



**THURBER** ENGINEERING LTD.

**FINAL**

**FOUNDATION INVESTIGATION REPORT  
HIGHWAY 11 UNDERPASS STRUCTURE  
MUSKOKA RD 3, DISTRICT OF MUSKOKA  
AGREEMENT NO. 5017-E-0003  
Site No.: 42-169**

**G.W.P. 5336-11-00**

Geocres No.: 31E-393

Report to:

**McIntosh Perry Consulting Engineers Limited**

Latitude: 45.312632°  
Longitude: -79.245535°

August 2019  
Thurber File: 20244

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**G.W.P. 5336-11-00**

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**PART 1. FACTUAL INFORMATION**

**1 INTRODUCTION**

This section of the report presents the factual findings obtained from a foundation investigation completed at the Muskoka Road 3 crossing of Highway 11, located approximately 4 km south of Highway 60 within the District of Muskoka. Thurber Engineering Limited (Thurber) carried out the current field investigation as a sub-consultant to McIntosh Perry Consulting Engineers Ltd. (MPCE) under Assignment No. 5017-E-0003.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profile, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions influencing design and construction was developed in the course of the current investigation. The following historical foundation investigation report was obtained from the online Geocres library and reviewed in preparation of this report.

Foundation Investigation Report, W.P. 74-74-06, Hwy 11 District 11, Huntsville, Muskoka Road No. 3, South Junction to Huntsville, 2.6 Miles South of Hwy. 60 [Geocres No. 31E-79]

**2 SITE DESCRIPTION**

The project assignment includes an underpass structure that is a two span cast in place post tensioned voided concrete slab bridge. The existing underpass conveys Muskoka Road 3 in a west – east alignment at an approximate skew of 4 degrees over Highway 11.

The underpass (Structure No.42-169) has two spans of 36.6 m each, an overall width varying from 11.6 to 13.1 m and a road width varying from 9.1 to 10.6 m. The clearance under the structure is approximately 4.6 m. The structure is understood to have been constructed in 1980 and rehabilitated in 2000. The foundations are documented to consist of H-piles driven to refusal.

At the location of the underpass structure, Highway 11 includes two driving lanes plus a speed change lane in each direction. Highway 11 has a rural cross-section, paved

shoulders and a grassed median. Ramp intersection are located on Muskoka Road 3 approximately 100 to 150 m from both ends of the structure.

The approach fill height is approximately 7.3 m with the Muskoka Road 3 road surface at elevation 329.2 m. The existing Muskoka Road 3 embankment slopes are inclined at approximately 3.2H:1V. Reinforced concrete barrier walls with railing are situated on each side of the deck as guardrails.

The land adjacent to Highway 11 is vegetated with grasses and trees. Adjacent to the highway right-of-way, are primarily commercial properties. Traffic volumes on this section of Highway 11 are understood to be 18,200 AADT (2016).

Select photographs showing the existing conditions in the area of the underpass at the time of the field investigation are included in Appendix D for reference.

### 3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing program was carried out on April 27<sup>th</sup>, 2018. The field investigation consisted of advancing two boreholes, identified as 18-1 and 18-2 near the abutments of the structure. The drilling was carried out using a truck mounted CME 55 drill rig equipped with hollow stem augers. Prior to commencement of drilling, utility clearances were obtained in the vicinity of the borehole locations.

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). The boreholes were sampled to depths of 16.5 and 18.0 m below the existing ground surface (elev. 312.9 and 311.1 m) in Boreholes 18-1 and 18-2, respectively. The drilling and sampling operations were supervised on a full time basis by an experienced member of Thurber’s technical staff. The drilling supervisor logged the boreholes and processed the recovered soil samples for transport to Thurber’s Ottawa geotechnical laboratory for further examination and testing.

The approximate borehole locations are shown on the Borehole Locations and Soil Strata Drawing included in Appendix A. The coordinates and elevations of the boreholes from the current investigation are provided on this drawing and on the individual Record of Borehole sheets. The northing and easting (MTM zone 10), elevation, and termination depth of the boreholes are summarized below in Table 3-1. The borehole elevations were surveyed relative to benchmark HCM 820120090 (elev. 329.535 m), shown on Drawing B-625-11-10 dated April 20, 2017, provided by MPCE, with a Nikon-AP-8 with an accuracy of +/- 1.5 mm. Horizontal locations were measured relative to existing site features.

**Table 3-1: Borehole Summary**

Borehole No.	Drilled Location	Northing (m)	Easting (m)	Ground Surface Elevation (m)	Termination Depth (m)
18-1	West of Structure, EB Lane	5 019 219.7	324 701.2	329.3	16.5
18-2	East of Structure, WB Lane	5 019 209.0	324 804.6	329.1	18.0

Following completion of the field investigation the boreholes were backfilled in accordance with MOE requirements (O.Reg. 903, as amended). All boreholes were backfilled with granulars within the depth of pavement structure and capped with 150 mm of cold patch asphalt to reinstate the traveling surface.

#### **4 LABORATORY TESTING**

The recovered soil samples were subjected to visual identification and to natural moisture content determination. Selected samples were also subjected to gradation analysis (hydrometer and/or sieve) and Atterberg Limit testing. The results of these tests are summarized on the Record of Borehole sheets included in Appendix B. One sample of soil recovered from within each Borehole was selected and submitted for analytical testing of corrosivity parameters. All laboratory test results are provided in Appendix C.

#### **5 DESCRIPTION OF SUBSURFACE CONDITIONS**

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix B and the Borehole Location and Soil Strata drawing included in Appendix A. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description for interpretation of the site conditions. It must be recognized that the soil and groundwater conditions may vary between and beyond borehole locations.

In general terms, the site was found to be underlain by a pavement structure and sand to silty sand fill overlying native silt to silty clay to clayey silt and silty sand. Bedrock was not encountered within the depth of the current investigation.

A review of the historic Geocres report indicated elevation discrepancies with the current investigation and benchmarks, thus the information has not been included in the discussion provided herein.

##### **5.1 Embankment**

###### **5.1.1 Asphalt**

Both boreholes were drilled through the existing Muskoka Road 3 approach embankments and encountered a layer of asphalt at the surface with a thickness of 100 to 150 mm.

###### **5.1.2 Fill: Sand**

Encountered below the asphalt was a layer of granular fill consisting of sand with varying amounts of silt and gravel. The underside depth of the granular fill ranged from 6.1 to 7.2 m (elev. 321.9 to 323.2 m) below the existing roadway.

The SPT tests conducted in this fill gave N-values typically ranging from 3 to 40 blows indicating a relative density of very loose to dense.

Recorded moisture contents ranged from 1 to 8%. The results of grain size analyses conducted on two samples of the sand fill are summarized below and are illustrated on Figure C1 in Appendix C.

Soil Particle	Percentage (%)
Gravel	0 – 19
Sand	76 – 89
Silt & Clay	5 – 11

### 5.1.3 Fill: Silty Sand

Encountered below the sand fill in Borehole 18-2 was a layer of silty sand fill. The thickness of this fill deposit was 3.0 m with a base elevation of 318.9 m.

The SPT tests conducted in this silty sand layer gave N-values of 3 and 5 blows indicating a relative density of very loose to loose.

The recorded moisture contents were approximately 23%. Atterberg Limits testing conducted on one sample of the silty sand indicate this material to be non-plastic. The results of a grain size analysis conducted on one sample of the silty sand indicated the material to consist of 0% gravel, 52% sand, 38% silt and 10% clay, and the results are summarized on the Record of Borehole sheet in Appendix B and are illustrated on Figure C1 in Appendix C.

## 5.2 Silty Clay (CL-ML)

Below the west embankment fill in Borehole 18-1 and the silty sand in Borehole 18-2 (see Section 5.1.3) was a native deposit of silty clay with varying amounts of sand. The silty clay deposit was 1.5 to 4.1 m thick and extended to a base elevation ranging from 317.4 to 319.1 m.

The SPT tests conducted in the silty clay layer gave N-values ranging from 5 to 35 indicating a firm to hard consistency.

Recorded moisture contents ranged from 16 to 39%. The results of grain size analysis conducted on two samples of the silty clay are summarized below and are illustrated on Figure C2 in Appendix C.

Soil Particle	Percentage (%)
Gravel	0 – 2
Sand	5 – 10
Silt	72 – 74
Clay	18 – 19

The results of Atterberg Limits testing completed on two samples of this material indicated a liquid limit ranging from 22 to 25, a plastic limit ranging from 17 to 21, and a plasticity index ranging from 4 to 5. The laboratory results indicate that the silty clay has low plasticity

(CL- ML). The results are summarized on the Record of Borehole sheets in Appendix B and the Atterberg Limits graph is included in Figure C5 of Appendix C.

### **5.3 Clayey Silt (MI)**

Encountered below the silty clay in Borehole 18-2 (see Section 5.2) was a native deposit of clayey silt. The thickness of this clayey silt deposit was 4.6 m and it extended to a base elevation of 312.8 m.

In-situ shear vane test results indicated varying undrained shear strength ranging from 27 to 81 kPa indicating a firm to stiff consistency. SPT tests gave N-values ranging from Weight of Hammer to 15.

Recorded moisture contents ranged from 34 to 44%. The results of grain size analysis conducted on one sample of the clayey silt indicated the material to consist of 0% gravel, 1% sand, 50% silt and 49% clay, and the results are summarized on the Record of Borehole sheet in Appendix B and are illustrated on Figure C2 in Appendix C.

The results of Atterberg Limits testing completed on one sample of this material indicated a liquid limit of 37, a plastic limit of 26, and a plasticity index of 11. The laboratory results indicate that the clayey silt has intermediate plasticity (MI). The results are summarized on the Record of Borehole sheet in Appendix B and the Atterberg Limits graph is included in Figure C5 of Appendix C.

### **5.4 Silt (ML)**

Encountered below the silty clay in Borehole 18-1 and the clayey silt in Borehole 18-2 was a silt deposit. Borehole 18-2 was terminated within this layer at a base elevation of 311.1 m. The thickness of this layer in Borehole 18-1 was 4.6 m with a base elevation of 314.5 m.

The SPT tests conducted in the silt layer gave N-values ranging from 8 to 18 indicating a relative density of loose to compact.

Recorded moisture contents ranged from 24 to 32%. Atterberg Limits testing conducted on one sample of the silt indicate this material to be non-plastic. The results of grain size analysis conducted on one sample of the silt indicated this material to consist of 0% gravel, 2% sand, 71% silt and 27% clay and the results are summarized on the Record of Borehole sheet in Appendix B and illustrated on Figure C3 in Appendix C.

### **5.5 Silty Sand (SM) with gravel**

Borehole 18-1 encountered a silty sand with gravel deposit below the silt. The borehole was terminated within this layer at a base elevation of 312.9 m.

The SPT tests conducted in this silty sand layer gave N-values of 18 and 22 blows indicating a relative density of compact.

The recorded moisture contents ranged from 14 to 28%. Atterberg Limits testing conducted on one sample of the silty sand indicate this material to be non-plastic. The results of a grain size analysis conducted on one sample of the silty sand indicated the material to consist of 16% gravel, 48% sand, 33% silt and 3% clay, and the results are summarized on the Record of Borehole sheet in Appendix B and illustrated on Figure C4 in Appendix C.

## 5.6 Groundwater

The groundwater level measured in both boreholes during drilling operations on April 27<sup>th</sup>, 2018 was recorded at an elevation of approximately 322.0 to 322.1 m.

These observations are considered short term and it should be noted that the groundwater level at the time of construction could be different and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant and/or prolonged precipitation events.

## 5.7 Analytical Testing

Two samples of soil were submitted to Paracel Laboratories in Ottawa, Ontario for analysis of pH, water soluble sulphate, sulphide and chloride concentrations, resistivity and conductivity. The analysis results are summarized in the table below:

Borehole (sample)	Depth (mbgs)	Sulphate ( $\mu\text{g/g}$ )	pH (-)	Resistivity (Ohm-cm)	Conductivity ( $\mu\text{S/cm}$ )	Chloride ( $\mu\text{g/g}$ )	Sulphide %
18-1 (SS10)	7.6 – 8.2	11	6.39	16,400	61	21	<0.02
18-2 (SS10)	7.6 – 8.2	9	6.44	6,310	158	83	<0.02

## 6 MISCELLANEOUS

Borehole locations were selected by Thurber relative to the bridge abutments and other site features. The as-drilled locations and ground surface elevation of the boreholes were measured by Thurber following completion of the field program. Base plan drawings and survey benchmarks were provided by MPCE.

George Downing Estate Drilling Ltd. of Hawkesbury, Ontario supplied and operated the drilling equipment to conduct the drilling, soil sampling, in-situ testing and borehole decommissioning. The field investigation was supervised on a full time basis by Mr. Sean O'Bryan. of Thurber. Overall supervision of the field investigation program was provided by Mr. Stephen Peters, P.Eng.

Routine geotechnical laboratory testing was completed by Thurber's laboratory in Ottawa, Ontario. Analytical testing was completed by Parcel Laboratories in Ottawa, Ontario.

Interpretation of the factual data and preparation of this report were carried out by Miss Katya Edney, P.Eng. and Mr. Stephen Peters, P.Eng. The report was reviewed by Dr. Fred Griffiths, P.Eng and Dr. P.K. Chatterji, P.Eng. a Designated Principal Contact for MTO Foundation Projects.

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**Appendix A.**

**Borehole Location Plan and Stratigraphic Drawings**



**Appendix B.**

**Record of Borehole Sheets**



## SYMBOLS, ABBREVIATIONS AND TERMS USED ON TEST HOLE RECORDS

### TERMINOLOGY DESCRIBING COMMON SOIL GENESIS

Topsoil	mixture of soil and humus capable of supporting vegetative growth
Peat	mixture of fragments of decayed organic matter
Till	unstratified glacial deposit which may include particles ranging in sizes from clay to boulder
Fill	material below the surface identified as placed by humans (excluding buried services)

### TERMINOLOGY DESCRIBING SOIL STRUCTURE:

Desiccated	having visible signs of weathering by oxidization of clay materials, shrinkage cracks, etc.
Fissured	having cracks, and hence a blocky structure
Varved	composed of alternating layers of silt and clay
Stratified	composed of alternating successions of different soil types, e.g. silt and sand
Layer	> 75 mm in thickness
Seam	2 mm to 75 mm in thickness
Parting	< 2 mm in thickness

### RECOVERY:

For soil samples, the recovery is recorded as the length of the soil sample recovered.

### N-VALUE:

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 63.5 kg hammer falling 0.76 m, required to drive a 50 mm O.D. split spoon sampler 0.3 m into undisturbed soil. For samples where insufficient penetration was achieved and N-value cannot be presented, the number of blows are reported over the sampler penetration in millimetres (e.g. 50/75).

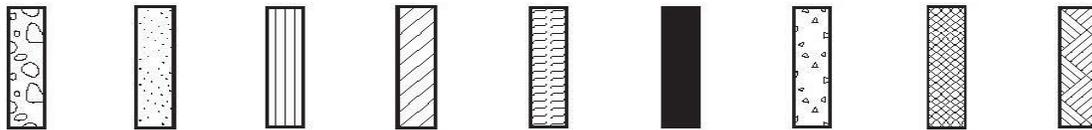
### DYNAMIC CONE PENETRATION TEST (DCPT):

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to an "A" size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone 0.3 m into the soil. The DCPT is used as a probe to assess soil variability.



**STRATA PLOT:**

Strata plots symbolize the soil and bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



Boulders  
Cobbles  
Gravel      Sand      Silt      Clay      Organics      Asphalt      Concrete      Fill      Bedrock

**TEXTURING CLASSIFICATION OF SOILS**

Classification	Particle Size
Boulders	Greater than 200 mm
Cobbles	75 – 200 mm
Gravel	4.75 – 75 mm
Sand	0.075 – 4.75 mm
Silt	0.002 – 0.075 mm
Clay	Less than 0.002 mm

**TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)**

Descriptive Term	Undrained Shear Strength (kPa)
Very Soft	12 or less
Soft	12 – 25
Firm	25 – 50
Stiff	50 – 100
Very Stiff	100 – 200
Hard	Greater than 200

NOTE: Clay sensitivity is defined as the ratio of the undisturbed strength over the remolded strength.

**SAMPLE TYPES**

SS	Split spoon samples
ST	Shelby tube or thin wall tube
DP	Direct push sample
PS	Piston sample
BS	Bulk sample
WS	Wash sample
HQ, NQ, BQ etc.	Rock core sample obtained with the use of standard size diamond coring equipment

**TERMS DESCRIBING CONSISTENCY (COHESIONLESS SOILS ONLY)**

Descriptive Term	SPT "N" Value
Very Loose	Less than 4
Loose	4 – 10
Compact	10 – 30
Dense	30 – 50
Very Dense	Greater than 50



**MODIFIED UNIFIED SOIL CLASSIFICATION**

Major Divisions		Group Symbol	Typical Description
<b>COARSE GRAINED SOIL</b>	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
<b>FINE GRAINED SOILS</b>	SILT AND CLAY SOILS $W_L < 35\%$	ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
		OL	Organic silts and organic silty-clays of low plasticity.
	SILT AND CLAY SOILS $35\% < W_L < 50\%$	MI	Inorganic compressible fine sandy silt with clay of medium plasticity, clayey silts.
		CI	Inorganic clays of medium plasticity, silty clays.
		OI	Organic silty clays of medium plasticity.
	SILT AND CLAY SOILS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of high plasticity, organic silts.
<b>HIGHLY ORGANIC SOILS</b>		Pt	Peat and other organic soils.

Note -  $W_L$  = Liquid Limit



## EXPLANATION OF ROCK LOGGING TERMS

### ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock materials.
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structures are preserved.

### TERMS

Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.
Solid Core Recovery: (SCR)	Percent ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1 m in length or larger, as a percentage of total core length
Unconfined Compressive Strength: (UCS)	Axial stress required to break the specimen.
Fracture Index: (FI)	Frequency of natural fractures per 0.3 m of core run.

### DISCONTINUITY SPACING

Bedding	Bedding Plane Spacing
Very thickly bedded	Greater than 2 m
Thickly bedded	0.6 to 2 m
Medium bedded	0.2 to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 to 60 mm
Laminated	6 to 20 mm
Thinly laminated	Less than 6 mm

### STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength (MPa)
Extremely Strong	Greater than 250
Very Strong	100 – 250
Strong	50 – 100
Medium Strong	25 – 50
Weak	5 – 25
Very Weak	1 – 5
Extremely Weak	0.25 – 1

### RECORD OF BOREHOLE No 18-1

1 OF 2

METRIC

GWP# 5336-11-00 LOCATION Lat: 45.312647°, Long: -79.246187°  
HWY 11 BOREHOLE TYPE CME55 Truck with HSA ORIGINATED BY SOB  
 DATUM Geodetic DATE 2018.04.27 - 2018.04.27 COMPILED BY KE  
 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							
329.3															
0.0	<b>ASPHALT (100 mm)</b>														
0.1	SAND with silt and gravel loose to dense brown FILL		1	SS	40		329								
			2	SS	33		328								
			3	SS	7		327								
			4	SS	31		326								
			5	SS	31		325								
			6	SS	26		324							19 76 5 (SI+CL)	
			7	SS	25		323								
			8	SS	24		322								
323.2	<b>SILTY CLAY (CL-ML)</b> some sand stiff, grey-brown		9	SS	35		321							0 10 72 18	
6.1			10	SS	10		320								
			11	SS	5										

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

### RECORD OF BOREHOLE No 18-1

2 OF 2

METRIC

GWP# 5336-11-00 LOCATION Lat: 45.312647°, Long: -79.246187°  
HWY 11 Underpass at Muskoka Rd 3, MTM Zone 10: N 5 019 219.7 E 324 701.2 ORIGINATED BY SOB  
 HWY 11 BOREHOLE TYPE CME55 Truck with HSA COMPILED BY KE  
 DATUM Geodetic DATE 2018.04.27 - 2018.04.27 CHECKED BY SP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
Continued From Previous Page		STRAT PLOT			PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT W <sub>p</sub> W      W <sub>L</sub> WATER CONTENT (%)					GR SA SI CL			
319.1													
10.2	<b>SILT (ML)</b> loose to compact, grey												0 2 71 27 Non-Plastic
			12	SS	8								
			13	SS	11								
			14	SS	10								
314.5													
14.8	<b>SILTY SAND (SM)</b> with gravel compact, brown-grey												
			15	SS	18								
			16	SS	22								16 48 33 3 Non-Plastic
312.9													
16.5	End of Borehole Water level during drilling operations at 7.3 mbgs in HSA (elev. 322.0 m)												

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

### RECORD OF BOREHOLE No 18-2

1 OF 2

METRIC

GWP# 5336-11-00 LOCATION Lat: 45.312548°, Long: -79.244869° HWY 11 BOREHOLE TYPE CME55 Truck with HSA ORIGINATED BY SOB  
 DATUM Geodetic DATE 2018.04.27 - 2018.04.27 COMPILED BY KE CHECKED BY SP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa						
329.1	ASPHALT (150 mm)													
0.0														
0.2	SAND trace gravel dense to loose, brown FILL		1	SS	37									
			2	SS	37									
			3	SS	13									
			4	SS	3									
			5	SS	7									
325.3	SAND with silt compact, brown-grey FILL		6	SS	17									
3.8			7	SS	16								0 89 11 (SI+CL)	
			8	SS	20									
			9	SS	16									
321.9	SILTY SAND compact to very loose grey-brown to grey FILL		10	SS	5									
7.2			11	SS	3								0 52 38 10 Non-Plastic	

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Continued Next Page

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

### RECORD OF BOREHOLE No 18-2

2 OF 2

METRIC

GWP# 5336-11-00 LOCATION Lat: 45.312548°, Long: -79.244869°  
 HWY 11 BOREHOLE TYPE CME55 Truck with HSA ORIGINATED BY SOB  
 DATUM Geodetic DATE 2018.04.27 - 2018.04.27 COMPILED BY KE  
 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
	Continued From Previous Page						20 40 60 80 100									
318.9	SILTY CLAY (CL-ML) trace sand stiff, grey		12	SS	11										2 5 74 19	
317.4			CLAYEY SILT (MI) firm to stiff, grey		13	SS	WH									0 1 50 49
316									2.0							
315									2.0							
312.8	SILT (ML) compact, grey				14	SS	5									
312																
311.1																
18.0	End of Borehole Water level during drilling operations at 7.0 mbgs in HSA (elev. 322.1 m)															

DOUBLE LINE 20244\_MUSKOKARD3.GPJ 2012TEMPLATE(MTO).GDT 19/8/19

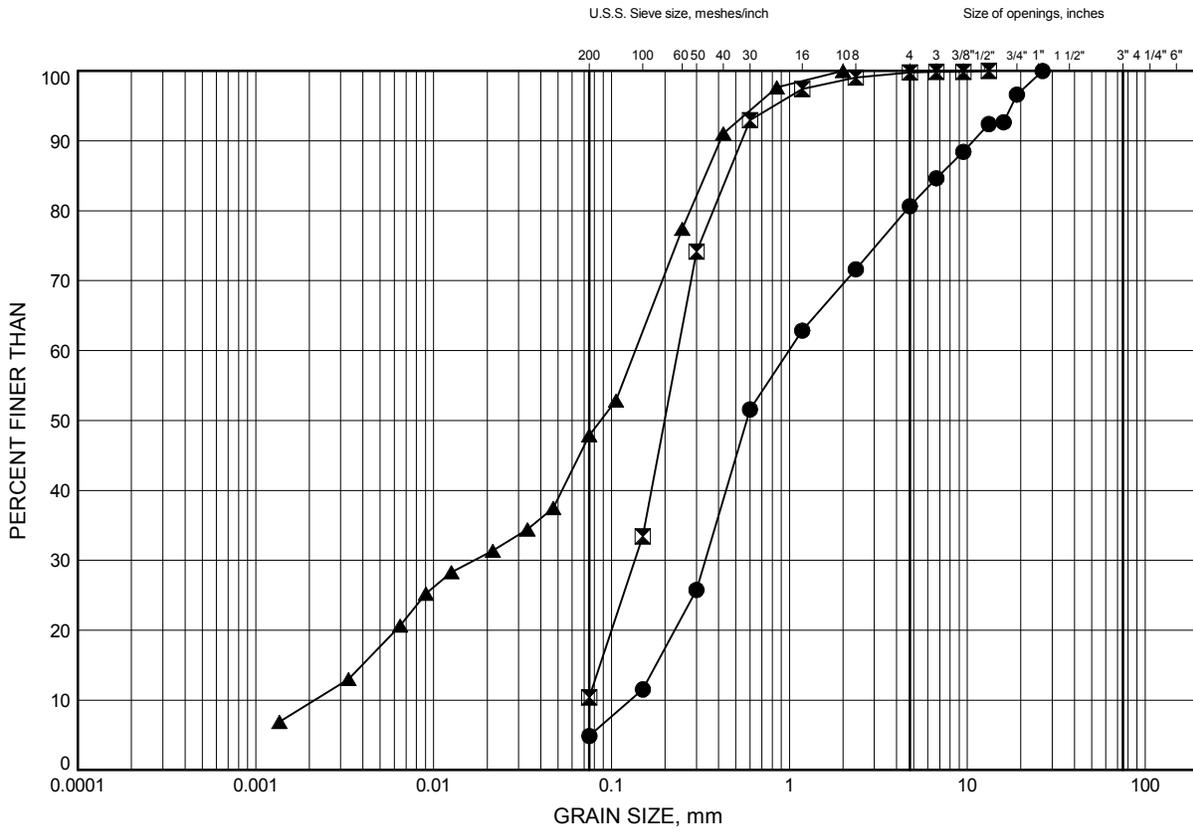
+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity  
 20  
 15 10 5 0  
 (%) STRAIN AT FAILURE

**Appendix C.**  
**Laboratory Testing**

Hwy's 11 and 118 - Muskoka Road 3  
**GRAIN SIZE DISTRIBUTION**

FIGURE C1

**FILL**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-1	4.1	325.2
⊠	18-2	4.9	324.2
▲	18-2	9.4	319.6

Date August 2019  
 GWP# 5336-11-00



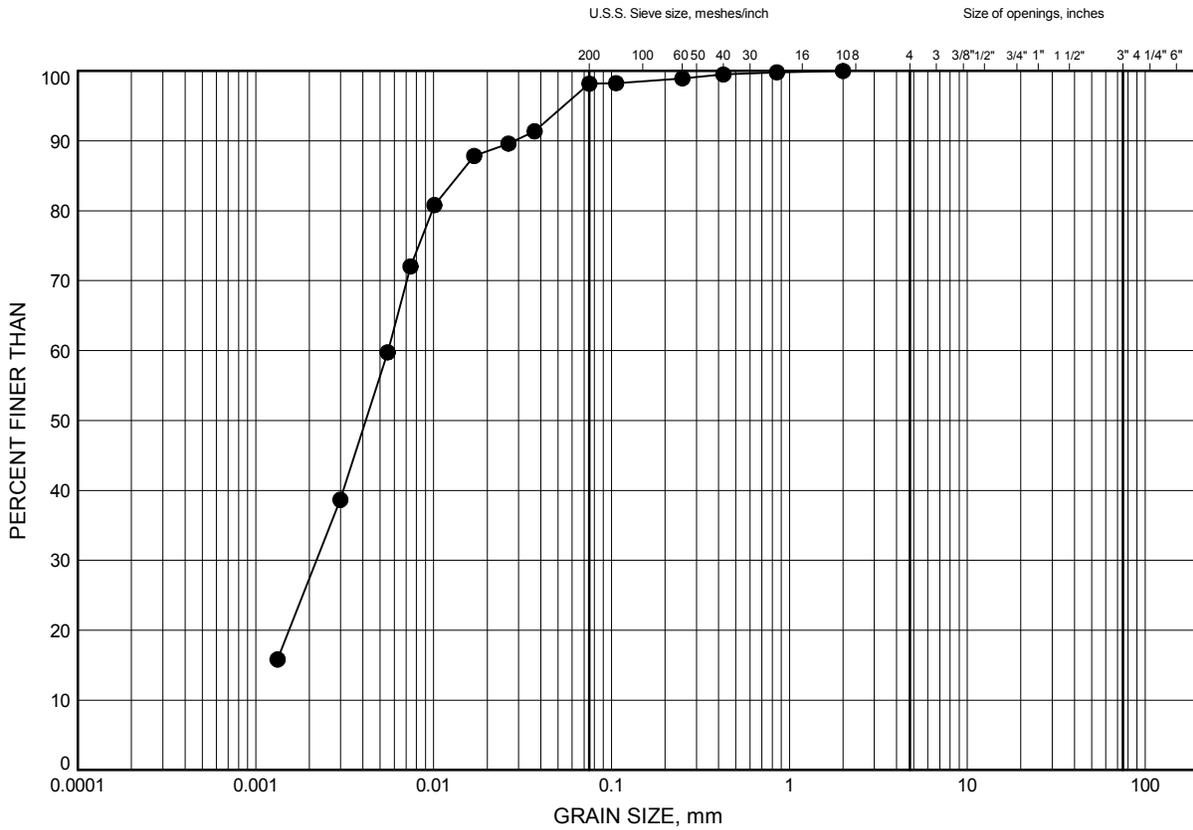
Prep'd KE  
 Chkd. SP



Hwy's 11 and 118 - Muskoka Road 3  
**GRAIN SIZE DISTRIBUTION**

FIGURE C3

**SILT**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-1	11.0	318.4

Date August 2019  
 GWP# 5336-11-00

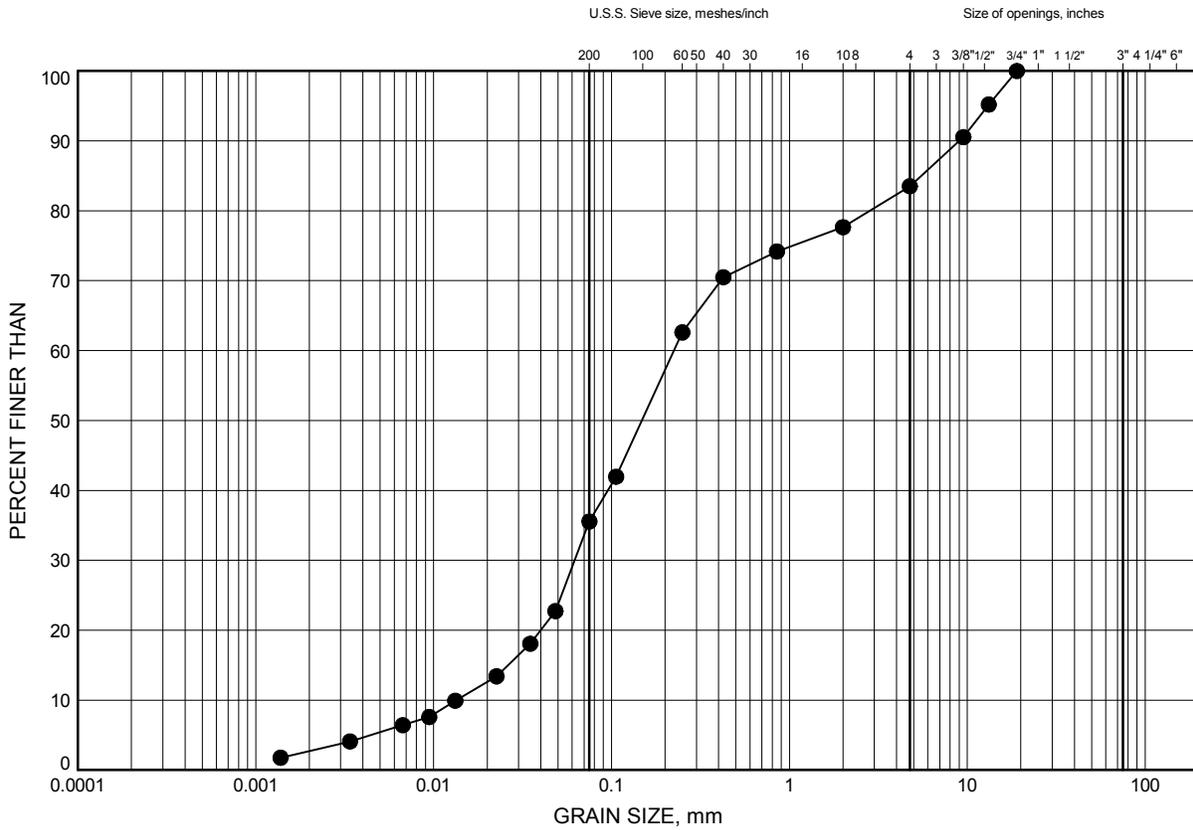


Prep'd KE  
 Chkd. SP

Hwy's 11 and 118 - Muskoka Road 3  
**GRAIN SIZE DISTRIBUTION**

FIGURE C4

**SILTY SAND with gravel**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-1	16.2	313.2

GRAIN SIZE DISTRIBUTION - THURBER 20244\_MUSKOKARD3.GPJ 19/8/19

Date August 2019  
 GWP# 5336-11-00

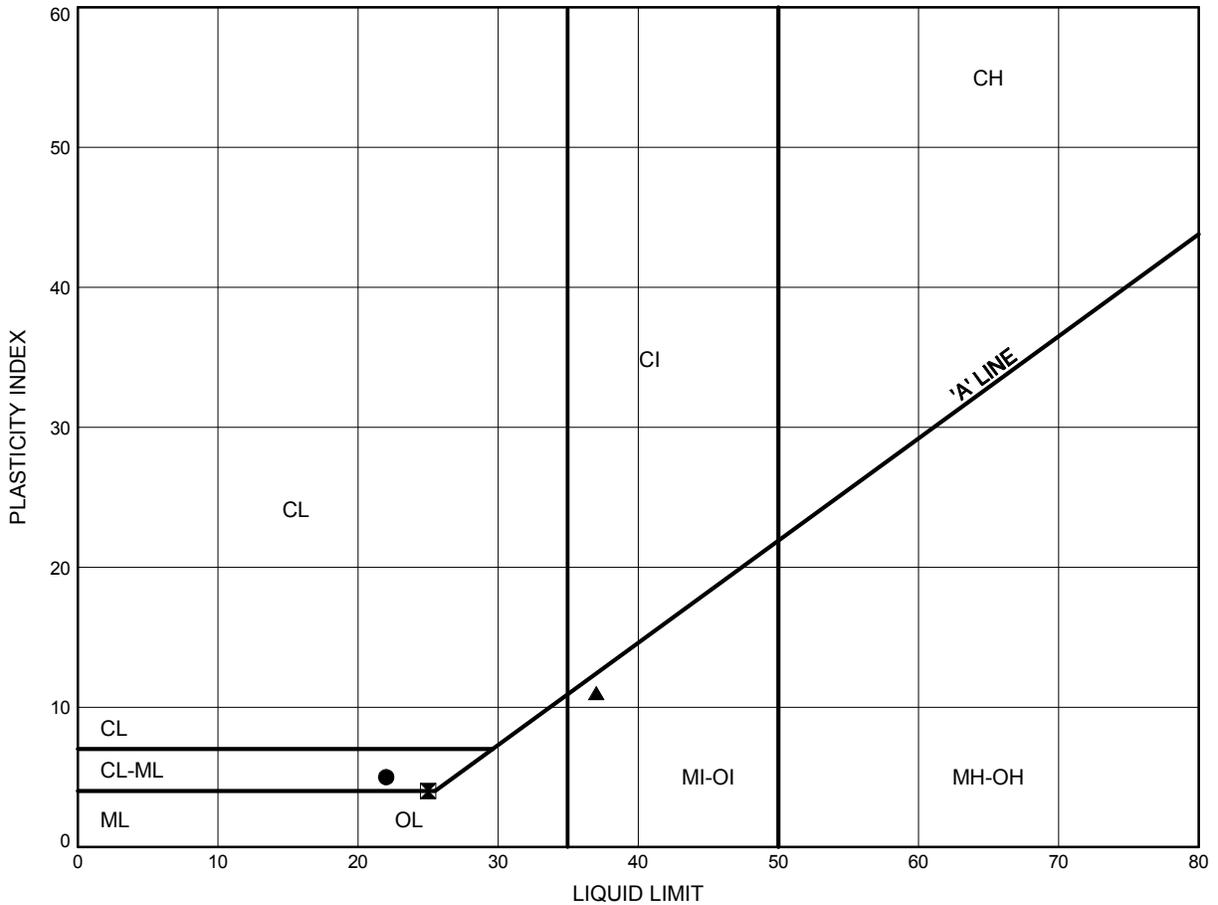


Prep'd KE  
 Chkd. SP

Hwy's 11 and 118 - Muskoka Road 3  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE C5

**SILTY CLAY to CLAYEY SILT**



**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-1	6.4	322.9
⊠	18-2	11.0	318.1
▲	18-2	12.5	316.6

Date August 2019  
 GWP# 5336-11-00



Prep'd KE  
 Chkd. SP

## Certificate of Analysis

**Thurber Engineering Ltd.**

2460 Lancaster Rd, Suite 104  
Ottawa, ON K1B 4S5  
Attn: Katya Edney

Client PO:  
Project: HWY 11 + 118  
Custody: 39845

Report Date: 10-May-2018  
Order Date: 4-May-2018

**Order #: 1818669**

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

Parcel ID	Client ID
1818669-01	Road 117 18-1'ss13 40-42'
1818669-02	Road 117 18-2 'SS12 35-37'
1818669-03	Fraserburg '18-1SS10 22'6-24'6"
1818669-04	Fraserburg'18-2 SS12A 35-36'6"
1818669-05	Road 2 '18-1 SS9 20-22'
1818669-06	Road 2 '18-2 SS10 25-27'
1818669-07	Bullens '18-1 SS11 23'3"-25'3"
1818669-08	Road 3 18-1 SS10 25-27'
1818669-09	Road 3 18-2 SS10 25-27'
1818669-10	Siding 18-2SS5 10-12'
1818669-11	Siding 18-3 SS5 10-12'

Approved By:



Dale Robertson, BSc  
Laboratory Director

Certificate of Analysis  
**Client: Thurber Engineering Ltd.**  
**Client PO:**

Report Date: 10-May-2018

Order Date: 4-May-2018

**Project Description: HWY 11 + 118**

### Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	8-May-18	8-May-18
Conductivity	MOE E3138 - probe @25 °C, water ext	8-May-18	9-May-18
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	7-May-18	7-May-18
Resistivity	EPA 120.1 - probe, water extraction	8-May-18	9-May-18
Solids, %	Gravimetric, calculation	7-May-18	7-May-18

Certificate of Analysis  
 Client: Thurber Engineering Ltd.  
 Client PO:

Report Date: 10-May-2018

Order Date: 4-May-2018

**Project Description: HWY 11 + 118**

<b>Client ID:</b>	Road 117 18-1'ss13 40-42'	Road 117 18-2 'SS12 35-37'	Fraserburg '18-1SS10 22'6-24'6"	Fraserburg'18-2 SS12A 35-36'6"
<b>Sample Date:</b>	04/30/2018 09:00	04/30/2018 09:00	04/29/2018 09:00	04/29/2018 09:00
<b>Sample ID:</b>	1818669-01	1818669-02	1818669-03	1818669-04
<b>MDL/Units</b>	Soil	Soil	Soil	Soil

**Physical Characteristics**

% Solids	0.1 % by Wt.	83.9	83.9	68.9	70.1
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**General Inorganics**

Conductivity	5 uS/cm	133	234	469	262
pH	0.05 pH Units	5.84	6.14	5.56	5.32
Resistivity	0.10 Ohm.m	75.0	42.7	21.3	38.1

**Anions**

Chloride	5 ug/g dry	82	113	246	120
Sulphate	5 ug/g dry	12	9	51	10

<b>Client ID:</b>	Road 2 '18-1 SS9 20-22'	Road 2 '18-2 SS10 25-27'	Bullens '18-1 SS11 23'3"-25'3"	Road 3 18-1 SS10 25-27'
<b>Sample Date:</b>	04/28/2018 09:00	05/01/2018 09:00	04/21/2018 09:00	04/27/2018 09:00
<b>Sample ID:</b>	1818669-05	1818669-06	1818669-07	1818669-08
<b>MDL/Units</b>	Soil	Soil	Soil	Soil

**Physical Characteristics**

% Solids	0.1 % by Wt.	87.0	72.7	77.5	80.3
----------	--------------	------	------	------	------

**General Inorganics**

Conductivity	5 uS/cm	218	1780	400	61
pH	0.05 pH Units	6.41	5.76	7.44	6.39
Resistivity	0.10 Ohm.m	45.8	5.61	25.0	164

**Anions**

Chloride	5 ug/g dry	124	1170	23	21
Sulphate	5 ug/g dry	7	10	200	11

<b>Client ID:</b>	Road 3 18-2 SS10 25-27'	Siding 18-2SS5 10-12'	Siding 18-3 SS5 10-12'	-
<b>Sample Date:</b>	04/27/2018 09:00	04/24/2018 09:00	04/23/2018 09:00	-
<b>Sample ID:</b>	1818669-09	1818669-10	1818669-11	-
<b>MDL/Units</b>	Soil	Soil	Soil	-

**Physical Characteristics**

% Solids	0.1 % by Wt.	82.5	79.5	72.3	-
----------	--------------	------	------	------	---

**General Inorganics**

Conductivity	5 uS/cm	158	2120	428	-
pH	0.05 pH Units	6.44	6.34	6.13	-
Resistivity	0.10 Ohm.m	63.1	4.71	23.4	-

**Anions**

Chloride	5 ug/g dry	83	1590	154	-
Sulphate	5 ug/g dry	9	19	76	-

Certificate of Analysis  
**Client: Thurber Engineering Ltd.**  
**Client PO:**

Report Date: 10-May-2018

Order Date: 4-May-2018

**Project Description: HWY 11 + 118**

**Method Quality Control: Blank**

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>									
Chloride	ND	5	ug/g						
Sulphate	ND	5	ug/g						
<b>General Inorganics</b>									
Conductivity	ND	5	uS/cm						
Resistivity	ND	0.10	Ohm.m						

Certificate of Analysis  
 Client: **Thurber Engineering Ltd.**  
 Client PO:

Report Date: 10-May-2018  
 Order Date: 4-May-2018  
 Project Description: **HWY 11 + 118**

**Method Quality Control: Duplicate**

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>									
Chloride	55.9	5	ug/g dry	55.6			0.7	20	
Sulphate	23.4	5	ug/g dry	22.9			2.1	20	
<b>General Inorganics</b>									
Conductivity	443	5	uS/cm	424			4.4	6.2	
pH	7.77	0.05	pH Units	7.77			0.0	10	
Resistivity	22.6	0.10	Ohm.m	23.6			4.4	20	
<b>Physical Characteristics</b>									
% Solids	98.2	0.1	% by Wt.	98.0			0.2	25	

Certificate of Analysis  
 Client: Thurber Engineering Ltd.  
 Client PO:

Report Date: 10-May-2018

Order Date: 4-May-2018

**Project Description: HWY 11 + 118**

**Method Quality Control: Spike**

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>									
Chloride	149	5	ug/g	55.6	93.2	78-113			
Sulphate	119	5	ug/g	22.9	95.8	78-111			

Certificate of Analysis  
**Client: Thurber Engineering Ltd.**  
**Client PO:**

Report Date: 10-May-2018

Order Date: 4-May-2018

**Project Description: HWY 11 + 118**

**Qualifier Notes:**

***Login Qualifiers :***

Container(s) - Bottle and COC sample ID don't match -

*Applies to samples: Road 117 18-1'ss13 40-42', Road 117 18-2 'SS12 35-37', Fraserburg '18-1SS10 22'6-24'6',  
Bullens '18-1 SS11 23'3"-25'3"*

**Sample Data Revisions**

None

**Work Order Revisions / Comments:**

None

**Other Report Notes:**

n/a: not applicable

ND: Not Detected

MDL: Method Detection Limit

Source Result: Data used as source for matrix and duplicate samples

%REC: Percent recovery.

RPD: Relative percent difference.

Soil results are reported on a dry weight basis when the units are denoted with 'dry'.  
Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

## Subcontracted Analysis

**Thurber Engineering Ltd.**  
2460 Lancaster Rd, Suite 104  
Ottawa, ON K1B 4S5  
Attn: Katya Edney

Tel: (613) 247-2121  
Fax: (613) 247-2185

Paracel Report No **1818669**  
Client Project(s): **HWY 11 + 118**  
Client PO:  
Reference: **Standing Offer**  
CoC Number: **39845**

Order Date: 04-May-18  
Report Date: 15-May-18

Sample(s) from this project were subcontracted for the listed parameters. A copy of the subcontractor's report is attached

Paracel ID	Client ID	Analysis
1818669-01	Road 117 18-1'ss13 40-42'	Sulphide, solid
1818669-02	Road 117 18-2 'SS12 35-37'	Sulphide, solid
1818669-03	Fraserburg '18-1SS10 22'6-24'6"	Sulphide, solid
1818669-04	Fraserburg'18-2 SS12A 35-36'6"	Sulphide, solid
1818669-05	Road 2 '18-1 SS9 20-22'	Sulphide, solid
1818669-06	Road 2 '18-2 SS10 25-27'	Sulphide, solid
1818669-07	Bullens '18-1 SS11 23'3"-25'3"	Sulphide, solid
1818669-08	Road 3 18-1 SS10 25-27'	Sulphide, solid
1818669-09	Road 3 18-2 SS10 25-27'	Sulphide, solid
1818669-10	Siding 18-2SS5 10-12'	Sulphide, solid
1818669-11	Siding 18-3 SS5 10-12'	Sulphide, solid



**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.  
Lakefield - Ontario - K0L 2H0  
Phone: 705-652-2000 FAX: 705-652-6365

15-May-2018

**Paracel Laboratories**

Attn : Dale Robertson

300-2319 St.Laurent Blvd.  
Ottawa, ON  
K1G 4K6,

Phone: 613-731-9577  
Fax:613-731-9064

**Date Rec. :** 08 May 2018  
**LR Report:** CA13203-MAY18  
**Reference:** Project#: 1818669

**Copy:** #1

# CERTIFICATE OF ANALYSIS

## Final Report

Sample ID	Sample Date & Time	Sulphide %
1: Analysis Start Date		14-May-18
2: Analysis Start Time		13:09
3: Analysis Completed Date		14-May-18
4: Analysis Completed Time		14:54
5: QC - Blank		< 0.02
6: QC - STD % Recovery		101%
7: QC - DUP % RPD		ND
8: RL		0.02
9: Road 117 18-1'ss13 40-42'	30-Apr-18	< 0.02
10: Road 117 18-2 'SS12 35-37'	30-Apr-18	< 0.02
11: Fraserburg '18-1SS10 22'6-24'6"	29-Apr-18	< 0.02
12: Fraserburg '18-2 SS12A 35-36'6"	29-Apr-18	< 0.02
13: Road 2 '18-1 SS9 20-22'	28-Apr-18	< 0.02
14: Road 2 '18-2 SS10 25-27'	01-May-18	< 0.02
15: Bullens '18-1 SS11 23'3"-25'3"	21-Apr-18	0.40
16: Road 3 18-1 SS10 25-27'	27-Apr-18	< 0.02
17: Road 3 18-2 SS10 25-27'	27-Apr-18	< 0.02
18: Siding 18-2SS5 10-12'	24-Apr-18	< 0.02
19: Siding 18-3 SS5 10-12'	23-Apr-18	< 0.02

RL - SGS Reporting Limit

Carrie Greenlaw  
Project Specialist  
Environmental Services, Analytical

**Appendix D.**

**Site Photographs**



**Photo 1. Looking north along Highway 11 from East of Muskoka Road 3 Underpass Structure (May 9<sup>th</sup>, 2018)**



**Photo 2. Muskoka Road 3 Underpass Structure from east (May 9<sup>th</sup>, 2018)**



**Photo 3. Looking east along Muskoka Road 3 (May 9<sup>th</sup>, 2018)**



**Photo 4. Looking west along Muskoka Road 3 (April 27<sup>th</sup>, 2018)**