	Open Borehole
11+780 17L	Mar. 26, 2014	6.2	227.7	Open Borehole
11+785 08R	Feb. 11, 2014	2.7	228.3	Open Borehole
11+790 20R	Feb. 10, 2014	3.0	226.2	Open Borehole
11+795 35R	Mar. 27, 2014	2.3	226.6	Piezometer

## 5.10 Highway 11/17 EBL and WBL, Sta. 11+900 to 11+950 (Appendix K)

### 5.10.1 General

Five boreholes were advanced along the proposed culvert alignment for Culvert 5 A/B. The site stratigraphy encountered generally consists of peat or existing embankment fill, underlain by a deposit of silty clay with trace sand and occasional sand seams, which was further underlain by silt with trace sand and trace clay.

### 5.10.2 Peat

A 0.8 to 1.5 m thick layer of peat containing rootlets was encountered at the surface of Boreholes 11+912 19L, 11+923 02R, 11+930 19R, 11+940 33R. The underside elevation of the peat varied from Elev. 228.0 to 230.3 m. At the time of the field investigation, the peat was generally frozen, or covered with ice.

SPT N-values recorded in the frozen peat were between 4 and 12 blows per 0.3 m of penetration. The moisture content ranged from 64 to 207%.

### 5.10.3 Sand Fill

Borehole 11+905 32L was drilled on the existing Highway 11/17 embankment and encountered sand fill with trace to some gravel and trace to some silt. The thickness of the sand fill was 3.0 m with a corresponding underside elevation of Elev. 230.3 m. At the time of the field investigation, the sand fill was generally frozen, or covered with ice.

SPT N-values of 11 blows per 0.3 m of penetration to 50 blows per 0.075 m of penetration were recorded in the sand fill; however the N-values likely reflect the frozen nature of the soil at the time of investigation. The moisture content varied from 8 to 17%.

### 5.10.4 Silty Clay

A native deposit of silty clay with trace sand and occasional sand seams was encountered beneath the peat and sand fill layers. The thickness of this layer ranged from 2.5 to 7.7 m with the lower boundary encountered at depths from 4.9 to 8.5 m (Elev. 220.4 to 227.7 m).

SPT N-values were recorded between 2 and 13 blows per 0.3 m of penetration. In situ field vane testing measured undrained shear strengths ranging of 34 kPa or greater. The field vane testing indicates that the silty clay layer is typically firm to stiff. The measured sensitivity, from remolded field vane testing, ranged from 3 to 10 indicating that the silty clay ranges from medium to extra sensitive. The moisture content of the deposit ranged from 24 to 49%.

Grain size distribution and Atterberg Limits testing were carried out on select samples. The results of the testing are presented on the Record of Borehole Sheets included in Appendix K. The grain size distribution curves for four samples are plotted on Figure K1 and nine Atterberg Limits test results are plotted on Figure K3 and K4 of Appendix K. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	0 to 3
Silt %	37 to 51
Clay %	49 to 62
Liquid Limit %	25 to 46
Plastic Limit %	15 to 18

The results of the Atterberg Limit tests indicate that the tested samples of silty clay range from low to intermediate plasticity with group symbols CL to CI.

### 5.10.5 Silt

Below the silty clay deposit, a layer of silt with trace sand and trace clay was encountered in all five boreholes. Boreholes 11+905 32L, 11+912 19L, 11+923 02R and 11+930 19R were terminated within this deposit at depths ranging from 14.2 to 14.3 m (Elev. 215.2 to 218.9 m). A DCPT was conducted in Borehole 11+940 33R at the bottom of the borehole to refusal encountered at a depth of 15.5 m (Elev. 213.3 m).

A localized 1.2 m thick layer of silt with trace sand and trace clay was encountered within the silty clay layer in Borehole 11+940 33R. The silt layer had a lower boundary depth of depths of 6.1 m, with an underside elevation of 222.8 m.

SPT N-values generally increased with depth with values recorded at 6 to 117 blows per 0.3 m of penetration indicating an increasing relative density from very loose to very dense. The measured moisture content of the silt ranged from 17 to 26%.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silt. The results of the testing are presented on the Record of Borehole Sheets included in Appendix K. The grain size distribution curves for five samples are plotted on Figure K2. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	2 to 3
Silt %	90 to 92
Clay %	6 to 7

### 5.10.6 Groundwater Conditions

A standpipe piezometer was installed in one borehole to monitor water levels after completion of drilling. The water levels observed in open boreholes and measured in the piezometer are summarized in Table 5-10.

**Table 5-10 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
11+905 32L	Mar. 26, 2014	6.3	226.9	Open Borehole
11+912 19L	Feb. 6, 2014	3.7	228.1	Open Borehole
11+923 02R	Feb. 7, 2014	3.9	227.0	Open Borehole
11+930 19R	Mar. 19, 2014	2.2	227.4	Piezometer
	Mar. 27, 2014	2.2	227.4	Piezometer
11+940 33R	Feb. 9, 2014	13.1	215.8	Open Borehole

## **5.11 Highway 11/17 EBL and WBL, Sta. 12+070 to 12+080 (Appendix L)**

### **5.11.1 General**

Four boreholes were advanced along the proposed culvert alignment for Culvert 6 A/B. Two boreholes (12+080 19L and 12+080.9 17.8R) were completed previously in 2013 during the fill embankments investigation but are included on the Borehole Location and Soil Strata Drawing included in Appendix L. The site stratigraphy encountered typically consists of surficial peat or silty clay to sandy silt fill overlying a deposit of silty clay with occasional sand seams, which was further underlain by silt with trace to some clay and trace sand. Below the above deposits was a lower layer of silty clay with trace sand.

### **5.11.2 Peat**

A 0.7 to 2.1 m thick layer of peat containing trace rootlets and trace sand was encountered at the surface of Boreholes 12+075 33L 12+075 35R and buried beneath silty clay to sandy silt fill in Boreholes 12+075 05R and 12+075 06L. The underside elevation of the peat varied from Elev. 224.0 to 227.0 m. At the time of the field investigation, the peat was generally frozen, or covered with ice where encountered at the surface.

SPT N-values recorded in the peat were between 2 and 23 blows per 0.3 m of penetration; however the N-values likely reflect the frozen nature of the soil at the time of investigation. The moisture content ranged from 45 to 93%.

### **5.11.3 Silty Clay to Sandy Silt Fill**

A 0.3 and 0.8 m thick layer of fill with a composition ranging from silty clay to sandy silt with trace gravel was encountered at the surface of Boreholes 12+075 05R and 12+075 06L. At the time of the field investigation, the fill was generally frozen, or covered with ice.

A single SPT N-value of 38 blows per 0.3 m of penetration was recorded; however the N-value likely reflects the frozen nature of the soil at the time of investigation. A moisture content of 18% was recorded.

### **5.11.4 Silty Clay**

A silty clay deposit with occasional sand seams was encountered beneath the peat and fill layers. The thickness of this layer ranged from 1.6 to 5.5 m with the lower boundary encountered at depths from 3.0 to 7.6 m (Elev. 218.5 to 225.4 m).

SPT N-values were recorded between 0 to 10 blows per 0.3 m of penetration. In situ field vane testing measured undrained shear strengths greater than 80 kPa indicating that the silty clay layer is typically stiff. The measured sensitivity of 4 to 5, from remolded field vane testing, indicates that the silty clay is sensitive. The moisture content of the deposit ranged from 30 to 55%.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silty clay. The results of the testing are presented on the Record of Borehole Sheets included in Appendix L. The grain size distribution curve for one sample is plotted on Figure L1 and four Atterberg Limits test results are plotted on Figure L4 of Appendix L. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	0
Silt %	47
Clay %	53
Liquid Limit %	33 to 37
Plastic Limit %	17 to 18

The results of the Atterberg Limit tests indicate that the tested sampled of silty clay have low to intermediate plasticity with group symbols CL to CI.

### 5.11.5 Silt

Below the silty clay deposit, a layer of silt with trace to some clay and trace sand was encountered in all four boreholes. In Boreholes 12+075 05R, 12+075 33L and 12+075 35R, the thickness of the silt layer ranged from 6.1 to 8.3 m with the lower boundary encountered at depths between 11.3 and 13.7 m (Elev. 212.4 to 217.2 m). Borehole 12+075 33L was terminated at the base of the silt upon auger refusal on probable bedrock or boulder. Borehole 12+075 06L was terminated in the silt at a depth of 13.4 m (Elev. 214.5 m).

The SPT N-values ranged from 5 to 125 blows per 0.3 m of penetration, indicating a widely variable relative density of very loose to very dense. The measured moisture content of the silt ranged from 19 to 36%.

The results of grain size distribution tests conducted on three samples of the silt layer are presented on the Record of Borehole sheets in Appendix L. The grain size distribution curves are plotted on Figure L2 of Appendix L. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	2 to 3
Silt %	86 to 89
Clay %	8 to 12

### 5.11.6 Lower Silty Clay

A lower silty clay deposit with trace sand was encountered beneath the silt layer in Boreholes 12+075 05R and 12+075 35R. Borehole 12+075 05R was terminated in the lower silty clay upon auger refusal on probable bedrock or boulder at a depth of 14.1 m (Elev. 213.6 m). A DCPT was conducted in Borehole 12+075 35R at the bottom of the borehole to refusal encountered at a depth of 15.7 m (Elev. 210.4 m).

The lower silty clay was stiff, based on the SPT N-values which ranged from 12 to 20 blows per 0.3 m of penetration. The moisture content of the lower silty clay ranged from 22 to 28%.

The results of grain size distribution tests conducted on two samples of the lower silty clay are presented on the Record of Borehole sheets in Appendix L. The grain size distribution curves are plotted on Figure L3 of Appendix L. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	0 to 3
Silt %	70 to 72
Clay %	25 to 30

### 5.11.7 Groundwater Conditions

A standpipe piezometer was installed in one borehole to monitor water levels after completion of drilling. The water levels observed in open boreholes and measured in the piezometer are summarized in Table 5-11.

**Table 5-11 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
12+075 05R	Feb. 13, 2014	7.6	220.1	Open Borehole
12+075 06L	Feb. 13, 2014	3.7	224.2	Open Borehole
12+075 33L	Feb. 12, 2014	2.4	226.0	Open Borehole
12+075 35R	Mar. 27, 2014	2.0	224.1	Piezometer

## 5.12 Highway 11/17 EBL, Sta. 12+100 to 12+170 (Appendix M)

### 5.12.1 General

One borehole was advanced within Sta. 12+100 to 12+170. The site stratigraphy encountered typically consists of surficial organic soils underlain by a deposit of silt with trace to some sand and trace clay, which was further underlain by silty clay with trace sand. Below the above deposits was a lower layer of silt with trace sand to sandy and some clay.

### 5.12.2 Organic Soils

A 0.8 m thick layer of organic soils containing trace rootlets and trace wood was encountered at the surface of Borehole 12+130 15R.

A single SPT N-value of 3 blows per 0.3 m of penetration was recorded in the organic soils, indicating a soft relative density. A corresponding moisture content of 30% was measured.

### 5.12.3 Silt

Below the organic soils was a 1.5 m thick layer of silt with trace to some sand and trace clay with a lower boundary depth of 2.3 m (Elev. 227.1 m).

SPT N-values of 3 and 11 blows per 0.3 m of penetration were recorded; indicating a very loose to compact relative density. Corresponding moisture contents ranging from 31 to 44% were recorded.

### 5.12.4 Silty Clay

A silty clay deposit with trace sand was encountered beneath the silt layer. The thickness of this layer was 5.3 m with the lower boundary encountered at a depth of 7.6 m (Elev. 221.8 m).

SPT N-values were recorded between 0 and 4 blows per 0.3 m of penetration. In situ field vane testing measured undrained shear strengths greater than 85 kPa with a sensitivity of 4, indicating that the silty clay layer is stiff with medium sensitivity. The moisture content of the deposit ranged from 35 to 50%.

The results of Atterberg Limits testing carried out on one sample of the silty clay is presented on the Record of Borehole Sheets included in Appendix M. One Atterberg Limits test is plotted on Figure M2 of Appendix M. The results of the laboratory test are summarized as follows:

Liquid Limit %	37
Plastic Limit %	18

The results of the Atterberg Limit test indicate that the tested sample of silty clay has intermediate plasticity with group symbol of CI.

### 5.12.5 Lower Silt

Below the silty clay deposit, a lower layer of silt with trace sand to sandy and some clay was encountered. The borehole was terminated within this layer at a depth 14.3 m (Elev. 215.1 m).

SPT N-values were recorded from 13 to 42 blows per 0.3 m of penetration, indicating a compact to dense relative density. The measured moisture content of the silt varied from 21 to 26%.

Grain size distribution testing was carried out on a sample of the silt. The results of the testing are presented on the Record of Borehole Sheet included in Appendix M. The grain size distribution curve for is plotted on Figure M1 of Appendix M. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	1
Silt %	82
Clay %	17

### 5.12.6 Groundwater Conditions

The water levels observed in the open borehole upon completion of drilling is summarized in Table 5-12.

**Table 5-12 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
12+130 15R	Feb. 15, 2014	3.0	226.4	Open borehole

## 5.13 Highway 11/17 EBL and WBL, Sta. 12+230 to 12+250 (Appendix N)

### 5.13.1 General

Three boreholes were advanced along the proposed culvert alignment for Culvert 7 A/B. Two boreholes (12+230 19R and 12+243 30.7L) were completed previously in 2013 during the fill embankments investigation but are included on the Borehole Location and Soil Strata Drawing included in Appendix N. The site stratigraphy encountered typically consists of peat underlain by silt with some clay and trace sand or silty clay with trace sand. Below the silty clay was a layer of silty sand in Borehole 12+230 43R.

### 5.13.2 Peat

A 1.5 to 1.7 m thick layer of peat containing trace rootlets and trace wood fragments was encountered at the surface of all three boreholes. The underside elevation of the peat varied from Elev. 222.9 to 225.1 m.

SPT N-values recorded in the peat varied from 2 to 5 blows per 0.3 m of penetration. The moisture content ranged from 91 to 179%.

### 5.13.3 Silt

Below the surficial peat, a layer of silt with some clay and trace sand was encountered in Borehole 12+240 42L. The thickness of the silt was 0.8 m with a lower boundary depth at 2.3 m (Elev. 223.8 m).

A single SPT N-value of 3 blows per 0.3 m of penetration was recorded, indicating a very loose relative density. A moisture content of 36% was recorded.

The results of a grain size distribution test conducted on one sample of the silt is presented on the Record of Borehole sheets in Appendix N and plotted on Figure N1 of Appendix N. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	2
Silt %	81
Clay %	17

#### 5.13.4 Silty Clay

A silty clay deposit with trace sand, occasional silt seams and occasional cobbles was encountered beneath the silt or peat layers. In Borehole 12+230 43R, the thickness of the silty clay layer was 7.6 m with the lower boundary encountered at a depth of 9.1 m (Elev. 215.3 m). Boreholes 12+235 CL and 12+240 42L were terminated at the base of the deposit upon auger refusal on probable bedrock or boulder at depths ranging from 4.7 to 8.6 m (Elev. 218.2 to 221.3 m).

SPT N-values were typically recorded between 3 and 11 blows per 0.3 m of penetration. A single in situ field vane test measured an undrained shear strength of 85 kPa with a sensitivity of 3, indicating that the silty clay is firm to stiff with medium sensitivity. The moisture content of the silty clay deposit ranged from 23 to 40%.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silty clay. The results of the testing are presented on the Record of Borehole Sheets included in Appendix N. The grain size distribution curves for two samples are plotted on Figure N2 and three Atterberg Limits test results are plotted on Figure N3 of Appendix N. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	1
Silt %	69 to 70
Clay %	29 to 30
Liquid Limit %	33 to 35
Plastic Limit %	17 to 18

The results of the Atterberg Limit tests indicate that the tested samples of silty clay have low to intermediate plasticity with group symbols CL to CI.

#### 5.13.5 Silty Sand

Below the silty clay in Borehole 12+230 43R, a 1.0 m thick layer of silty sand was encountered. The borehole was terminated at the base of the layer upon auger refusal on probable bedrock or boulder at a depth of 10.1 m (Elev. 214.4 m).

A single SPT N-value of 97 blows per 0.3 m of penetration was recorded, indicating a very dense relative density. A corresponding moisture content of 29% was recorded.

#### 5.13.6 Groundwater Conditions

A standpipe piezometer was installed in one borehole to monitor water levels after completion of drilling. The water levels observed in open boreholes and measured in the piezometer are summarized in Table 5-13.

**Table 5-13 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
12+230 43R	Mar. 27, 2014	1.6 <sup>(1)</sup>	222.8	Piezometer
12+235 CL	Feb. 16, 2014	5.5	221.3	Open Borehole
12+240 42L	Feb. 15, 2014	3.7	222.4	Open Borehole

Note: (1) Frozen

## 5.14 Highway 11/17 EBL, Sta. 12+270 to 12+420 (Appendix O)

### 5.14.1 General

One borehole was advanced within Sta. 12+275 to 12+420. The site stratigraphy encountered typically consists of existing embankment fill underlain by a deposit of silty clay, which was further underlain by a sand layer with trace silt.

### 5.14.2 Sandy Silt Fill

Borehole 12+350 19R was drilled on the existing Highway 11/17 embankment and encountered a 2.3 m thick layer of sandy silt fill containing trace organics with an underside elevation of Elev. 225.3 m.

SPT N-values recorded in the fill varied from 2 to 7 blows per 0.3 m of penetration, indicating a very loose to loose relative density. The moisture content ranged from 34 to 37%.

### 5.14.3 Silty Clay

A native deposit of silty clay was encountered beneath the sandy silt fill. The encountered thickness of this layer of 8.4 m had a corresponding lower boundary at a depth of 10.7 m (Elev. 216.9 m).

SPT N-values were recorded between 0 and 5 blows per 0.3 m of penetration. A single in situ field vane test measured an undrained shear strength of 70 kPa with a sensitivity of 4, indicating that the silty clay is firm to stiff with medium sensitivity. The moisture content of the silty clay deposit ranged from 34 to 58%.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silty clay. The results of the testing are presented on the Record of Borehole Sheets included in Appendix O. The grain size distribution curve for one sample is plotted on Figure O1 and two Atterberg Limits test results are plotted on Figure O2 of Appendix O. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	0
Silt %	47
Clay %	53
Liquid Limit %	25 to 27
Plastic Limit %	16 to 18

The results of the Atterberg Limit tests indicate that the tested samples of the silty clay have low plasticity with group symbol of CL.

#### 5.14.4 Sand

A 1.5 m thick layer of sand with trace silt was encountered below the silty clay deposit. The borehole was terminated at the base of the sand upon auger refusal on probable bedrock or boulder at a depth of 12.2 m (Elev. 215.4 m).

The sand was dense based on a single SPT N-value of 84 blows per 0.3 m of penetration. A moisture content of 15% was measured.

#### 5.14.5 Groundwater Conditions

The water levels observed in the open borehole upon completion of drilling is summarized in Table 5-14.

**Table 5-14 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
12+350 19R	Feb. 16, 2014	3.0	224.6	Open borehole

### 5.15 Highway 11/17 EBL, Sta. 12+540 to 12+590 (Appendix P)

#### 5.15.1 General

One borehole was advanced within Sta. 12+540 to 12+590. The site stratigraphy encountered typically consists of peat overlying a deposit of silty clay.

#### 5.15.2 Peat

A 0.8 m thick layer of peat containing trace rootlets and trace wood was encountered at the surface of Borehole 12+540 21R with an underside elevation of Elev. 223.4 m. At the time of the field investigation, the peat was generally frozen or covered with ice.

A single SPT N-value of 4 blows per 0.3 m of penetration was recorded; however the N-value likely reflects the frozen nature of the soil at the time of investigation. A moisture content of 146% was measured.

**5.15.3 Silty Clay**

A silty clay deposit was encountered beneath the peat. The borehole was terminated at the base of the silty clay upon auger refusal on probable bedrock or boulder at a depth of 3.7 m (Elev. 220.5 m).

SPT N-values from 0 to 9 blows per 0.3 m of penetration were recorded, indicating a very soft to stiff consistency. The moisture content of the silty clay ranged from 28 to 65%.

A grain size distribution test was carried out on a sample of the silty clay. The results of the testing are presented on the Record of Borehole Sheets included in Appendix P. The grain size distribution curve for one sample is plotted on Figure P1 of Appendix P. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	1
Silt %	59
Clay %	40

**5.15.4 Groundwater Conditions**

The water levels observed in the open borehole upon completion of drilling is summarized in Table 5-15.

**Table 5-15 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
12+540 21R	Feb. 16, 2014	3.4	220.8	Open borehole

**5.16 Highway 11/17 WBL Sta. 12+730 to 12+900 (Appendix Q)**

**5.16.1 General**

Two boreholes were advanced within Sta. 12+730 to 12+900. The site stratigraphy encountered typically consists of existing embankment fill underlain by peat or sand with peat pockets, which was further underlain by clayey silt. Below the clayey silt was a layer of silty clay.

**5.16.2 Sand to Clayey Silt Fill**

Boreholes 12+770 23L and 12+845 20L drilled on the existing Highway 11/17 embankment encountered fill comprising of sand with some gravel and occasional cobbles to clayey silt. The thickness of the fill ranged from 2.1 to 2.4 m with corresponding underside elevations ranging from of Elev. 218.9 to 219.9 m. At the time of the field investigation, the fill was generally frozen or covered with ice.

SPT N-values of 72 blows per 0.3 m of penetration to 50 blows per 0.050 m of penetration were recorded in the fill, however the N-values likely reflect the frozen nature of the fill at the time of investigation. The moisture content varied from 5 to 30%.

### 5.16.3 Peat

A 0.5 m thick layer of peat was encountered below the fill in Borehole 12+770 23L with an underside elevation of Elev. 219.4 m. A single moisture content of 38% was measured.

### 5.16.4 Sand

Below the fill in Borehole of 12+845 20L was a 2.0 m thick layer of sand with peat pockets with a lower boundary depth at 4.1 m (Elev. 216.9 m).

SPT N-values of 2 to 12 blows per 0.3 m of penetration were recorded, indicating a very loose to compact relative density. Moisture contents ranging from 26 to 37% were measured.

### 5.16.5 Clayey Silt

A clayey silt deposit was encountered beneath the sand layer in borehole 12+845 20L. The clayey silt was 3.2 m thick with a lower boundary depth at 7.3 m (Elev. 213.7 m).

SPT N-values were recorded between 2 and 4 blows per 0.3 m of penetration. In situ field vane testing measured undrained shear strengths greater than 82 kPa with a sensitivity of 2, indicate that the clayey silt is firm to stiff with low sensitivity. The moisture content of the silty clay deposit ranged from 30 to 34%.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the clayey silt. The results of the testing are presented on the Record of Borehole Sheets included in Appendix Q. The grain size distribution curve for a sample is plotted on Figure Q1 and one Atterberg Limits test is plotted on Figures Q3 of Appendix Q. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	0
Silt %	84
Clay %	16
Liquid Limit %	24
Plastic Limit %	19

The results of the Atterberg Limit tests indicate that the tested samples of the clayey silt is low plasticity with group symbols from CL-ML.

### 5.16.6 Silty Clay

A silty clay deposit was encountered beneath the clayey silt layer in Borehole 12+845 20L and beneath the peat in borehole 12+770 23L. The thickness of the deposit was 2.5 m in Borehole 12+770 23L which was terminated at the base of the silty clay deposit upon auger

refusal on probable bedrock or boulder at a depth of 5.4 m (Elev. 216.9 m). Borehole 12+845 20L was terminated within this layer at a depth of 14.3 m (Elev. 206.7 m).

SPT N-values were recorded between 1 to 11 blows per 0.3 m of penetration. In situ field vane testing measured undrained shear strengths ranging from 59 to 77 kPa with a sensitivity of 2, indicating that the silty clay is typically firm to stiff with a low sensitivity. The moisture content of the silty clay deposit ranged from 30 to 51%.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silty clay. The results of the testing are presented on the Record of Borehole Sheets included in Appendix Q. The grain size distribution curve for two sample are plotted on Figure Q2 and four Atterberg Limits test results are plotted on Figure Q4 of Appendix Q. The results of the laboratory tests are summarized as follows:

Gravel %	0 to 1
Sand %	0 to 2
Silt %	44 to 64
Clay %	33 to 56
Liquid Limit %	36 to 39
Plastic Limit %	17 to 20

The results of the Atterberg Limit tests indicate that the tested samples of the silty clay have low to intermediate plasticity with group symbols of CL to CI.

**5.16.7 Groundwater Conditions**

The water levels observed in the open boreholes upon completion of drilling are summarized in Table 5-16.

**Table 5-16 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
12+770 23L	Mar. 28, 2014	3.1	219.2	Open borehole
12+845 20L	Mar. 28, 2014	6.9	214.1	Open borehole

**5.17 Off Highway 11/17, Sta. 13+100 Red Rock Road #8 (Appendix R)**

**5.17.1 General**

One borehole was advanced at Sta. 13+100 for Red Rock Road #8. The site stratigraphy encountered generally consists of a surficial layer of organic soils underlain by a deposit of clayey silt with some sand and trace organics, which was further underlain by silty clay with trace sand. Below the above deposits was a layer of sand with some gravel.

### 5.17.2 Organic Soils

A layer of organic soils with a thickness of 0.4 m was encountered at the surface of Borehole 9+965 CL (RR8). A single moisture content of 74% was obtained.

### 5.17.3 Clayey Silt

A clayey silt deposit with some sand and trace organics was encountered below the organics. The investigated thickness of this layer was 2.6 m, with a lower boundary depth of 3.0 m (Elev. 215.8 m).

SPT N-values were recorded between 1 and 5 blows per 0.3 m of penetration. A single in situ field vane test conducted in the clayey silt measured an undrained shear strength of 26 kPa with a sensitivity of 11, indicating that the layer is typically firm and extra sensitive. The moisture content varied between 32 and 53%.

### 5.17.4 Silty Clay

A layer of silty clay with trace sand was encountered below the clayey silt. The thickness of the clayey silt layer was 9.2 m with an underside depth of 12.2 m (Elev. 206.7 m).

SPT N-values were recorded between 0 and 2 blows per 0.3 m of penetration. In situ field vane tests conducted in the silty clay measured undrained shear strengths between 38 and 65 kPa with a sensitivity varying from 10 to 11, indicating that the layer is typically firm to stiff and extra sensitive. The moisture content in the silty clay varied between 43 and 59%.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silt. The results of the testing are presented on the Record of Borehole Sheets included in Appendix R. The grain size distribution curve for one sample is plotted on Figure R1 and two Atterberg Limits test results are plotted on Figure R2 of Appendix R. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	1
Silt %	46
Clay %	53
Liquid Limit %	39 to 41
Plastic Limit %	19

The results of the Atterberg Limit tests indicate that the tested samples of silty clay have intermediate plasticity with group symbol CI.

### 5.17.5 Sand

Below the silty clay deposit was a deposit of sand with some gravel. The borehole was terminated upon auger refusal on probable bedrock at a depth of 14.1 m (Elev. 204.7 m).

A SPT N-value of 16 blows per 0.3 m of penetration were recorded in the deposit, indicating a compact relative density. The measured moisture content of the sand varied between 14 and 16%.

### 5.17.6 Groundwater Conditions

The water level observed in the open borehole upon completion of drilling is summarized in Table 5-17.

**Table 5-17 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
9+965 CL (RR8)	Feb. 15, 2014	3.1	215.7	Open borehole

## 5.18 Highway 11/17 EBL and WBL, Sta. 13+100 to 13+300 (Appendix S)

### 5.18.1 General

Three boreholes were advanced within Sta. 13+100 to 13+300. The site stratigraphy encountered typically consists of organic soils underlain by a deposit of silty clay with some sand, which was further underlain by a sand layer with some silt to silty and trace to some gravel.

### 5.18.2 Organic Soils

A 0.1 to 0.5 m thick layer of organic soils containing roots and rootlets was encountered at the surface of the three boreholes. At the time of the field investigation, the organic material was generally frozen, or covered with ice.

### 5.18.3 Silty Clay

A silty clay deposit was encountered beneath the organic soils. The thickness of this layer ranged from 11.4 to 13.9 m with the lower boundary encountered at depths from 11.7 to 14.0 m (Elev. 204.6 to 207.4 m).

SPT N-values were recorded between 0 and 8 blows per 0.3 m of penetration. In situ field vane testing measured undrained shear strengths of 23 to 74 kPa with sensitivities between 8 and 11, indicating that the silty clay is typically soft to stiff and extra-sensitive. The moisture content of the deposit ranged from 28 to 56%.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silty clay. The results of the testing are presented on the Record of Borehole Sheets included in Appendix S. The grain size distribution curves for five samples are plotted on Figure S1 and seven Atterberg Limits test results are plotted on Figure S3 and S4 of Appendix S. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	0 to 8
Silt %	33 to 57
Clay %	43 to 67
Liquid Limit %	38 to 49
Plastic Limit %	18 to 20

The results of the Atterberg Limit tests indicate that the tested samples of the silty clay have intermediate plasticity with group symbol of CI.

#### 5.18.4 Sand

A layer of sand with some silt to silty, trace to some gravel, trace clay and occasional cobbles was encountered below the silty clay deposit. The thickness of the sand layer varied from 1.7 to 1.9 m with a lower boundary depth between 13.4 and 13.8 m (Elev. 205.5 to 205.6 m) in boreholes 13+150 20R and 13+205 19L which were terminated at the base of the sand upon auger refusal on probable bedrock or boulder. Borehole 13+250 20R was terminated within the sand at a depth of 14.3 m (Elev. 204.2 m).

SPT N-values of 10 to 21 blows per 0.3 m of penetration, indicating a loose to compact relative density. The moisture content of the sand ranged from 8 to 14%.

A grain size distribution test was carried out on one sample of the sand. The result of the test is presented on the Record of Borehole Sheet included in Appendix S. The grain size distribution curve for the sample is plotted on Figure S2 of Appendix S. The results of the laboratory tests are summarized as follows:

Gravel %	15
Sand %	47
Silt and Clay %	38

#### 5.18.5 Groundwater Conditions

The water levels observed in the open boreholes upon completion of drilling are summarized in Table 5-18.

**Table 5-18 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
13+150 20R	Feb. 16, 2014	1.3	217.9	Open borehole
13+205 19L	Feb. 16, 2014	2.9	216.2	Open borehole
13+250 20R	Feb. 16, 2014	1.4	217.2	Open borehole

## **5.19 Highway 11/17 WBL, Sta. 13+450 to 13+550 (Appendix T)**

### **5.19.1 General**

Three boreholes were advanced within Sta. 13+400 to 13+550. The site stratigraphy encountered typically consists of a layer of organic soils underlain by a layer of silty clay or silt with some sand to sandy and some clay. Below these layers was a deposit of silty sand with trace gravel.

### **5.19.2 Organic Soils**

A layer of organic soils ranging in thickness from 0.1 to 0.9 m was encountered at the surface of all three boreholes.

A single SPT N-value of 3 blows per 0.3 m of penetration was recorded. A moisture content of 82% was measured.

### **5.19.3 Silty Sand**

Below the organic soils, a layer of silty sand mixed with organics was encountered in Borehole 13+520 19L. The thickness of the silty sand was 0.5 m with a lower boundary depth at 0.6 m (Elev. 218.5 m).

### **5.19.4 Silty Clay**

A deposit of silty clay with trace to some sand, trace organics, occasional wood fibres and occasional sand seams was encountered beneath the organic soils in Borehole 13+505 40L, below the silty sand layer in Borehole 13+520 19L, and below the silt layer in Borehole 13+455 39L. The thickness of the silty clay was 10.3 m with the lower boundary encountered at a depth of 10.9 m (Elev. 208.2 m) in Borehole 13+520 19L. Boreholes 13+455 39L and 13+505 40L were terminated within the silty clay at depths between 5.6 and 8.7 m (Elev. 210.6 to 213.1 m).

SPT N-values were recorded between 0 to 8 blows per 0.3 m of penetration. In situ field vane testing measured undrained shear strengths of 37 to greater than 80 kPa with sensitivities ranging from 2 to 13, indicating that the silty clay is typically firm to stiff and classified as medium sensitivity to extra-sensitive. The moisture content of the deposit ranged from 29 to 59%.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silty clay. The results of the testing are presented on the Record of Borehole Sheets included in Appendix T. The grain size distribution curves for three samples are plotted on Figure T1 and five Atterberg Limits test results are plotted on Figure T4 of Appendix T. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	0
Silt %	26 to 44
Clay %	56 to 74
Liquid Limit %	42 to 56
Plastic Limit %	20 to 22

The results of the Atterberg Limit tests indicate that the tested samples of the silty clay range from intermediate to high plasticity with group symbols from CI to CH.

### 5.19.5 Silt

Below the surficial organic soils in Borehole 13+455 39L, a deposit of silt with some sand to sandy, some clay and trace rootlets was encountered. The thickness of the silt deposit was 4.0 m with a lower boundary depth of 4.1 m (Elev. 214.6 m).

SPT N-values of 0 to 3 blows per 0.3 m of penetration were recorded, indicating a loose relative density. The moisture content was measured between 20 and 30%.

A grain size distribution test was carried out on one sample of the silt. The results of the testing are presented on the Record of Borehole Sheets included in Appendix T. The grain size distribution curve is plotted on Figure T2 of Appendix T. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	14
Silt %	72
Clay %	14

### 5.19.6 Lower Silty Sand

Below the silty clay deposit, a layer of silty sand with trace gravel was encountered in Borehole 13+520 19L which was terminated in the sand deposit at a depth of 13.8 m (Elev. 205.3 m).

SPT N-values of 41 blows per 0.3 m of penetration to 50 blows per 0.1 m of penetration were recorded, indicating a dense to very dense relative density. A moisture content of 28% was measured.

A grain size distribution test was carried out on one samples of the sand. The results of the testing are presented on the Record of Borehole Sheets included in Appendix T. The grain size distribution curve for one sample is plotted on Figure T3 in Appendix T. The results of the laboratory tests are summarized as follows:

Gravel %	4
Sand %	37
Silt and Clay %	59

### 5.19.7 Groundwater Conditions

The water level observed in one of the open boreholes upon completion of drilling is summarized in Table 5-19.

**Table 5-19 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
13+520 19L	Feb. 17, 2014	2.3	216.8	Open Borehole

## 5.20 Highway 11/17 EBL and WBL, Sta. 13+590 to 13+660 (Appendix U)

### 5.20.1 General

Two boreholes were advanced within Sta. 13+590 to 13+660. The site stratigraphy encountered typically consists of organic soils underlain by a deposit of silty clay with some sand, which was further underlain by sand with some silt to silty, trace gravel, and trace clay.

### 5.20.2 Organic Soils

A 0.1 m thick layer of organic soils was encountered at the surface of both boreholes.

### 5.20.3 Sandy Silt

A layer of sandy silt with trace clay was encountered below the surficial organics in Borehole 13+650 40L. The layer had a thickness of 0.7 m with a lower boundary depth of 0.8 m (Elev. 218.0 m).

### 5.20.4 Silty Clay

A deposit of silty clay with some sand, trace organics and occasional wood fibres was encountered beneath the sandy silt layer in Borehole 13+650 40L and below the organic soils in Borehole 13+660 15R.. The thickness of the silty clay varied from 3.4 to 3.9 m with the lower boundary encountered at depths ranging from of 4.0 to 4.2 m (Elev. 212.7 to 214.6 m).

SPT N-values were recorded between 3 to 8 blows per 0.3 m of penetration. In situ field vane testing measured undrained shear strengths of 120 kPa or greater with a sensitivity of 3, indicating that the silty clay is typically firm to very stiff with medium sensitivity. The moisture content of the silty clay deposit ranged from 30 to 57%.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silty clay. The results of the testing are presented on the Record of Borehole Sheets included in Appendix U. The grain size distribution curve for one sample is plotted on Figure U1 and one Atterberg Limits test is plotted on Figure U3 of Appendix U. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	0
Silt %	43
Clay %	57
Liquid Limit %	54
Plastic Limit %	24

The results of the Atterberg Limit tests indicate that the tested sample of the silty clay has high plasticity with group symbol CH.

### 5.20.5 Sand

A layer of sand with some silt to silty, trace gravel, trace clay and occasional cobbles was encountered below the silty clay deposit in both boreholes. Both boreholes were terminated in the sand layer at depths ranging from 6.4 to 6.5 m (Elev. 210.2 to 212.4 m).

SPT N-values of 39 to 51 blows per 0.3 m of penetration were recorded, indicating a dense to very dense relative density. Moisture contents between 2 and 11% were measured.

A grain size distribution test was carried out on a sample of the sand. The result of the test is presented on the Record of Borehole Sheet included in Appendix U. The grain size distribution curve is plotted on Figure U2 of Appendix U. The results of the laboratory test are summarized as follows:

Gravel %	4
Sand %	77
Silt %	14
Clay %	5

### 5.20.6 Groundwater Conditions

The water level observed in one of the open boreholes upon completion of drilling is summarized in Table 5-20.

**Table 5-20 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
13+660 15R	Nov. 13, 2014	3.7	213.0	Open borehole

**5.21 Highway 11/17 EBL, Sta. 13+875 to 14+100 and Highway 11/17 WBL, Sta. 13+875 to 14+190 (Appendix V)**

**5.21.1 General**

Five boreholes were advanced within Sta. 13+875 to 14+105. The site stratigraphy encountered typically consists of organic soils underlain by a deposit of silty clay with trace to some sand, which was further underlain by gravelly sand and silt with some sand to sandy.

**5.21.2 Organic Soils**

A 0.2 to 0.9 m thick layer of organic soils containing trace clay, trace roots and rootlets and occasional wood fibres was encountered at the surface of all five boreholes. At the time of the field investigation, the organic soils were generally frozen, or covered with ice.

SPT N-values recorded in the frozen organic soils ranged from 10 to 19 blows per 0.3 m of penetration. The moisture content ranged from 102 to 165%.

**5.21.3 Silty Clay**

A silty clay deposit with trace to some sand was encountered beneath the organic soils in Boreholes 13+925 19L, 14+000 19L, 14+050 20R and 14+105 19L. The thickness of this layer ranged from 1.5 to 3.3 m with the lower boundary encountered at a depth of 2.1 to 3.6 m (Elev. 216.1 to 217.8 m).

SPT N-values were recorded between 1 to 10 blows per 0.3 m of penetration indicating stiff to firm consistency. The moisture content ranged from 33 to 57%.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silty clay. The results of the testing are presented on the Record of Borehole Sheets included in Appendix U. The grain size distribution curves for two samples are plotted on Figure V1 and four Atterberg Limits test results are plotted on Figure V3 of Appendix V. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	1 to 10
Silt %	44 to 51
Clay %	39 to 55
Liquid Limit %	40 to 54
Plastic Limit %	21 to 25

The results of the Atterberg Limit tests indicate that the tested samples of the silty clay range from intermediate to high plasticity with group symbols from CI to CH.

**5.21.4 Gravelly Sand**

Below the silty clay deposit in Boreholes 13+925 19L and 14+000 19L, a layer of gravelly sand with occasional cobbles was encountered. The thickness of the sand ranged from 0.6 to 1.8 m with a lower boundary depth from 2.7 to 4.7 m (Elev. 214.4 to 217.3 m).

A single SPT N-value of 17 blows per 0.3 m of penetration was recorded, indicating a compact relative density. The recorded moisture content ranged from 13 to 15%.

**5.21.5 Silt**

Below the above noted layers was a layer of silt with some sand to sandy, trace gravel, trace clay and occasional bedrock fragments. All five boreholes were terminated at the base of the silt upon auger refusal on probable bedrock or boulder at depths ranging from 2.7 to 9.2 m (Elev. 210.8 to 216.6 m).

SPT N-values typically ranged from 25 to 70 blows per 0.3 m of penetration, indicating a relative density of compact to very dense. The measured moisture content of the silt varied from 10 to 21%.

Grain size distribution testing was carried out on select samples of the silt. The results of the testing are presented on the Record of Borehole Sheets included in Appendix V. The grain size distribution curves for three samples are plotted on Figure V2 of Appendix V. The results of the laboratory tests are summarized as follows:

Gravel %	0 to 4
Sand %	13 to 48
Silt %	73 to 82
Clay %	4 to 5
Silt & Clay	48

**5.21.6 Groundwater Conditions**

The water levels observed in two of the open boreholes upon completion of drilling are summarized in Table 5-21.

**Table 5-21 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
13+925 19L	Feb. 18, 2014	3.5	215.5	Open borehole
14+000 19L	Feb. 19, 2014	5.0	215.0	Open borehole

**5.22 Highway 11/17 EBL and WBL, Sta. 14+190 to 14+210 (Appendix W)**

**5.22.1 General**

Four boreholes were advanced along the proposed culvert alignment for Culvert 13 A/B. One borehole (14+200 19R) was completed previously in 2012 during the high fill embankments investigation but is included on the Borehole Location and Soil Strata Drawing included in Appendix W. The site stratigraphy encountered typically consists of

organic soils underlain by a deposit of silty clay with trace to some sand, which was further underlain by silty sand with some clay, some gravel.

### 5.22.2 Organic Soils

A 0.1 to 0.5 m thick layer of organic soils containing some clay and trace roots and rootlets was encountered at the surface of all four boreholes. Boreholes 14+201 19L and 14+201 CL were terminated at the base of this layer upon auger refusal on probable bedrock or boulder at depths ranging from 0.3 to 0.5 m (Elev. 218.6 to 220.2 m). At the time of the field investigation, the organic soils was generally frozen, or covered with ice.

Moisture contents ranging from 26 to 81% were measured in the organic soils.

### 5.22.3 Silty Clay

A silty clay deposit with some sand trace gravel was encountered beneath the organic soils in Boreholes 14+201 35L and 14+201 37R. The thickness of this layer ranged from 0.7 to 1.1 m with the lower boundary encountered at a depth of 0.9 to 1.3 m (Elev. 216.1 to 220.5 m).

A single SPT N-value of 6 blows per 0.3 m of penetration was recorded, indicating a firm consistency. A moisture content of 37% was recorded in the silty clay.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silty clay. The results of the testing are presented on the Record of Borehole Sheets included in Appendix V. The grain size distribution curve for one sample is plotted on Figure W1 and one Atterberg Limits test result is plotted on Figure W2 of Appendix W. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	11
Silt %	61
Clay %	28
Liquid Limit %	40
Plastic Limit %	23

The results of the Atterberg Limit tests indicate that the tested sample of the silty clay has intermediate plasticity with group symbol CI.

### 5.22.4 Silty Sand

A layer of silty sand with some clay, some gravel and occasional cobbles was encountered below the silty clay deposit. Boreholes 14+201 35L and 14+201 37R were terminated at the base of the silty sand upon auger refusal on probable bedrock or boulder at depths ranging from 1.6 to 2.2 m (Elev. 215.3 to 219.8 m).

A SPT N-value of 63 blows per 0.3 m of penetration was recorded; indicating a very dense relative density. A moisture content of 9 to 25% was recorded in the silty sand.

**5.22.5 Groundwater Conditions**

The water level observed in one of the open boreholes upon completion of drilling is summarized in Table 5-22.

**Table 5-22 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
14+201 35L	Feb. 19, 2014	0.9	220.5	Open borehole

**5.23 Highway 11/17 WBL, Sta. 14+210 to 14+410 (Appendix X)**

**5.23.1 General**

Five boreholes were advanced within Sta. 14+255 to 14+410. The site stratigraphy encountered typically consists of organic soils underlain by a deposit of silty clay with trace to some sand, trace gravel, which was further underlain by sand with some gravel.

**5.23.2 Organic Soils**

A 0.1 m thick layer of organic soils consisting of topsoil was encountered at the surface of Boreholes 14+255 19L and 14+300 49L.

**5.23.3 Silty Clay**

A silty clay deposit with trace to some sand was encountered beneath the organic soils in Boreholes 14+255 19L and 14+300 49L and at the surface of Boreholes 14+350 48L, 14+375 23L and 14+400 33L. The thickness of this layer was 0.6 to 3.6 m with the lower boundary encountered at a depth of 0.7 to 3.7 m (Elev. 220.8 to 228.3 m). Boreholes 14+300 49L, 14+350 48L, 14+375 23L and 14+400 33L were terminated at the base of the silty clay upon auger refusal on probable bedrock or boulder at depths ranging from 1.5 to 3.7 m (Elev. 224.3 to 228.3 m).

SPT N-values of 11 to 31 blows per 0.3 m of penetration, indicating a stiff to very stiff consistency. Moisture contents ranging from 30 to 69% were recorded in the silty clay.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silty clay. The results of the testing are presented on the Record of Borehole Sheets included in Appendix W. The grain size distribution curves for three samples are plotted on Figure X1 and three Atterberg Limits test results are plotted on Figure X3 of Appendix X. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	0 to 2
Silt %	38 to 41
Clay %	58 to 62
Liquid Limit %	47 to 64
Plastic Limit %	20 to 23

The results of the Atterberg Limit tests indicate that the tested samples of the silty clay range from intermediate to high plasticity with group symbols from CI to CH.

#### 5.23.4 Sand

A 0.7 m thick layer of sand with some gravel, trace silt and occasional bedrock fragments was encountered below the silty clay deposit in Borehole 14+255 19L. The borehole was terminated at the base of the sand upon auger refusal on probable bedrock or boulder at a depth of 1.4 m (Elev. 220.1 m).

A single SPT N-value of 49 blows per 0.3 m of penetration was recorded; indicating a dense relative density. A moisture content of 12% was recorded in the sand.

A grain size distribution test was carried out on one sample of the sand. The results of the testing are presented on the Record of Borehole Sheet included in Appendix X. The grain size distribution curve for one sample is plotted on Figure X2 of Appendix X. The results of the laboratory test are summarized as follows:

Gravel %	29
Sand %	48
Silt & Clay %	23

#### 5.23.5 Groundwater Conditions

All boreholes were dry upon completion of drilling.

### 5.24 Highway 11/17 EBL and WBL, Sta. 14+720 to 14+760 (Appendix Y)

#### 5.24.1 General

Two boreholes were advanced along the proposed culvert alignment for Culvert 14 A/B. Three boreholes (14+750 08L, 14+750 20R and 14+750 30L) were completed previously in 2012 during the high fill embankments investigation but are included on the Borehole Location and Soil Strata Drawing included in Appendix Y. The site stratigraphy encountered typically consists of organic soils underlain by silty clay, which contained a localized deposit of silt with some clay to clayey. Below the above deposits was a lower layer of silt.

### 5.24.2 Organic Soils

A 0.1 to 0.5 m thick layer of organic soils consisting of peat to topsoil with trace rootlets was encountered at the surface of both boreholes. Borehole 14+739 58R was terminated at the base of the deposit upon auger refusal on probable bedrock or boulder at a depth of 0.5 m with an underside elevation of Elev. 216.5 m.

### 5.24.3 Silty Clay

A silty clay deposit was encountered beneath the organics in Borehole 14+741 43L. The thickness of this layer was 12.0 m with the lower boundary encountered at a depth of 12.2 m (Elev. 206.2 m).

SPT N-values of 0 to 6 blows per 0.3 m of penetration were recorded. In situ field vane testing measured undrained shear strengths typically from 33 to 60 kPa with sensitivities ranging from 6 to 10, indicating that the silty clay layer is typically firm to stiff and classified as sensitive to extra-sensitive. Moisture contents ranging from 30 to 50% were measured.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silty clay. The results of the testing are presented on the Record of Borehole Sheets included in Appendix Y. The grain size distribution curve for one sample is plotted on Figure Y1 and three Atterberg Limits test results are plotted on Figure Y3 of Appendix Y. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	0
Silt %	40
Clay %	60
Liquid Limit %	34 to 43
Plastic Limit %	18 to 20

The results of the Atterberg Limit tests indicate that the tested samples of the silty clay have low to intermediate plasticity with group symbols CL to CI.

### 5.24.4 Silt

A localized layer of silt with some clay to clayey was encountered within the silty clay layer in Borehole 14+741 43L at a depth of 9.1 m. The silt layer had a thickness of 1.3 m with a lower boundary depth of 10.4 m (Elev. 208.0 m). A layer of silt with trace clay and trace sand was also encountered below the silty clay layer and the borehole was terminated at the base of this deposit upon auger refusal on probable bedrock or boulder at a depth of 12.5 m (Elev. 205.9 m).

A single SPT N-value of 14 blows per 0.3 m of penetration was recorded, indicating a compact relative density. A moisture content of 30 to 36% was recorded in the silt layer.

A grain size distribution test was carried out on one sample of the silt. The results of the testing are presented on the Record of Borehole Sheets included in Appendix Y. The grain

size distribution curve for the sample is plotted on Figure Y2 of Appendix Y. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	0
Silt %	77
Clay %	23

#### 5.24.5 Groundwater Conditions

The water level observed in one of the open boreholes upon completion of drilling is summarized in Table 5-23.

**Table 5-23 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
14+741 43L	Mar. 2, 2014	11.4	207.0	Open borehole

#### 5.25 Off Highway 11/17 Sta. 14+800, Highway 628 (Appendix Z)

##### 5.25.1 General

Five boreholes were advanced at Sta. 14+800 along Highway 628. The site stratigraphy encountered generally consists of a layer of peat underlain by a deposit of silty clay, which was further underlain by sand with trace gravel to gravelly sand with some silt.

##### 5.25.2 Peat

A layer of peat ranging from 0.6 to 0.8 m thick was encountered at the surface of all five boreholes. At the time of the field investigation, the peat was generally frozen, or covered with ice.

SPT N-values recorded in the frozen peat were between 4 and 23 blows per 0.3 m of penetration. The moisture content ranged from 86 to 403%.

##### 5.25.3 Silty Clay

A silty clay deposit with trace sand and occasional silt seams was encountered below the organic layers. The investigated thickness of this layer ranged from 1.1 to 12.8 m, with a lower boundary at depths between 1.8 to 13.6 m (Elev. 201.2 to 212.7 m). Boreholes 10+160 18L (628), 10+160 CL (628) and 10+210 05L (628) were terminated at the base of this layer upon auger refusal on probable bedrock or boulder at depths from 1.8 to 5.8 m (Elev. 208.4 to 212.7 m).

SPT N-values were recorded between 0 to 6 blows per 0.3 m of penetration. In situ field vane tests conducted in the silty clay measured undrained shear strengths of 58 kPa or greater

with sensitivities between 7 and 11, indicating that the layer is typically firm to stiff and classified as sensitive to extra-sensitive. The moisture content in the silty clay varied between 25 and 60%.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silty clay. The results of the testing are presented on the Record of Borehole Sheets included in Appendix Y. The grain size distribution curves for three samples are plotted on Figure Z1 and eight Atterberg Limits test results are plotted on Figure Z4 and Z5 of Appendix Z. The results of the laboratory tests are summarized as follows:

Gravel %	0 to 2
Sand %	0 to 1
Silt %	33 to 58
Clay %	40 to 67
Liquid Limit %	23 to 56
Plastic Limit %	16 to 26

The results of the Atterberg Limit tests indicate that the tested samples of silty clay range from low to high plasticity with group symbols CL to CH.

#### 5.25.4 Silt

A localized layer of silt with some clay and occasional oxide staining was encountered within the silty clay deposit at a depth of 1.5 m in Borehole 10+210 05L (628). The thickness of the silt layer was 0.6 m with an underside depth of 2.1 m (Elev. 212.1 m).

A single SPT N-value of 5 blows per 0.3 m of penetration was recorded indicating a loose relative density. A corresponding moisture content of 31% was measured.

A grain size distribution test was carried out on one sample of the silt. The results of the testing are presented on the Record of Borehole Sheets included in Appendix Z. The grain size distribution curve for the sample is plotted on Figure Z2 of Appendix Z. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	0
Silt %	89
Clay %	11

#### 5.25.5 Sand to Gravelly Sand

A deposit of sand ranging in composition from sand with trace gravel to gravelly sand with some silt was encountered below the silty clay deposit in Boreholes 10+160 16R (628) and 10+260 05L (628). The deposit had a thickness of 0.2 m in Borehole 10+260 05L which was terminated at the base of the sand upon auger refusal on probable bedrock or boulder at

a depth of 5.2 m (Elev. 208.5 m). A DCPT was conducted in Borehole 10+160 16R at the bottom of the borehole to refusal encountered at a depth of 14.9 m (Elev. 199.8 m).

A single SPT N-value of 19 blows per 0.3 m of penetration was recorded, indicating a compact relative density. The measured moisture content of the sand was 9%.

The results of a grain size distribution test conducted on one sample of the sand is presented on the Record of Borehole sheets in Appendix Z. The grain size distribution curve for the sample is plotted on Figure Z3 of Appendix Z. The results of the laboratory test are summarized as follows:

Gravel %	35
Sand %	46
Silt & Clay %	19

### 5.25.6 Groundwater Conditions

A standpipe piezometer was installed in one borehole to monitor water levels after completion of drilling. The water levels observed in open boreholes and measured in the piezometer are summarized in Table 5-24.

**Table 5-24 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
10+160 16R (628)	Mar. 27, 2014	1.7	213.1	Piezometer
10+160 CL	Mar. 1, 2014	1.6	212.8	Open Borehole
10+210 05L	Mar. 2, 2014	4.3	209.9	Open Borehole
10+260 05L	Mar. 1, 2014	1.8	211.9	Open Borehole

## 5.26 Highway 11/17 EBL, Sta. 14+900 to 14+930 (Appendix AA)

### 5.26.1 General

One borehole was advanced within Sta. 14+900 to 14+930. The site stratigraphy encountered typically consists of peat underlain by silty clay.

### 5.26.2 Peat

A layer of peat containing trace rootlets was encountered in Borehole 14+910 19R. The peat had a thickness of 0.8 m with an underside elevation of 216.6 m. At the time of the field investigation, the peat was generally frozen, or covered with ice.

A SPT N-value of 19 blows per 0.3 m of penetration was recorded in the frozen peat. A moisture content of 55% was measured in the peat.

### 5.26.3 Silty Clay

A 1.9 m thick silty clay deposit was encountered beneath the peat. The borehole was terminated at the base of the silty clay upon auger refusal on probable bedrock or boulder at a depth of 2.7 m (Elev. 214.7 m).

SPT N-values were recorded between 4 to 6 blows per 0.3 m of penetration indicating that the silty clay is typically firm. The moisture content ranged from 30 to 44%.

Grain size distribution and Atterberg Limits testing were carried out on a sample of the silty clay. The results of the testing are presented on the Record of Borehole Sheet included in Appendix Z. The grain size distribution curve for one sample is plotted on Figure AA1 and one Atterberg Limits test result is plotted on Figure AA2 of Appendix AA. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	0
Silt %	46
Clay %	54
Liquid Limit %	37
Plastic Limit %	20

The results of the Atterberg Limit test indicate that the tested sample of silty clay has intermediate plasticity with group symbol of CI.

### 5.26.4 Groundwater Conditions

The borehole was dry upon completion of drilling.

## 5.27 Highway 11/17 EBL and WBL, Sta. 15+190 to 15+220 (Appendix AB)

### 5.27.1 General

Five boreholes were advanced along the proposed culvert alignment for Culvert 18 A/B. The site stratigraphy encountered typically consists of peat underlain by silty clay, which contained a localized layer of silt. Underlying the above layers was a layer of silt to sandy silt.

### 5.27.2 Peat

A layer of peat containing trace rootlets was encountered in all five boreholes. The peat had a thickness ranging from 0.6 to 0.8 m. At the time of the field investigation, the peat was generally frozen, or covered with ice.

SPT N-values of 4 to 26 blows per 0.3 m of penetration were recorded in the frozen peat. Moisture contents varying from 60 to 116% were recorded.

### 5.27.3 Silty Clay

A silty clay deposit with trace sand and occasional silt seams was encountered beneath the peat at all five borehole locations. The thickness of this layer ranged from 10.5 to 12.9 m with the lower boundary encountered at depths from 11.1 to 13.7 m (Elev. 199.4 to 203.1 m) in Boreholes 15+218 35L, 15+213 21L and 15+ 203 21R. Boreholes 15+210 01R and 15+196 42R were terminated within this deposit at a depth of 14.8 m at an underside elevation of Elev. 197.7 to 198.2 m.

SPT N-values were recorded between 0 to 5 blows per 0.3 m of penetration. In situ field vane testing measured undrained shear strengths of 30 kPa or greater with sensitivities varying from 3 to 14 indicating that the silty clay is typically firm to very stiff and classified as medium sensitivity to extra-sensitive. The moisture content of the silty clay deposit ranged from 25 to 59%.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silty clay. The results of the testing are presented on the Record of Borehole Sheets included in Appendix AB. The grain size distribution curves for eight samples are plotted on Figures AB1 and AB2 and fourteen Atterberg Limits test results are plotted on Figures AB4 to AB6 of Appendix AB. The results of the laboratory tests are summarized as follows:

Gravel %	0 to 2
Sand %	0 to 3
Silt %	38 to 68
Clay %	29 to 62
Liquid Limit %	27 to 48
Plastic Limit %	18 to 22

The results of the Atterberg Limit test indicate that the tested samples of the silty clay range from low to intermediate plasticity but are predominantly intermediate plasticity with group symbol CI.

### 5.27.4 Silt

A localized layer of silt with trace clay and trace sand was encountered at a depth of 9.1 m within the silty clay layer in Borehole 15+210 01R. The silt layer had a thickness of 1.6 m with a lower boundary depth of 10.7m (Elev. 202.3 m).

A single SPT N-value of 7 blows per 0.3 m of penetration was recorded, indicating a loose relative density. A moisture content of 28% was recorded in the silt.

A grain size distribution test was carried out on one sample of the silt. The result of the test is presented on the Record of Borehole Sheet included in Appendix AB. The grain size distribution curve for the sample is plotted on Figure AB3 of Appendix AB. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	1
Silt %	91
Clay %	8

### 5.27.5 Lower Silt to Sandy Silt

A lower layer of silt with trace sand to sandy silt with trace gravel was encountered below the silty clay deposit in Boreholes 15+218 35L, 15+213 21L and 15+203 21R. The thickness of the deposit ranged from 0.3 to 0.8 m in Boreholes 15+218 35L and 15+213 21L which were terminated at the base of the deposit upon auger refusal on probable bedrock or boulder at depths ranging from 11.9 to 13.1 m (Elev. 200.5 to 202.3 m). A DCPT was conducted in Borehole 15+203 21R at the bottom of the borehole to refusal encountered at a depth of 16.8 m (Elev. 196.3 m).

A SPT N-value of 3 blows per 0.3 m of penetration was recorded, indicating a loose relative density. The moisture content was measured to be 28%.

### 5.27.6 Groundwater Conditions

A standpipe piezometer was installed in one borehole to monitor water levels after completion of drilling. The water levels observed in open boreholes and measured in the piezometer are summarized in Table 5-25.

**Table 5-25 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
15+196 42R	Mar. 27, 2014	1.3	211.2	Piezometer
15+203 21R	Feb. 28, 2014	2.5	210.6	Open Borehole
15+210 01R	Feb. 26, 2014	3.0	210.0	Open Borehole
15+213 21L	Feb. 27, 2014	3.4	210.2	Open Borehole

## 5.28 Highway 11/17 EBL and WBL, Sta. 15+725 to 16+250 (Appendix AC)

### 5.28.1 General

Thirteen boreholes were advanced within Sta. 15+730 to 16+250. The site stratigraphy encountered typically consists of a layer of organic soils underlain by a deposit of silty clay with trace to some sand which was further underlain by a clayey silt layer with some sand and trace gravel or a layer of sand with some silt and trace gravel.

### 5.28.2 Organic Soils

A layer of organic soils ranging from 0.1 to 1.7 m thick was encountered at the surface of all boreholes except Borehole 15+940 49L where bedrock was exposed at the ground surface. Boreholes 15+890 45L, 15+940 19L and 15+990 45L were terminated at the base of the organics upon bedrock at an underside elevation varying from Elev. 233.0 to 236.4 m. The underside elevation of the organics varied from Elev. 220.2 to 237.1 m in the remaining boreholes. At the time of the field investigation, the organic soils were generally frozen, or covered with ice.

SPT N-values of 3 to 11 blows per 0.3 m of penetration were recorded in the frozen peat. The moisture content of the organic material ranged from 21 to 131%.

### 5.28.3 Silty Clay

A silty clay layer with trace sand was encountered beneath the organic soils in Boreholes 15+740 24R, 15+850 23R, 15+950 23R, 16+050 23R, 16+150 20R, 16+040 19L, 16+090 35L and 16+175 34L. The thickness of the silty clay layer varied from 1.7 to 9.0 m with a lower boundary depth ranging from 1.7 to 10.7 m (Elev. 217.4 to 231.6 m). Boreholes 15+740 24R, 15+850 23R, 15+950 23R, 16+050 23R, 16+090 35L and 16+175 34L were terminated at the base of the silty clay upon auger refusal on probable bedrock or boulder at depths varying from 2.5 to 5.6 m (Elev. 217.4 to 230.3 m).

SPT N-values were typically recorded between 0 to 14 blows per 0.3 m of penetration. In situ field vane testing measured undrained shear strengths of 75 kPa or greater with sensitivities ranging from 3 to 14, indicating that the silty clay is typically stiff and classified as medium sensitivity to extra-sensitive. The moisture content ranged from 28 to 60%.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silty clay. The results of the testing are presented on the Record of Borehole Sheets included in Appendix AC. The grain size distribution curves for eight samples are plotted on Figures AC1 and AC2 and ten Atterberg Limits test results are plotted on Figures AC4 and AC5 of Appendix AC. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	0 to 7
Silt %	26 to 54
Clay %	46 to 74
Liquid Limit %	32 to 56
Plastic Limit %	20 to 24

The results of the Atterberg Limit test indicate that the tested samples of the silty clay range from intermediate to high plasticity with group symbols CI to CH.

#### 5.28.4 Clayey Silt

A layer of clayey silt with some sand and trace gravel was encountered below the silty clay layer in Borehole 16+150 20R. Borehole 16+150 20R was terminated within this layer at a depth of 11.4 m (Elev. 220.0 m).

A SPT N-value of 6 blows per 0.3 m of penetration was recorded, indicating a firm consistency. A moisture content of 31% was measured.

A grain size distribution test was carried out on a sample of the clayey silt. The result of the test is presented on the Record of Borehole Sheet included in Appendix AC. The grain size distribution curve for one sample is plotted on Figure AC3 of Appendix AC. The results of the laboratory tests are summarized as follows:

Gravel %	6
Sand %	15
Silt %	49
Clay %	30

#### 5.28.5 Sand

A 0.2 to 0.7 m thick deposit of sand with some silt, trace gravel, occasional wood fibres and occasional bedrock fragments was encountered below the silty clay in Borehole 16+040 19L and below the organics in Borehole 16+040 49L. Both boreholes were terminated at the base of the sand upon auger refusal on probable bedrock or boulder at depths varying from 0.7 to 1.9 m (Elev. 231.3 to 235.8 m).

SPT N-values of 4 blows per 0.3 m of penetration was recorded, indicating a loose relative density. The moisture content in the sand ranged from 10 to 20%.

#### 5.28.6 Groundwater Conditions

The water levels observed in six of the open boreholes upon completion of drilling are summarized in Table 5-26.

**Table 5-26 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
15+740 24R	Feb. 17, 2014	3.7	218.0	Open borehole
15+850 23R	Feb. 17, 2014	3.0	223.3	Open borehole
16+050 23R	Feb. 18, 2014	3.7	226.6	Open borehole
16+150 20R	Feb. 18, 2014	4.6	226.8	Open borehole
16+040 19L	Nov. 13, 2013	1.4	231.8	Open borehole
16+040 49L	Nov. 12, 2013	0.5	235.9	Open borehole

## 5.29 Off Highway 11/17 Sta. 16+200, Median Connector (Appendix AD)

### 5.29.1 General

One borehole was advanced at Sta. 16+200) for the median connector. The site stratigraphy encountered generally consists of a layer of peat underlain by a deposit of silty clay.

### 5.29.2 Peat

A 0.8 m thick layer of peat with trace rootles was encountered at the surface of Borehole 10+020 CL (CON). At the time of the field investigation, the peat was generally frozen, or covered with ice.

A single SPT N-value of 6 blows per 0.3 m was recorded in the frozen peat. A moisture content of 44% was measured.

### 5.29.3 Silty Clay

A deposit of silty clay with trace sand was encountered below the peat. The borehole was terminated at the base of the silty clay upon auger refusal on probable bedrock or boulder at a depth of 6.0 m (Elev. 226.1 m).

SPT N-values were recorded between 0 and 7 blows per 0.3 m of penetration, indicating a soft to firm consistency. The moisture content varied between 32 and 60%.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silty clay. The results of the testing are presented on the Record of Borehole Sheet included in Appendix AC. The grain size distribution curve for one sample is plotted on Figure AD1 and two Atterberg Limits test results are plotted on Figure AD2 of Appendix AC. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	1
Silt %	56
Clay %	43
Liquid Limit %	37 to 57
Plastic Limit %	19 to 22

The results of the Atterberg Limit tests indicate that the tested samples of the silty clay have intermediate to high plasticity with group symbols of CI to CH.

### 5.29.4 Groundwater Conditions

The water level observed in the open borehole upon completion of drilling is summarized in Table 5-27.

**Table 5-27 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
10+020 CL (CON)	Feb. 18, 2014	3.0	229.1	Open borehole

**5.30 Highway 11/17 EBL, Sta. 16+390 to 16+410 and Highway 11/17 WBL, Sta. 16+430 to 16+470 (Appendix AE)**

**5.30.1 General**

Five boreholes were advanced within the vicinity of the proposed culvert alignment for Culvert 24 A/B. Three boreholes (16+405 19R, 16+435 CL and 16+460 29L) were completed previously in 2013 during the fill embankments investigation but are included on the Borehole Locations and Soil Strata Drawings included in Appendix AE. The site stratigraphy encountered typically consists of a layer of organic soils underlain by a deposit of silty clay.

**5.30.2 Organic Soils**

A 0.6 to 1.5 m thick layer of peat with trace rootlets and trace wood was encountered at the surface of all five boreholes. At the time of the field investigation, the organic soils were generally frozen, or covered with ice.

SPT N-values of 2 to 9 blows per 0.3 m of penetration were recorded in the frozen peat. The moisture content of the organic material ranged from 58 to 220%.

**5.30.3 Silty Clay**

A silty clay layer with trace sand and occasional silt seams was encountered beneath the organic soils in all five boreholes. All five boreholes were terminated at the base of the silty clay deposit upon auger refusal on probable bedrock or boulder at depths ranging from 6.6 to 8.7 m (Elev. 224.6 to 227.6 m).

SPT N-values were recorded between 0 to 6 blows per 0.3 m of penetration. In situ field vane testing measured undrained shear strengths of 77 kPa or greater and sensitivities between 3 and 6, indicating that the silty clay is typically stiff with medium sensitivity to sensitive. The moisture content ranged from 27 to 59%.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silty clay. The results of the testing are presented on the Record of Borehole Sheets included in Appendix AE. The grain size distribution curves for five samples are plotted on Figure AE1 and nine Atterberg Limits test results are plotted on Figures AE2 and AE3 of Appendix AE. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	0 to 28
Silt %	31 to 59
Clay %	31 to 68
Liquid Limit %	36 to 54
Plastic Limit %	18 to 20

The results of the Atterberg Limit test indicate that the tested samples of the silty clay range from intermediate to high plasticity with group symbols from CI to CH.

#### 5.30.4 Groundwater Conditions

A standpipe piezometer was installed in two boreholes to monitor water levels after completion of drilling. The water levels observed in open boreholes and measured in the piezometers are summarized in Table 5-28.

**Table 5-28 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
16+400 02R	Mar. 5, 2014	4.3	229.9	Open Borehole
16+404 13R	Mar. 27, 2014	1.1	232.5	Piezometer
16+440 01L	Mar. 27, 2014	0.4	232.1	Piezometer
16+450 17L	Feb. 19, 2014	4.6	228.3	Open Borehole
16+460 34L	Feb. 19, 2014	4.6	228.6	Open Borehole

### 5.31 Highway 11/17 EBL and WBL, Sta. 16+820 to 16+900 (Appendix AF)

#### 5.31.1 General

Three boreholes were advanced within the vicinity of the proposed culvert alignment for Culvert 25 A/B. Two boreholes (16+850 19R and 16+896.5 28.2L) were completed previously in 2013 during the fill embankments investigation but are included on the Borehole Location and Soil Strata Drawing included in Appendix AF. The site stratigraphy encountered generally consists of a layer of peat underlain by a deposit of silty clay with trace to some sand, which was further underlain by sand with some silt, some gravel.

#### 5.31.2 Peat

A layer of peat ranging from 1.5 to 2.1 m thick was encountered at the surface of all three boreholes. The underside elevation of the peat varied from Elev. 240.5 to 241.2 m. At the time of the field investigation, the peat was generally frozen, or covered with ice.

SPT N-values of 3 to 12 blows per 0.3 m of penetration were recorded in the frozen peat. The moisture contents ranged from 52 to 262%.

### 5.31.3 Silty Clay

A silty clay deposit with trace to some sand was encountered below the peat layer. The silty clay had a thickness of 3.8 to 7.6 m, with the lower boundary encountered at a depth of 5.9 to 9.1 m (Elev. 233.6 to 237.1 m). Boreholes 16+875 23L and 16+825 33R were terminated at the base of the silty clay upon auger refusal on probable bedrock or boulder.

SPT N-values ranging from 1 to 6 blows per 0.3 m of penetration were recorded. In situ field vane tests conducted in the silty clay measured undrained shear strengths of 68 kPa or greater with sensitivities ranging from 4 to 6, indicating that the silty clay is typically stiff and sensitive.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silty clay. The results of the testing are presented on the Record of Borehole Sheets included in Appendix AF. The grain size distribution curves for three samples are plotted on Figure AF1 and seven Atterberg Limits test results are plotted on Figures AF3 and AF4 of Appendix AEF. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	0 to 11
Silt %	30 to 71
Clay %	18 to 69
Liquid Limit %	20 to 52
Plastic Limit %	16 to 29

The results of the Atterberg Limit tests indicate that the tested samples of the silty clay are typically of low to intermediate plasticity with group symbols CL to CI.

### 5.31.4 Sand

A deposit of sand with some silt, some gravel and occasional cobbles was encountered in below the silty clay deposit in Borehole 16+857 CL. The borehole was terminated at the base of the sand upon auger refusal on probable bedrock or boulder at a depth of 11.7 m (Elev. 231.0 m).

SPT N-values of 22 and 39 blows per 0.3 m of penetration were recorded in this cohesionless deposit, indicating compact to dense relative density. The moisture content of the sand ranged between 12 and 19%.

The results of a grain size distribution analysis conducted on one sample of the sand is presented on the Record of Borehole sheet in Appendix AF. The grain size distribution curve is plotted on Figure AF2 of Appendix AF. The results of the laboratory tests are summarized as follows:

Gravel %	20
Sand %	57
Silt & Clay %	23

### 5.31.5 Groundwater Conditions

A standpipe piezometer was installed in one borehole to monitor water levels after completion of drilling. The water levels observed in open boreholes and measured in the piezometer are summarized in Table 5-29.

**Table 5-29 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
16+825 33R	Feb. 20, 2014	4.6	237.4	Open Borehole
16+857 CL	Feb. 19, 2014	4.9	237.8	Open Borehole
16+875 23L	Mar. 27, 2014	1.2	241.9	Piezometer

## 5.32 Highway 11/17 EBL and WBL, Sta. 17+250 to 17+400 (Appendix AG)

### 5.32.1 General

Two boreholes were advanced within Sta. 17+250 to 17+400. The site stratigraphy encountered generally varied from silty clay with an interlayer of sand to peat overlying silt with some sand underlain by sand.

### 5.32.2 Peat

A 0.3 m thick deposit of peat with trace rootlets was encountered at the surface of Borehole 17+380 19L.

### 5.32.3 Silty Clay

A 3.1 m thick silty clay deposit with trace rootlets was encountered in Borehole 17+330 24R. The borehole was terminated at the base of the silty clay upon auger refusal on probable bedrock or boulder at a depth of 4.3 m (Elev. 249.9 m).

SPT N-values recorded within the silty clay deposit ranged from 0 to 11 blows per 0.3 m of penetration indicating a firm to stiff consistency. The moisture content ranged from 25 to 45%.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silty clay. The results of the testing are presented on the Record of Borehole Sheet included in Appendix AF. The grain size distribution curve for one sample is plotted on Figure AG1 and one Atterberg Limits test result is plotted on Figure AG3 of Appendix AF. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	3
Silt %	68
Clay %	29
Liquid Limit %	28
Plastic Limit %	16

The results of the Atterberg Limit test indicate that the tested sample of the silty clay has low plasticity with group symbol CL.

#### 5.32.4 Silt

A deposit of silt with some sand to sandy with increasing clay content with depth was encountered directly below the peat deposit in Borehole 17+380 19L. The thickness of the silt deposit was 3.8 m with an underside depth of 4.1 m (Elev. 251.4 m).

SPT N-values ranging from 1 to 13 blows per 0.3 m of penetration were recorded, indicating a very loose to compact relative density. The moisture content in the silt varied from 21 to 38%.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silt. The results of the testing are presented on the Record of Borehole Sheet included in Appendix AF. The grain size distribution curve for one sample is plotted on Figure AG2 and the Atterberg Limits test result is plotted on Figure AG4 of Appendix AG. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	18
Silt %	67
Clay %	15
Liquid Limit %	32
Plastic Limit %	17

The results of the Atterberg Limit tests indicate that the tested sample of silt has low plasticity with group symbol CL.

#### 5.32.5 Sand

A 2.0 m thick layer of sand with trace silt and trace gravel was encountered below the silt deposit. Borehole 17+380 19L was terminated at the base of the sand layer upon auger refusal on probable bedrock or boulder at a depth of 6.1 m (Elev. 249.4 m).

A SPT N-value of 37 blows per 0.3 m of penetration was recorded in the sand, indicating a dense relative density. A moisture content of 9% was measured.

An interlayer of sand with trace silt was also encountered within the silty clay in Borehole 17+330 24R. The sand layer had a thickness of 0.6 m with a lower boundary depth of 1.2 m (Elev. 252.9 m).

### 5.32.6 Groundwater Conditions

The water levels observed in the open boreholes upon completion of drilling are summarized in Table 5-30.

**Table 5-30 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
17+330 24R	Mar. 4, 2014	0.7	253.5	Open borehole
17+380 19L	Mar. 4, 2014	0.9	245.6	Open borehole

## 5.33 Highway 11/17 EBL and WBL, Sta. 17+550 to 17+675 (Appendix AH)

### 5.33.1 General

Two boreholes were advanced within Sta. 17+550 to 17+675. The site stratigraphy encountered generally consists of existing embankment fill underlain by a deposit of silty clay, which was further underlain by sandy silt.

### 5.33.2 Crushed Gravel to Sand Fill

Boreholes 17+600 19L and 17+600 29R were drilled through the existing highway fill and consisted of crushed gravel or sand with trace to some gravel. The fill in these boreholes extended to depths of 0.6 to 1.6 m (Elev. 259.9 to 260.7 m). At the time of the field investigation, the fill was generally frozen, or covered with ice.

SPT N-values in the frozen fill varied from 50 blows per 0.050 m of penetration to 50 blows per 0.025 m of penetration. The moisture content was measured to be 8%.

### 5.33.3 Silty Clay

A deposit of silty clay with trace sand and trace rootlets was encountered directly below the fill. The thickness of the silty clay deposit was 0.2 to 1.5 m with an underside depth of 1.7 to 2.1 m (Elev. 259.2 to 259.7 m). Borehole 17+600 29R was terminated at the base of the silty clay upon auger refusal on probable bedrock or boulder at a depth of 1.7 m (Elev. 259.8 m).

SPT N-values ranging from 14 blows per 0.3 m of penetration were recorded, indicating a stiff consistency. The moisture content in the silty clay varied from 19 to 45%.

An Atterberg Limits test was carried out on a sample of the silty clay. The results of the test are presented on the Record of Borehole Sheet included in Appendix AH. The results from

one Atterberg Limits test is plotted on Figure AH2 of Appendix AH. The results of the laboratory tests are summarized as follows:

Liquid Limit %	45
Plastic Limit %	29

The results of the Atterberg Limit tests indicate that the tested sample of silty clay has intermediate plasticity with group symbol CI.

#### 5.33.4 Sandy Silt

A layer of sandy silt with trace clay was encountered below the silty clay deposit in Borehole 17+600 19L. The borehole was terminated at the base of the sandy silt upon auger refusal on probable bedrock or boulder at a depth of 4.9 m (Elev. 256.4 m).

SPT N-values ranging from 23 to 40 blows per 0.3 m of penetration were recorded, indicating a compact to dense relative density. Moisture contents ranged from 11 to 13%.

A grain size distribution test was carried out on one sample of the silt. The results of the test are presented on the Record of Borehole Sheet included in Appendix AH. The grain size distribution curve for one sample is plotted on Figure AH1 of Appendix AH. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	32
Silt %	61
Clay %	7

#### 5.33.5 Groundwater Conditions

The water levels observed in both open boreholes upon completion of drilling are summarized in Table 5-31.

**Table 5-31 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
17+600 19L	Mar. 4, 2014	Dry	-	Open borehole
17+600 29R	Mar. 29, 2014	Dry	-	Open borehole

### 5.34 Highway 11/17 EBL and WBL, Sta. 17+720 to 17+750 (Appendix AI)

#### 5.34.1 General

Three boreholes were advanced within the vicinity of the proposed culvert alignment for Culvert 28. The site stratigraphy encountered generally consists of surficial peat or existing

embankment fill underlain by a deposit of silty clay, which was further underlain by silt and sand to sandy silt. Below the above layers was a deposit of sand with trace gravel.

#### 5.34.2 Sand Fill

Borehole 17+720 22R was drilled on the existing Highway 11/17 embankment and consisted of a 0.075 m thick layer of asphalt underlain by a 1.7 m thick layer of sand fill containing trace to some gravel. The borehole was terminated at the base of the fill upon auger refusal on probable bedrock or boulder at an underside elevation of Elev. 260.4 m. At the time of the investigation, the fill was generally frozen to 0.6 m.

SPT N-values recorded in the frozen fill varied from 50 blows per 0.125 m of penetration to 50 blows per 0.150 m of penetration. The moisture content ranged from 4 to 8%.

#### 5.34.3 Peat

A deposit of peat was encountered at the surface of Boreholes 17+750 34L and 17+736 CL with a thickness of 0.8 m.

SPT N-values recorded in the peat were between 2 to 3 blows per 0.3 m of penetration, indicating a soft consistency. The moisture contents ranged from 120 to 226%.

#### 5.34.4 Silty Clay

A deposit of silty clay with occasional sand seams was encountered directly below the surficial peat in borehole 17+750 34L and below the sand layer in borehole 17+736 CL. The thickness of this layer ranged from 0.9 to 2.7 m with the lower boundary encountered at depths of 2.4 to 3.5 m (Elev. 255.1 to 255.6 m).

SPT N-values ranging from 1 to 2 blows per 0.3 m of penetration were recorded. A single in situ field vane test conducted in the silty clay measured an undrained shear strength of 63 kPa with a sensitivity of 5, indicating that the silty clay is typically stiff and sensitive. The moisture content in the silty clay varied from 28 to 46%.

Atterberg Limits testing was carried out on select samples of the silty clay. The results of the testing are presented on the Record of Borehole Sheet included in Appendix AI. Two Atterberg Limits test results are plotted on Figures AI2 of Appendix AI. The results of the laboratory tests are summarized as follows:

Liquid Limit %	37 to 45
Plastic Limit %	17 to 19

The results of the Atterberg Limit tests indicate that the tested samples of the silty clay have intermediate plasticity with group symbol of CI.

#### 5.34.5 Silt and Sand to Sandy Silt

A layer of silt and sand to sandy silt with trace gravel and trace clay was encountered below the silty clay deposit. The investigated thickness of this layer was 1.9 to 5.0 m thick with a lower boundary at a depth of 4.3 to 8.5 m (Elev. 250.1 to 253.7 m). Borehole 17+750 34L

was terminated at the base of this layer upon auger refusal on probable bedrock or boulder at a depth of 8.5 m (Elev. 250.1 m).

SPT N-values ranging from 6 to 29 blows per 0.3 m of penetration were recorded, indicating a loose to compact relative density. Moisture contents ranging from 17 to 24% were measured.

Grain size distribution tests were carried out on two samples within this layer. The results of the testing are presented on the Record of Borehole Sheets in Appendix AI. The grain size distribution curves for the two samples are plotted on Figure AI1 of Appendix AI. The results of the laboratory tests are summarized as follows:

Gravel %	0 to 1
Sand %	22 to 46
Silt %	76
Clay %	1
Silt & Clay %	54

#### 5.34.6 Sand

A layer of sand with trace gravel was encountered between the peat and silty clay layer and below the sandy silt layer in Borehole 17+736 CL. Borehole 17+736 CL was terminated at the base of the sand layer upon auger refusal on probable bedrock or boulder at a depth of 5.2 m (Elev. 252.8 m).

SPT N-values varied from 2 to 27 blows per 0.3 m of penetration in the sand, indicating a very loose to compact relative density. The moisture content varied from 12 to 35%.

#### 5.34.7 Groundwater Conditions

The water levels observed in two of the open boreholes upon completion of drilling are summarized in Table 5-32.

**Table 5-32 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
17+736 CL	Mar. 5, 2014	0.6	257.4	Open borehole
17+750 34L	Mar. 5, 2014	0.9	257.7	Open borehole

### 5.35 Highway 11/17 EBL and WBL, Sta. 17+900 to 17+910 (Appendix AJ)

#### 5.35.1 General

Four boreholes were advanced along the proposed culvert alignment for Culvert 29 A/B. One borehole (17+900 23R) was completed previously in 2012 during the high fill embankments investigation but is included on the Borehole Location and Soil Strata

Drawing included in Appendix AJ. The site stratigraphy encountered adjacent to the existing embankment generally consists of sand with trace to some silt and with trace to some gravel.

#### **5.35.2 Sand Fill**

Borehole 17+905 29R was drilled on the existing Highway 11/17 embankment and consists of a 0.075 m thick layer of asphalt underlain by sand fill containing trace to some gravel and occasional cobbles. The borehole was terminated in the fill upon auger refusal at a depth of 1.2 m (Elev. 267.8 m). At the time of the field investigation, the fill was generally frozen, or covered with ice.

An SPT N-value of 50 blows per 0.075 m of penetration was recorded in the frozen fill. The moisture contents ranged from 4 to 5%.

#### **5.35.3 Organic Soils**

A layer of organic soils consisting of topsoil was encountered at the surface of Borehole 17+905 02L. The thickness of this layer was 0.2 m with an underside elevation of Elev. 262.8 m.

#### **5.35.4 Sand**

A layer of sand with trace silt to silty, some gravel and occasional cobbles was encountered at the surface in Boreholes 17+905 34L, 17+905 16L and below the organics in Borehole 17+905 02L. All three boreholes were terminated at the base of this layer upon auger refusal on probable bedrock or boulder at depths ranging from 4.0 to 6.7 m (Elev. 256.6 to 259.5 m).

SPT N-values ranging from 17 to 65 blows per 0.3 m of penetration were recorded, indicating a compact to very dense relative density. Typical moisture contents ranged from 4 to 18% were measured.

Grain size distribution testing was carried out on select samples within this layer. The results of the testing are presented on the Record of Borehole Sheets included in Appendix AJ. The grain size distribution curves for four samples are plotted on Figure AJ1 of Appendix AJ. The results of the laboratory tests are summarized as follows:

Gravel %	0 to 17
Sand %	60 to 77
Silt & Clay %	6 to 23

#### **5.35.5 Groundwater Conditions**

The water levels observed in two of the open boreholes upon completion of drilling are summarized in Table 5-33.

**Table 5-33 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
17+905 02L	Mar. 27, 2014	Dry	-	Piezometer
17+905 16L	Mar 6, 2014	4.6	258.7	Open Borehole

**5.36 Highway 11/17 EBL and WBL, Sta. 18+740 to 18+790 (Appendix AK)**

**5.36.1 General**

One borehole was advanced near the proposed culvert alignment for Culvert 32 A/B. Three boreholes (18+750 45L, 18+775 19R and 18+800 41R) were completed previously in 2012 during the high fill embankments investigation but are included on the Borehole Location and Soil Strata Drawing included in Appendix AK. The site stratigraphy encountered generally consists of a deposit of peat underlain by silty clay which was further underlain by sand with some gravel.

**5.36.2 Peat**

A 1.5 m thick deposit of peat with trace rootlets was encountered at the surface in Borehole 18+755 CL.

SPT N-values recorded in the peat were 2 blows per 0.3 m of penetration, indicating a soft consistency. The moisture contents of ranged from 85 to 102%.

**5.36.3 Silty Clay**

A layer of silty clay with trace sand was encountered below the peat deposit. The thickness of the silty clay layer was 10.1 m with a lower boundary depth at 11.6 m (Elev. 245.0 m).

SPT N-values of 0 to 2 blows per 0.3 m of penetration were recorded. In situ field vane testing measured undrained shear strengths ranging from 23 to 42 kPa, indicating that the deposit is typically soft to firm. The measured sensitivity of 3, from remolded field vane testing, indicates that the clayey silt is of medium sensitivity. The moisture content measurements ranged between 24 to 56%.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silty clay. The results of the testing are presented on the Record of Borehole Sheets included in Appendix AK. The grain size distribution curves for two samples are plotted on Figure AK1 and three Atterberg Limits test results are plotted on Figure AK2 of Appendix AK. The results of the laboratory tests are summarized as follows:

Gravel %	0 to 2
Sand %	6 to 9
Silt %	58 to 70
Clay %	22 to 33

Liquid Limit %	24 to 35
Plastic Limit %	15 to 17

The results of the Atterberg Limit tests indicate that the tested samples of the silty clay have low to intermediate plasticity with group symbols of CL to CI.

#### 5.36.4 Sand

A layer of sand with some gravel was encountered below the silty clay deposit. The sand deposit was 2.1 m thick with a lower boundary depth of 13.7 m (Elev. 242.9 m).

A single SPT N-value of 29 blows per 0.3 m of penetration was recorded, indicating a compact relative density. A moisture content of 6% was measured.

#### 5.36.5 Groundwater Conditions

The water level observed in the open borehole upon completion of drilling is summarized in Table 5-34.

**Table 5-34 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
18+755 CL	Mar. 6, 2014	0.3	256.3	Open borehole

### 5.37 Highway 11/17 EBL, Sta. 19+110 to 19+120 (Appendix AL)

#### 5.37.1 General

Three boreholes were advanced within Sta. 19+110 to 19+120 along the proposed culvert alignment. The site stratigraphy encountered adjacent to the existing embankment generally consists of organic soils underlain by silty sand with trace to some gravel.

#### 5.37.2 Sand Fill

Borehole 19+115 03R was drilled on the existing Highway 11/17 embankment and consists of sand fill containing trace to some gravel. The borehole was terminated in the fill upon auger refusal at a depth of 2.3 m (Elev. 266.4 m). At the time of the field investigation, the fill was generally frozen, or covered with ice.

SPT N-values of 50 blows per 0.150 m of penetration to 50 blows per 0.075 m of penetration were recorded in the frozen fill. The moisture content ranged from 6 to 10%.

#### 5.37.3 Organic Soils

A 0.15 to 0.2 m thick layer of organic soils consisting of topsoil was encountered at the surface of Boreholes 19+116 22R and 19+115 32R.

**5.37.4 Silty Sand**

Below the organic soils deposit, a layer of silty sand with trace to some gravel, trace clay and occasional rootlets was encountered in Boreholes 19+116 22R and 19+115 32R. Both boreholes were terminated in the silty sand at depths ranging from 0.8 to 2.3 m (Elev. 263.4 to 265.4 m).

SPT N-values ranging from 4 to 30 blows per 0.3 m of penetration were recorded in this deposit, indicating a compact to dense relative density. Representative measured moisture contents ranged between 11 and 20%.

The results of grain size distribution testing conducted on select samples of the silty sand are presented on the Record of Borehole sheets in Appendix AL. The grain size distribution curves for two samples are plotted on Figure AL1 of Appendix AL. The results of the laboratory tests are summarized as follows:

Gravel %	9 to 16
Sand %	54 to 62
Silt & Clay %	29 to 30

**5.37.5 Groundwater Conditions**

The water level observed in two of the open boreholes upon completion of drilling are summarized in Table 5-35.

**Table 5-35 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
19+116 22R	Mar. 7, 2014	0.8	265.4	Open borehole
19+115 32R	Mar. 7, 2014	Dry	-	Open borehole

**5.38 Highway 11/17 EBL, Sta. 19+190 to 19+330 (Appendix AM)**

**5.38.1 General**

Two boreholes were advanced within Sta. 19+190 to 19+330. The site stratigraphy encountered generally consists of a surficial deposit of peat underlain by sand to silty sand, which was further underlain by silt with trace to some sand and trace to some clay.

**5.38.2 Peat**

A 0.8 m thick deposit of peat was encountered at the surface of Borehole 19+315 19R.

A single SPT N-value of 2 blows per 0.3 m of penetration was recorded in the peat. The measured moisture content was 75%.

### 5.38.3 Sand to Silty Sand

A layer of sand with trace silt to silty sand with trace clay, trace gravel and trace rootlets was encountered below the peat deposit in Borehole 19+315 19R and at the surface of Borehole 19+200 23R. The layer had a thickness of 1.5 to 2.3 m with a lower boundary depth of 2.3 m (Elev. 267.7 to 269.1 m). Borehole 19+200 23R was terminated at the base of the layer upon auger refusal on probable bedrock or boulder at a depth of 2.3 m (Elev. 267.7 m).

SPT N-values were recorded in the sand deposit between 4 and 11 blows per 0.3 m of penetration indicating loose to compact consistency. The measured moisture contents of the sand ranged between 18 and 29%.

Grain size distribution tests were carried out on select samples of the sand. The results of the tests are presented on the Record of Borehole Sheet included in Appendix AL. The grain size distribution curves for two samples are plotted on Figure AM1 of Appendix AL. The results of the laboratory tests are summarized as follows:

Gravel %	0 to 6
Sand %	54 to 91
Silt %	33
Clay %	7
Silt & Clay %	9

### 5.38.4 Silt

A deposit of silt with trace to some sand and trace to some clay was encountered below the sand layer in Borehole 19+315 19R. The borehole was terminated at the base of the silt layer upon auger refusal on probable bedrock or boulder at a depth of 5.2 m (Elev. 266.2 m).

SPT N-values ranging from 16 to 21 blows per 0.3 m of penetration were recorded in the silt, indicating a compact relative density. Measured moisture contents ranged from 19 to 21%.

A grain size distribution test was carried out on one sample of the silt. The results of the test are presented on the Record of Borehole Sheet included in Appendix AM. The grain size distribution curve for the sample is plotted on Figure AM2 of Appendix AM. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	16
Silt %	71
Clay %	13

### 5.38.5 Groundwater Conditions

The water levels observed in the open boreholes upon completion of drilling are summarized in Table 5-36.

**Table 5-36 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
19+200 23R	Mar. 7, 2014	0.9	269.1	Open borehole
19+315 19R	Mar. 7, 2014	0.9	270.5	Open borehole

**5.39 Highway 11/17 EBL and WBL, Sta. 19+670 to 19+690 (Appendix AN)**

**5.39.1 General**

Five boreholes were advanced within the vicinity of the proposed culvert alignment for Culvert 35 A/B. The site stratigraphy encountered typically consists of a layer of organics or existing embankment fill underlain by a deposit of sand to silty sand which was locally underlain by a deposit of silt with some clay.

**5.39.2 Organic Soils**

A layer of organic soils ranging in composition from peat with trace rootlets to topsoil was encountered at the surface of Boreholes 19+672 32L, 19+678 19R and 19+683 35R. The thickness of the organics was between 0.2 and 0.8 m.

An SPT N-value of 2 blows per 0.3 m of penetration was recorded in the organic soils, indicating a very soft consistency. The measured moisture contents of the organics were between 48 and 502%.

**5.39.3 Sand Fill**

Boreholes 19+683 15L and 19+683 01R were drilled on the existing Highway 11/17 embankment and encountered sand fill with trace gravel to gravelly and trace silt. The thickness of the sand fill ranged from 3.0 to 3.8 m, with an underside elevation at Elev. 271.3 to 273.5 m.

SPT N-values of 3 to 19 blows per 0.3 m of penetration were recorded in the non-frozen fill indicating a relative density of very loose to compact. The moisture contents ranged from 7 to 20%.

The results of grain size distribution testing conducted on select samples of fill are presented on the corresponding Record of Borehole sheets in Appendix AN. The grain size distribution curves for two samples are plotted on Figure AN1 of Appendix AN. The results of the laboratory tests are summarized as follows:

Gravel %	6 to 24
Sand %	66 to 87
Silt & Clay %	7 to 10

#### 5.39.4 Sand to Silty Sand

Below the organics or sand fill, a deposit of sand ranging in composition from sand with trace to some silt and trace gravel to silty sand was encountered in all five boreholes. The thickness of this layer was 8.9 to 10.5 m with the lower boundary encountered at a depth of 9.1 to 11.3 m (Elev. 262.3 to 264.2 m). Boreholes 19+672 32L, and 19+678 19R were terminated at the base of the sand upon auger refusal on probable bedrock or boulder at depths ranging from 10.1 to 11.3 m (Elev. 262.3 to 263.0 m).

SPT N-values recorded in the sand deposit were generally between 3 and 30 blows per 0.3 m of penetration, indicating a very loose to compact relative density. The measured moisture contents of the sand ranged from 18 to 35%.

The results of grain size distribution testing conducted on select samples of sand are presented on the corresponding Record of Borehole sheet in Appendix AN. The grain size distribution curves for seven samples are plotted on Figures AN2 and AN3 of Appendix AN. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	72 to 98
Silt & Clay %	2 to 28

#### 5.39.5 Silt

A layer of silt with some clay and trace sand was encountered below the sand deposit in Borehole 19+683 35R. The borehole was terminated at the base of the silt layer upon auger refusal on probable bedrock or boulder at a depth of 10.1 m (Elev. 263.2 m).

A single SPT N-value was measured at 6 blows per 0.3 m of penetration, indicating a loose relative density. A moisture content of 25% was measured.

Grain size distribution testing carried out on a sample of the silt layer. The results of the testing are presented on the Record of Borehole Sheet included in Appendix AN. The grain size distribution curve is plotted on Figure AN4 of Appendix AN. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	10
Silt %	77
Clay %	13

#### 5.39.6 Groundwater Conditions

A standpipe piezometer was installed in one borehole to monitor water levels after completion of drilling. The water levels observed in open boreholes and measured in the piezometer are summarized in Table 5-37.

**Table 5-37 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
19+672 32L	Mar. 13, 2014	1.2	272.4	Open Borehole
19+678 19R	Mar. 8, 2014	0.6	272.5	Open Borehole
19+683 01R	Mar. 29, 2014	3.0	273.5	Open Borehole
19+683 15L	Mar. 30, 2014	4.5	270.6	Open Borehole
19+683 35R	Mar. 27, 2014	0.7	272.6	Piezometer

#### 5.40 Highway 11/17 EBL and WBL, Sta. 19+730 to 19+770 (Appendix AO)

##### 5.40.1 General

Five boreholes were advanced within the vicinity of the proposed culvert alignment for Culvert 36 A/B. The site stratigraphy encountered typically consists of a surficial layer of organics or existing embankment fill underlain by a deposit of sand with trace to some silt which was further underlain by silt to silt and sand or silty clay with some sand.

##### 5.40.2 Organic Soils

A 0.1 and 0.8 m thick layer of organic soils ranging in composition from peat with trace rootlets to topsoil with rootlets was encountered at the surface of Boreholes 19+760 33L, 19+759 17L and 19+748 19R and buried beneath the embankment fill in Borehole 19+755 05L.

SPT N-values of 2 blows per 0.3 m of penetration were recorded in the organic soils, indicating a very soft consistency. The measured moisture contents of the organics were between 235 and 401%.

##### 5.40.3 Sand Fill

Borehole 19+755 05L was drilled on the existing Highway 11/17 embankment and consisted of sand fill with trace to some gravel and trace silt. The fill had a thickness of 3.0 m, with an underside elevation at Elev. 273.6 m.

A SPT N-value of 7 blows per 0.3 m of penetration was recorded in the non-frozen fill. The moisture content ranged from 6 to 13%.

##### 5.40.4 Sand

A deposit of sand with trace to some silt and trace gravel was encountered in all five boreholes below the organics or at the ground surface. The thickness of this layer varied from 5.5 to 10.7 m with the lower boundary encountered at depths of 9.1 to 10.7 m (Elev. 262.4 to 267.5 m). Borehole 19+755 05L was terminated at the base of the sand upon auger refusal on probable bedrock or boulder at a depth of 9.1 m (Elev. 267.5 m).

SPT N-values were recorded in the sand deposit between 3 and 29 blows per 0.3 m of penetration, indicating a very loose to dense relative density. The measured moisture contents of the sand typically ranged from 18 to 34%.

The results of grain size distribution testing conducted on eight samples of the sand are presented on the corresponding Record of Borehole sheets in Appendix AO and are plotted on Figures AO1 and AO2 of Appendix AO. The results of the laboratory tests are summarized as follows:

Gravel %	0 to 3
Sand %	92 to 98
Silt & Clay %	2 to 8

#### **5.40.5 Silt to Silt and Sand**

Below the sand deposit, in Boreholes 19+760 33L, 19+759 17L and 19+748 19R, a layer of silt ranging in composition from silt with trace to some sand and trace clay to silt and sand was encountered. Boreholes 19+759 17L and 19+748 19R were terminated within the silt layer at a depth of 14.3 m (Elev. 259.4 to 259.9 m). A DCPT was conducted in Borehole 19+760 33L at the bottom of the borehole to refusal encountered at a depth of 17.7 m (Elev. 256.1 m).

SPT N-values between 11 and 35 blows per 0.3 m of penetration were recorded, indicating a compact to dense consistency. The moisture contents ranged from 20 to 26%.

Grain size distribution tests were carried out on select samples of the silt layer. The results of the testing are presented on the Record of Borehole Sheets included in Appendix AO. The grain size distribution curves for two samples are plotted on Figure AO3 of Appendix AO. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	2 to 44
Silt %	91
Clay %	7
Silt & Clay %	56

#### **5.40.6 Silty Clay**

A silty clay deposit with some sand and trace gravel was encountered beneath the sand layer in Borehole 19+736 34R. The borehole was terminated at the base of the silty clay layer upon auger refusal on probable bedrock or boulder at a depth of 11.3 m (Elev. 261.8 m).

A single SPT N-value of 21 blows per 0.3 m of penetration was recorded at the base of the layer. A single moisture content was measured at 28%.

Grain size distribution and Atterberg Limits testing were carried out on a sample of the silty clay. The results of the testing are presented on the Record of Borehole Sheet included in Appendix AO. The grain size distribution curve for one sample is plotted on Figure AO4

and one Atterberg Limits test is plotted on Figure AO5 of Appendix AO. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	16
Silt %	54
Clay %	30
Liquid Limit %	29
Plastic Limit %	14

The results of the Atterberg Limit tests indicate that the tested sample of silty clay has low plasticity with group symbol of CL.

#### 5.40.7 Groundwater Conditions

A standpipe piezometer was installed in one borehole to monitor water levels after completion of drilling. The water levels observed in open boreholes and measured in the piezometer are summarized in Table 5-38.

**Table 5-38 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
19+736 34R	Mar. 27, 2014	0.5	272.6	Piezometer
19+748 19R	Mar. 11, 2014	0.6	273.1	Open Borehole
19+755 05L	Mar. 30, 2014	4.7	271.9	Open Borehole
19+759 17L	Mar. 12, 2014	1.2	273.0	Open Borehole
19+760 33L	Mar. 12, 2014	0.3	273.5	Open Borehole

### 5.41 Highway 11/17 EBL and WBL, Sta. 20+860 to 20+880 (Appendix AP)

#### 5.41.1 General

Two boreholes were advanced within the vicinity of the proposed culvert alignment for Culvert 37. The site stratigraphy encountered typically consists of a surficial layer of organics or existing embankment fill underlain by a deposit of silty sand to silt and sand to sand which was further underlain by silt.

#### 5.41.2 Organic Soils

A 0.1 m thick layer of topsoil with trace rootlets was encountered at the surface of Borehole 20+865 24L. A 1.1 m thick layer of peat with a lower boundary depth of 7.0 m (Elev. 262.6 m) was encountered beneath existing embankment fill in Borehole 20+855 16R.

An SPT N-value of 12 blows per 0.3 m of penetration was recorded in the organic soil. A moisture content of 309% was measured.

#### 5.41.3 Sand Fill

Borehole 20+855 16R which was drilled on the existing Highway 11/17 embankment encountered a 65 mm thick layer of asphalt overlying sand fill with trace to some gravel. The fill had a thickness of 5.8 m, with an underside depth at 5.9 m (Elev. 263.7 m).

SPT N-values of 13 to 32 blows per 0.3 m of penetration in the non-frozen fill were recorded, indicating a relative density of compact to dense. The moisture content ranged from 3 to 13%.

A grain size distribution test was carried out on one sample of the sand fill. The results of the testing are presented on the Record of Borehole Sheet included in Appendix AP. The grain size distribution curve for the sample is plotted on Figure AP1 of Appendix AP. The results of the laboratory tests are summarized as follows:

Gravel %	11
Sand %	78
Silt & Clay %	11

#### 5.41.4 Silty Sand to Silt and Sand to Sand

A deposit of sand ranging in composition from silty sand to silt and sand with trace gravel to sand with trace gravel and trace silt was encountered below the organics, in both boreholes. The thickness of this layer varied from 3.2 to 8.6 m with the lower boundary encountered at depths of 8.7 to 10.2 m (Elev. 259.4 to 260.4 m).

SPT N-values were recorded in the sand deposit between 11 and 28 blows per 0.3 m of penetration, indicating a compact relative density. The measured moisture contents of the sand ranged from 8 to 28%.

The results of grain size distribution testing conducted on two samples of the sand are presented on the corresponding Record of Borehole sheets in Appendix AP. The grain size distribution curves for the two samples are plotted on Figure AP2 of Appendix AP. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	44 to 61
Silt & Clay %	39 to 56

#### 5.41.5 Silt

A layer of silt with trace sand and trace clay was encountered below the sand deposit in both boreholes. The boreholes were terminated in the silt layer at the maximum investigation depth of 14.3 m (Elev. 254.8 to 255.3 m).

SPT N-values between 12 and 42 blows per 0.3 m of penetration were typically recorded, indicating a compact to dense consistency. The moisture content ranged from 23 to 29%.

Grain size distribution tests were carried out on two samples of the silt layer. The results of the testing are presented on the Record of Borehole Sheets included in Appendix AP. The grain size distribution curves for the two samples are plotted on Figure AP4 of Appendix AP. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	2 to 5
Silt %	92 to 95
Clay %	3

#### 5.41.6 Groundwater Conditions

The water levels observed in the open boreholes upon completion of drilling are summarized in Table 5-39.

**Table 5-39 Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
20+865 24L	Mar. 13, 2014	4.0	265.1	Open borehole
20+855 16R	Mar. 28, 2014	5.7	263.9	Open borehole

## 6 MISCELLANEOUS

Thunder Bay Testing and Engineering (TBTE) of Thunder Bay, Ontario supplied and operated the drilling, sampling and in-situ testing equipment for the field program. Full time supervision of the field activities was carried out by Ms. Eckie Siu, Mr. George Azzopardi, Mr. Stephane Loranger and Mr. Michael Eastman of Thurber.

Supervision of the field program was performed by Mr. Stephen Peters, P.Eng. and interpretation of the field data and preparation of the report was performed by Mr. Jason Lee, P.Eng., Mr. Michael Eastman, E.I.T. and Mr. Stephen Peters, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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## Appendix A

### Tables

Table A1-1 to A1-4  
Table A2

Borehole Summary  
Piezometer Installation Details

Culverts, Supplementary Embankments and Cut Slopes  
Highway 11/17 - Red Rock to Nipigon

**Table A1-1  
Borehole Summary**

Appendix	Borehole / DCPT (*) / BH+DCPT (**)	Description	Depth of Investigation (m)	Depth of Peat, Topsoil and Organics Deposit (m)
B	Highway 11/17 EBL, Sta. 10+500 to 10+600			
	10+580 05R	Left toe of EBL	14.3	0.0
C	Highway 11/17 EBL and WBL, Sta. 10+600 to 10+940			
	10+750 19R	CL of EBL	14.3	1.1 to 1.2
	10+850 13R	CL of EBL	11.3	
10+805 22L	CL of WBL	10.7	0.1	
D	Highway 11/17 EBL and WBL, Sta. 10+940 to 10+950			
	10+945 07R	Left toe of EBL	14.3	1.1 to 1.4
	10+945 15R	CL of EBL	14.3	
	10+945 27R**	Right toe of EBL	21.2	
	10+945 18L	CL of WBL	14.3	0.0 to 0.8
10+945 27L	Left toe of WBL	6.7		
E	Off Highway 11/17, Sta. 10+965, Red Rock Road #9			
	10+020 CL	Median centreline	14.3	0.3
F	Highway 11/17 EBL and WBL, Sta. 10+950 to 11+160			
	11+050 17R	CL of EBL	14.3	1.6
	11+050 28L	Left toe of WBL	8.5	0.0
G	Highway 11/17 EBL and WBL, Sta. 11+160 to 11+170			
	11+165 05R**	Left toe of EBL	21	0.6 to 1.0
	11+165 19R	CL of EBL	14.3	
	11+165 31R	Right toe of EBL	14.3	
	11+165 14L	CL of WBL	14.3	0.0 to 0.6
11+165 31L	Left toe of WBL	14.3		
H	Highway 11/17 EBL, Sta. 11+170 to 11+770			
	11+250 19R	CL of EBL	14.3	0.1 to 0.3
	11+405 19R	CL of EBL	14.3	
	11+450 22R	CL of EBL	14.3	
	11+550 24R	CL of EBL	14.3	
11+700 19R	CL of EBL	14		
I	Off Highway 11/17, Sta. 11+410, Landfill Road			
	9+965 CL	Median centreline	14.3	0.1 to 0.2
	10+010 CL	Median centreline	14.3	
J	Highway 11/17 EBL and WBL, Sta. 11+770 to 11+800			
	11+785 08R	Left toe of EBL	13.6	0.8 to 0.9
	11+790 20R**	CL of EBL	15.2	
	11+795 35R	Right toe of EBL	14.3	
	11+775 35L	Left toe of WBL	12.1	0.6 to 1.4
11+780 17L	CL of WBL	14		
K	Highway 11/17 EBL and WBL, Sta. 11+900 to 11+950			
	11+923 02R	Left toe of EBL	14.2	0.8 to 1.5
	11+930 19R	CL of EBL	14.3	
	11+940 33R**	Right toe of EBL	15.5	
	11+905 32L	Left toe of WBL	14.3	0.0 to 1.5
11+912 19L	CL of WBL	14.3		
L	Highway 11/17 EBL and WBL, Sta. 12+070 to 12+080			
	12+075 05R	Left toe of EBL	14.1	0.8 to 2.1

Culverts, Supplementary Embankments and Cut Slopes  
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**Table A1-2**  
**Borehole Summary**

Appendix	Borehole / DCPT (*) / BH+DCPT (**)	Description	Depth of Investigation (m)	Depth of Peat, Topsoil and Organics Deposit (m)
L	Highway 11/17 EBL and WBL, Sta. 12+070 to 12+080			
	12+075 35R**	Right toe of EBL	15.7	0.8 to 2.1
	12+075 06L	Right toe of WBL	13.4	1.2 to 1.5
	12+075 33L	Left toe of WBL	11.3	
M	Highway 11/17 EBL, Sta. 12+100 to 12+170			
	12+130 15R	CL of EBL	14.3	0.8
N	Highway 11/17 EBL and WBL, Sta. 12+230 to 12+250			
	12+230 43R	Right toe of EBL	10.1	1.5 to 1.7
	12+235 CL	Median centreline	8.6	
	12+240 42L	Left toe of WBL	4.7	1.5
O	Highway 11/17 EBL, Sta. 12+270 to 12+420			
	12+350 19R	CL of EBL	12.2	0.0
P	Highway 11/17 EBL, Sta. 12+540 to 12+590			
	12+540 21R	CL of EBL	3.7	0.8
Q	Highway 11/17 WBL, Sta. 12+730 to 12+900			
	12+770 23L	CL of WBL	5.4	0.0 to 0.5
	12+845 20L	CL of WBL	14.3	
R	Off Highway 11/17, Sta. 13+100, Red Rock Road #8			
	9+965 CL	Median centreline	14.1	0.4
S	Highway 11/17 EBL and WBL, Sta. 13+100 to 13+300			
	13+150 20R	CL of EBL	13.8	0.1 to 0.5
	13+250 20R	CL of EBL	14.3	
	13+205 19L	CL of WBL	13.4	0.2
T	Highway 11/17 WBL, Sta. 13+450 to 13+550			
	13+455 39L	Left toe of WBL	5.6	0.1 to 0.9
	13+505 40L	Left toe of WBL	8.7	
	13+520 19L	CL of WBL	13.8	
U	Highway 11/17 WBL, Sta. 13+590 to 13+660			
	13+660 15R	CL of EBL	6.5	0.0 to 0.1
	13+650 40L	Left toe of WBL	6.4	
V	Highway 11/17 EBL and WBL, Sta. 13+875 to 14+190			
	13+955 19R	CL of EBL	2.7	0.4 to 0.9
	14+050 20R	CL of EBL	5.3	
	13+925 19L	CL of WBL	6.3	0.2 to 0.8
	14+000 19L	CL of WBL	9.2	
14+105 19L	CL of WBL	3.9		
W	Highway 11/17 EBL and WBL, Sta. 14+190 to 14+210			
	14+201 37R	Right toe of EBL	2.2	0.2
	14+201 CL	Median centreline	0.5	0.2 to 0.5
	14+201 19L	CL of WBL	0.3	
	14+201 35L	Left toe of WBL	1.6	
X	Highway 11/17 WBL, Sta. 14+210 to 14+410			
	14+255 19L	CL of WBL	1.4	0.0 to 0.1
	14+300 49L	Left toe of WBL	3.7	0.0 to 0.1
	14+350 48L	Left toe of WBL	2.1	
	14+375 23L	CL of WBL	2.3	

Culverts, Supplementary Embankments and Cut Slopes  
Highway 11/17 - Red Rock to Nipigon

**Table A1-3**  
**Borehole Summary**

Appendix	Borehole / DCPT (*) / BH+DCPT (**)	Description	Depth of Investigation (m)	Depth of Peat, Topsoil and Organics Deposit (m)
X	Highway 11/17 WBL, Sta. 14+210 to 14+410			
	14+400 33L	Left toe of WBL	1.5	0.0 to 0.1
Y	Highway 11/17 EBL and WBL, Sta. 14+720 to 14+760			
	14+739 58R	Right toe of EBL	0.5	0.5
	14+741 43L	Left toe of WBL	12.5	0.2
Z	Off Highway 11/17, Sta. 14+800, Highway 628			
	10+160 CL	Median centreline	2.4	0.8
	10+160 16R**	Median centreline	14.9	
	10+160 18L	Median centreline	1.8	0.6 to 0.8
	10+210 05L	Median centreline	5.8	
	10+260 05L	Median centreline	5.2	
AA	Highway 11/17 EBL, Sta. 14+900 to 14+930			
	14+910 19R	CL of EBL	2.7	0.76
AB	Highway 11/17 EBL and WBL, Sta. 15+190 to 15+220			
	15+196 42R	Right toe of EBL	14.8	0.6 to 0.8
	15+203 21R**	CL of EBL	16.8	
	15+210 01R	Left toe of EBL	14.8	
	15+213 21L	CL of WBL	13.1	0.6
	15+218 35L	Left toe of WBL	11.9	
AC	Highway 11/17 EBL and WBL, Sta. 15+725 to 16+250			
	15+740 24R	CL of EBL	4.3	0.8 to 1.7
	15+850 23R	CL of EBL	3.8	
	15+950 23R	CL of EBL	2.5	
	16+050 23R	CL of EBL	5.5	
	16+150 20R	CL of EBL	11.4	
	15+890 45L	Left toe of WBL	0.1	0.0 to 0.6
	15+940 19L	CL of WBL	0.2	
	15+940 49L	Left toe of WBL	0	
	15+990 45L	Left toe of WBL	0.1	
	16+040 19L	CL of WBL	1.9	
	16+040 49L	Left toe of WBL	0.7	
	16+090 35L	Left toe of WBL	2.8	
	16+175 34L	Left toe of WBL	5.6	
AD	Off Highway 11/17, Sta. 16+200, Median Connector			
	10+020 CL	Median centreline	6	0.8
AE	Highway 11/17 EBL and WBL, Sta. 16+390 to 16+470			
	16+400 02R	Left toe of EBL	6.6	0.6
	16+404 13R	CL of EBL	6.7	
	16+440 01L	Right toe of WBL	7	1.5
	16+450 17L	CL of WBL	8.1	
16+460 34L	Left toe of WBL	8.7		
AF	Highway 11/17 EBL and WBL, Sta. 16+820 to 16+900			
	16+825 33R	Right toe of EBL	6.3	1.5
	16+857 CL	Median centreline	11.7	
	16+875 23L	Left toe of WBL	5.9	2.1

Culverts, Supplementary Embankments and Cut Slopes  
Highway 11/17 - Red Rock to Nipigon

**Table A1-4**  
**Borehole Summary**

Appendix	Borehole / DCPT (*) / BH+DCPT (**)	Description	Depth of Investigation (m)	Depth of Peat, Topsoil and Organics Deposit (m)
AG	Highway 11/17 EBL and WBL, Sta. 17+250 to 17+400			
	17+330 24R	Right toe of EBL	4.3	0.0
	17+380 19L	CL of WBL	6.1	0.3
AH	Highway 11/17 WBL, Sta. 17+550 to 17+675			
	17+600 19L	CL of WBL	4.9	0.0
	17+600 29R	Right toe of EBL	1.7	0.0
AI	Highway 11/17 EBL and WBL, Sta. 17+720 to 17+750			
	17+720 22R	CL of EBL	1.8	0.0
	17+736 CL	Median centreline	5.2	0.8
	17+750 34L	Left toe of WBL	8.5	
AJ	Highway 11/17 EBL and WBL, Sta. 17+900 to 17+910			
	17+905 29R	Right toe of EBL	1.2	0.0
	17+905 02L	Right toe of WBL	4.3	0.0 to 0.2
	17+905 16L	CL of WBL	6.7	
	17+905 34L	Left toe of WBL	4	
AK	Highway 11/17 EBL and WBL, Sta. 18+740 to 18+790			
	18+755 CL	Median centreline	13.8	1.5
AL	Highway 11/17 EBL, Sta. 19+110 to 19+120			
	19+115 03R	Left toe of EBL	2.3	0.0 to 1.2
	19+115 32R	Right toe of EBL	2.3	
	19+116 22R	CL of EBL	0.8	
AM	Highway 11/17 EBL, Sta. 19+190 to 19+330			
	19+200 23R	CL of EBL	2.3	0.0 to 0.8
	19+315 19R	CL of EBL	5.2	
AN	Highway 11/17 EBL and WBL, Sta. 19+670 to 19+690			
	19+678 19R	CL of EBL	10.1	0.0 to 0.8
	19+683 01R	Left toe of EBL	9.1	
	19+683 35R	Right toe of EBL	10.1	
	19+672 32L	Left toe of WBL	11.3	0.0 to 0.8
AN	Highway 11/17 EBL and WBL, Sta. 19+670 to 19+690			
	19+683 15L	CL of WBL	9.1	0.0 to 0.8
AO	Highway 11/17 EBL and WBL, Sta. 19+730 to 19+770			
	19+736 34R	Right toe of EBL	11.3	0.0 to 0.1
	19+748 19R	CL of EBL	14.3	
	19+755 05L	Right toe of WBL	9.1	0.1 to 0.8
	19+759 17L	CL of WBL	14.3	
	19+760 33L**	Left toe of WBL	17.7	
AP	Highway 11/17 EBL and WBL, Sta. 20+860 to 20+880			
	20+855 16R	CL of EBL	14.3	1.1
	20+865 24L	Left toe of WBL	14.3	0.1

Culvert, Supplementary Embankments and Cut Slopes  
 Highway 11/17 - Red Rock to Nipigon

**Table A2**  
**Piezometer Installation Details**

Borehole	Piezometer Tip Depth (m)	Installation Details
12+080.9 17.8R	12.2	Piezometer with 1.5 m slotted screen installed, sand filter from 13.7 to 10.4 m, bentonite seal from 10.4 to 9.1 m, cuttings from 9.1 to 1.5 m, bentonite from 1.5 m to ground surface.
12+080 19L	9.5	Piezometer with 1.5 m slotted screen installed, sand filter from 11.3 to 7.6 m, bentonite seal from 7.6 to 6.1 m, cuttings from 6.1 to 1.5 m, bentonite from 1.5 m to ground surface.
12+200 19L	7.6	Piezometer with 1.5 m slotted screen installed, sand filter from 8.5 to 5.8 m, bentonite seal from 5.8 to 4.9 m, cuttings from 4.9 to 1.5 m, bentonite from 1.5 m to ground surface.
12+230 19R	9.1	Piezometer with 1.5 m slotted screen installed, sand filter from 9.1 to 7.3 m, bentonite seal from 7.3 to 6.4 m, cuttings from 6.4 to 1.5 m, bentonite from 1.5 m to ground surface.
12+480 19R	13.7	Piezometer with 1.5 m slotted screen installed, sand filter from 14.3 to 11.9 m, cuttings from 11.9 to 1.2 m, bentonite from 1.2 m to ground surface.
12+800 19R	9.5	Piezometer with 1.5 m slotted screen installed, sand filter from 9.5 to 7.3 m, bentonite seal from 7.3 to 6.1 m, cuttings to 6.1 to 1.8 m, bentonite from 1.8 m to ground surface.
12+950 19L	13.7	Piezometer with 1.5 m slotted screen installed, sand filter from 14.0 to 11.0 m, bentonite seal from 11.0 to 8.2 m, cuttings from 8.2 to 1.2 m, bentonite from 1.2 m to ground surface.
13+049 18R	9.9	Piezometer with 1.5 m slotted screen installed, sand filter from 9.9 to 7.6 m, bentonite seal from 7.6 m to ground surface.
13+340 19R	13.1	Piezometer with 1.5 m slotted screen installed, sand filter from 13.7 to 11.3 m, cuttings from 11.3 to 1.2 m, bentonite from 1.2 m to ground surface.
SB-02	17.7	Piezometer 3.0 m slotted screen installed, sand filter from 17.7 m to 13.3 m, bentonite seal from 13.3 m to 1.5 m, cuttings from 1.5 m to ground surface.
13+400 19L	14.3	Piezometer with 1.5 m slotted screen installed, sand filter from 14.3 to 11.7 m, bentonite seal from 11.7 to 2.3 m, cuttings from 2.3 m to ground surface.
16+335.2 21.2R	6.1	Piezometer with 1.5 m slotted screen installed, sand filter from 6.8 to 4.1 m, bentonite seal from 4.1 to 1.1 m, cuttings from 1.1 m to ground surface.
16+460 19L	13.3	Piezometer with 1.5 m slotted screen installed, sand filter from 13.3 to 10.7 m, bentonite seal from 10.7 to 1.1 m, cuttings from 1.1 m to ground surface.
16+850 19R	12.3	Piezometer with 1.5 m slotted screen installed, sand filter from 12.4 to 9.7 m, bentonite seal from 9.7 to 1.9 m, cuttings from 1.9 m to ground surface.
16+910 19L	8.0	Piezometer with 1.5 m slotted screen installed, sand filter from 8.0 to 5.6 m, bentonite seal from 5.6 to 1.9 m, cuttings from 1.9 m to ground surface.
18+475 19L	9.1	Piezometer with 1.5 m slotted screen installed, sand filter from 9.2 to 6.9 m, bentonite seal from 6.9 to 1.4 m, cuttings from 1.4 m to ground surface.