



THURBER ENGINEERING LTD.

**FINAL
FOUNDATION INVESTIGATION REPORT
HIGHWAY 118 CULVERT STA. 11+494, OAKLEY TOWNSHIP
ASSIGNMENT NO. 5017-E-0003
G.W.P. 5287-14-00**

Geocres No.: 31E-397

Report to:

McIntosh Perry Consulting Engineers Limited

Latitude: 45.004130
Longitude: -79.108881

August 2019
Thurber File No.: 20244



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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 a culvert at Sta. 11+494 on Highway 118. The culvert crossing is located approximately 0.3 km west of Milne Road within Oakley Township in 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.

No previous foundation investigation information was available for the subject culvert site within the online Geocres Library. A Project Assessment Report (PAR) and a historical base plan survey were provided by MPCE.

2 SITE DESCRIPTION

For project purposes, Highway 118 will be considered to be oriented east-west with chainage increasing to the east. The existing culvert conveys (unnamed) creek flow from the north to the south under a high fill embankment supporting Highway 118. As described within the historical baseplan drawings provided by MPCE, the existing culvert is a non-structural corrugated steel pipe (CSP) culvert with a measured diameter of 1.1 m and a length of 29.9 m. The invert of the culvert is at approximate elevation 321.1 m at the inlet (north) and 320.9 m at the outlet (south). The culvert has a skew angle of approximately 18 degrees. Transverse cracking of the pavement was noted at the culvert. No signs of erosion or slope instability were noted on the existing highway embankments during the field investigation. The roadway surface over the culvert was generally in good condition with no dips or bumps noted during the field investigation. The condition of the existing

culvert, as assessed by MPCE, did show some signs of corrosion and the south end of the culvert has a substantial dent at the exposed end.

At the location of the culvert, Highway 118 is a two-lane highway with paved shoulders. The highway has a horizontal and vertical curve at the location of the culvert. The Highway 118 fill height above the culvert ranges from approximately 4.8 to 5.0 m with the road surface at approximate elevation 327.0 m. The existing northern and southern embankment slopes are inclined at approximately 2.0H:1V and 1.8H:1V, respectively. Cobbles and boulders were observed on the embankment slopes. Cable guidewires with wooden posts are present on both sides of the highway in the vicinity of the culvert. The land adjacent to the highway is undeveloped and is densely vegetated with shrubs and trees. A single family dwelling is located approximately 250 m west of the culvert. Bedrock outcrops and minor rock cuts are present at multiple locations within close proximity to the culvert site. Overhead utility lines run parallel to the north side of the highway. Traffic volumes on this section of Highway 118 are understood to be 4,300 AADT (2016).

Photographs showing the existing conditions in the area of the culvert 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 from September 15th to 29th, 2018. The field investigation consisted of advancing four boreholes identified as 18-1 through 18-4. The drilling was carried out using portable equipment for off-road boreholes 18-1 and 18-4 and a truck mounted CME 75 drill rig for the on-road boreholes 18-2 and 18-3. Prior to commencement of drilling, utility clearances were obtained in the vicinity of the borehole locations.

The northing, easting and elevation of the boreholes are shown on the Borehole Location and Soil Strata Drawing No. 1 in Appendix A, the individual Record of Borehole sheets in Appendix B and within Table 3-1. The termination depth of each of the boreholes is also provided. The site is within MTM Zone 10. The borehole elevations were surveyed with a Nikon-AP-8 with an accuracy of +/- 1.5 mm. The survey referenced the top of the north end of the culvert which has an elev. 322.193 m, as provided by MPCE. 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	Near Culvert Inlet	4 984 994.7	335 619.8	322.3	9.2
18-2	Westbound Lane HWY 118	4 984 982.2	335 616.5	326.7	15.2
18-3	Eastbound Lane HWY 118	4 984 973.6	335 624.5	327.2	16.2
18-4	Near Culvert Outlet	4 984 961.5	335 620.1	321.0	8.6

Note: () depths provided in table are from the ground surface*

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) following ASTM D1586. A half-weight (32 kg) hammer was used during SPT testing in Boreholes 18-1 and 18-4, which were drilled with portable equipment. The N-values reported herein for these off-road boreholes have been adjusted to an equivalent standard weight hammer (64 kg). A standard weight hammer was used during SPT testing for the on-road boreholes and no correction was necessary. All boreholes were advanced into bedrock with either NW or NWT casing in conjunction with coring techniques.

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.

A 19 mm diameter standpipe piezometer was installed in Borehole 18-4 to allow for measurements of the groundwater level after completion of drilling. The piezometer installation details are illustrated on the respective Record of Borehole sheet provided in Appendix B. The boreholes were backfilled in accordance with MOE requirements (O.Reg. 903, as amended). Boreholes 18-2 and 18-3 were backfilled with granulars within the depth of pavement structure and capped with 150 mm of cold patch asphalt to reinstate the travelling 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 respective Record of Borehole sheets included in Appendix B. One sample of soil recovered from within each of Boreholes 18-1 and 18-4 was selected and submitted for analytical testing of corrosivity parameters. One rock core sample underwent unconfined compressive strength testing. All laboratory test results are provided in Appendix C.

5 GENERAL 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 the Soil Strata Drawing and the general description. 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, granular fill and rock fill overlying native deposits of sand and silty sand over glacial till. Granite bedrock was encountered at varying elevations within the depths of investigation in all boreholes.

5.1 Embankment

5.1.1 Asphalt

Boreholes 18-2 and 18-3 were drilled through the existing Highway 118 embankment and encountered a layer of asphalt with a thickness of 100 mm at the ground surface.

5.1.2 Sand with Gravel (Fill)

A layer of granular fill (pavement structure), classified as sand with gravel to gravel with sand, was encountered below the asphalt in Boreholes 18-2 and 18-3. The underside of this fill was at 1.0 and 1.4 m below the existing roadway surface (elev. 325.7 and 325.8 m) in Boreholes 18-2 and 18-3, respectively.

The SPT tests conducted in the granular fill gave N-values ranging from 55 to 79 blows, indicating a relative density of very dense. Recorded moisture contents ranged from 4 to 8%.

5.1.3 Rock Fill

A layer consisting of rock fill was encountered beneath the granular pavement structure in Boreholes 18-02 and 18-03. This layer had a thickness ranging from 1.9 to 3.2 m (underside elev. 322.5 to 323.9 m). Boreholes were advanced through the rock fill using casing and coring techniques. Split spoon sampling was attempted between core runs; however, sample recovery was poor. SPT refusal was routinely encountered.

Rock fill pieces were cored and indicated mainly granite particles with cored lengths of up to 900 mm.

5.1.4 Sand with Silt and Gravel (Fill)

A second granular fill layer, consisting of sand with silt and gravel and occasional to frequent cobbles and boulders was encountered below the rock fill in Boreholes 18-2 and 18-3. The thickness of this granular fill ranged from 0.5 m to 2.0 m (underside elev. 322.0 m to 321.9 m).

The SPT tests conducted in this granular fill layer gave N-values ranging from 3 to 38 blows, indicating a relative density of very loose to dense.

Recorded moisture contents of 10 and 15% were measured in this layer. The results of grain size analysis conducted on one sample of the granular fill indicated this material to consist of 26% gravel, 67% sand and 7% fines. These results are illustrated on Figure C1 in Appendix C.

5.2 Silty Sand (SM) with organics

A native deposit of silty sand with organics was encountered at the ground surface in off-road Boreholes 18-1 and 18-4 with a thickness of 1.5 m and 0.6 m (underside elev. 320.8 m and 320.4 m), respectively.

SPT tests conducted in the silty sand deposit gave N-values ranging from 2 to 5 blows indicating a relative density of very loose to loose.

Recorded moisture contents of the silty sand ranged from 24 to 59%. The results of grain size analyses conducted on two samples of the silty sand are summarized below and are illustrated on Figure C2 in Appendix C.

Soil Particle	Percentage (%)
Gravel	0
Sand	65 – 69
Silt	25 – 30
Clay	5 – 6

Atterberg Limit testing was completed on two samples of the silty sand deposit and indicated that the material is non-plastic.

5.3 Sand (SP to SP-SM)

A native deposit of sand with varying amounts of silt was encountered below the organic silty sand in Boreholes 18-1 and 18-4 and below the fill materials in Boreholes 18-2 and 18-

3. The thickness of this sand deposit ranged from 2.5 to 6.9 m with a bottom elevation of 315.0 to 318.3 m.

The SPT N-values conducted in this layer ranged from 12 to 75 blows indicating a relative density of compact to very dense.

The moisture content of the samples tested ranged from 16 to 28%. The results of grain size analyses conducted on five samples of the sand are summarized below and are illustrated on Figure C3 in Appendix C.

Soil Particle	Percentage (%)
Gravel	0 – 1
Sand	91 – 98
Silt	2 – 9
Clay	

5.4 Sandy Silt (ML)

A 0.3 m thick layer of sandy silt with traces of organics was encountered below the sand in Borehole 18-2. The underside elevation of this layer was at 315.7 m.

A moisture content was measured to be 100%.

5.5 Sand (SP-SM) to Silty Sand (SM) – (Glacial Till)

Below the sand in Boreholes 18-1, 18-3 and 18-4 and below the sandy silt layer in Boreholes 18-2 was a deposit of glacial till consisting of sand to silty sand with varying amounts of gravel. Occasional cobbles and boulders were encountered in Borehole 18-4 and the till deposit encountered in Borehole 18-1 consisted predominantly of cobbles and boulders. Coring techniques were required to advance through the cobbles and boulders in Borehole 18-1. The thickness of the till deposit ranged from 0.8 m to 1.7 m with an underside elevation ranging from 316.6 m to 314.2 m.

SPT tests conducted in the till deposits within Boreholes 18-3 and 18-4 gave N-values ranging from 18 to 25 blows indicating a relative density of compact. SPT testing was not feasible in Borehole 18-1 due to the presence of boulders.

Recorded moisture contents of the till ranged from 8 to 20%. The result of grain size analyses conducted on three samples of the till are summarized below and are illustrated on Figure C4 in Appendix C.

Soil Particle	Percentage (%)
Gravel	0 – 42
Sand	47 – 81
Silt	11 – 19
Clay	

5.6 Bedrock

Bedrock was proven by coring in all boreholes. Information on the bedrock surface from the current investigation is summarized in the following table.

Table 5-1: Summary of Bedrock Elevations

Borehole No.	Depth to Bedrock below Existing Ground Surface (m)	Bedrock Elevation (m)
18-1	5.7	316.6
18-2	11.8	314.9
18-3	13.0	314.2
18-4	5.6	315.4

The bedrock core samples consisted of slightly weathered to fresh granite. The Total Core Recovery (TCR) from all core samples ranged from 94 to 100%, the Solid Core Recovery (SCR) ranged from 79 to 100% and the Rock Quality Designation (RQD) ranged from 70 to 100%. Based on the measured RQD values, the bedrock is classified as fair to excellent in quality, but predominantly good to excellent (Table 3.10, Canadian Foundation and Engineering Manual 2006).

Unconfined Compressive Strength (UCS) testing was carried out on one sample of the intact bedrock. The result of UCS testing was 88 MPa, indicating the intact granite bedrock to be strong. Photographs of the bedrock core are provided in Appendix C.

5.7 Groundwater

Representative water levels could not be recorded in the open boreholes due to water continuously being introduced into the borehole as part of the drilling operations. The groundwater level measured in the standpipe piezometer installed in Borehole 18-4, 10 days after installation was recorded at a depth of 1.2 m below the ground surface

(elev. 319.8 m) on September 29, 2018. The culvert was dry during the time of the field investigation.

These observations are considered short term and it should be noted that the groundwater level at the time of construction may 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.

5.8 Analytical Testing

Two samples from the native soils encountered at the site were submitted for analysis of pH, water soluble sulphate and chloride concentrations, and resistivity. The analysis results are summarized in the Table 5-2. A copy of the test results is provided in Appendix C.

Table 5-2: Results of Chemical Analysis

Borehole (Sample)	Depth ^(*) (mbgs)	Sulphate (µg/g)	pH (-)	Resistivity (Ohm-cm)	Conductivity (uS/cm)	Chloride (µg/g)	Sulphide (%)
18-1 (SS3B)	1.5 – 1.8	24	5.32	2,610	383	236	<0.02
18-4 (SS3)	1.2 – 1.8	7	6.22	4,450	225	124	<0.02

6 MISCELLANEOUS

Borehole locations were selected by Thurber relative to existing site features and the anticipated culvert location. The as-drilled locations and ground surface elevation of the boreholes were measured by Thurber following completion of the drilling. Elevation benchmarks were provided by MPCE.

George Downing Estate Drilling Ltd. and Forage M3 Drilling Services Inc., both of Hawksbury, Ontario, supplied and operated the drilling equipment to conduct the drilling, soil sampling, in-situ testing, standpipe installation and borehole decommissioning. NC Traffic Management Inc. of Kirkland Lake, Ontario supplied the traffic control equipment and personnel for lane closures required for the field work. The field investigation was supervised on a full time basis by Miss Allison Chow, EIT and Mr. Sean O'Bryan, C.E.T. of Thurber. Overall supervision of the investigation was provided by Miss Katya Edney, P.Eng.

Routine geotechnical laboratory testing was completed by Thurber's laboratory in Ottawa, Ontario. UCS testing was completed by Stantec's laboratory in Ottawa, Ontario. Analytical testing was completed by Paracel 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.

for *F.J.G.*

Katya Edney, P.Eng.
Geotechnical Engineer



Dr. Fred Griffiths, P.Eng.
Senior Associate
Senior Geotechnical Engineer



Stephen Peters, P.Eng.
Geotechnical Engineer

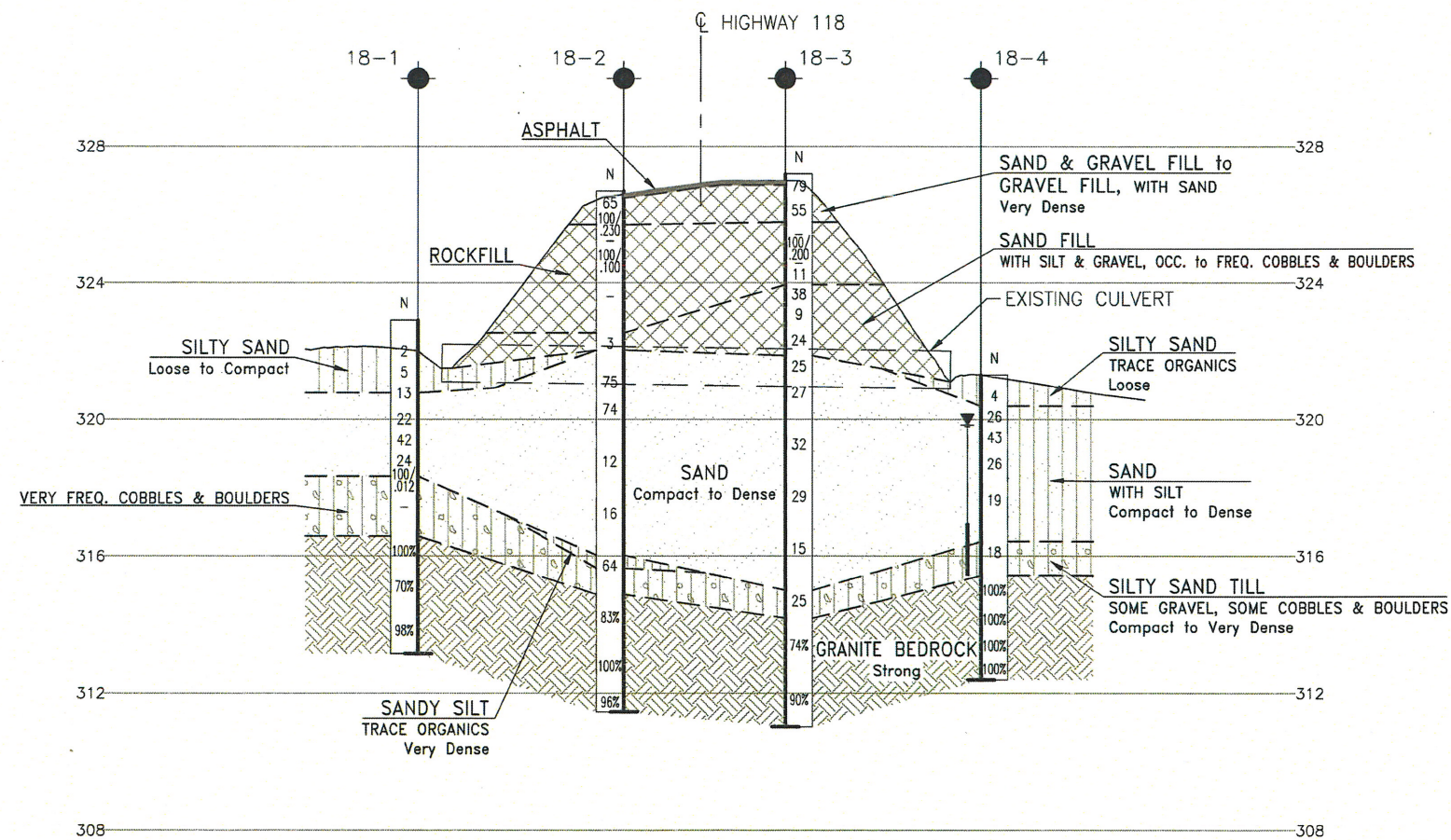
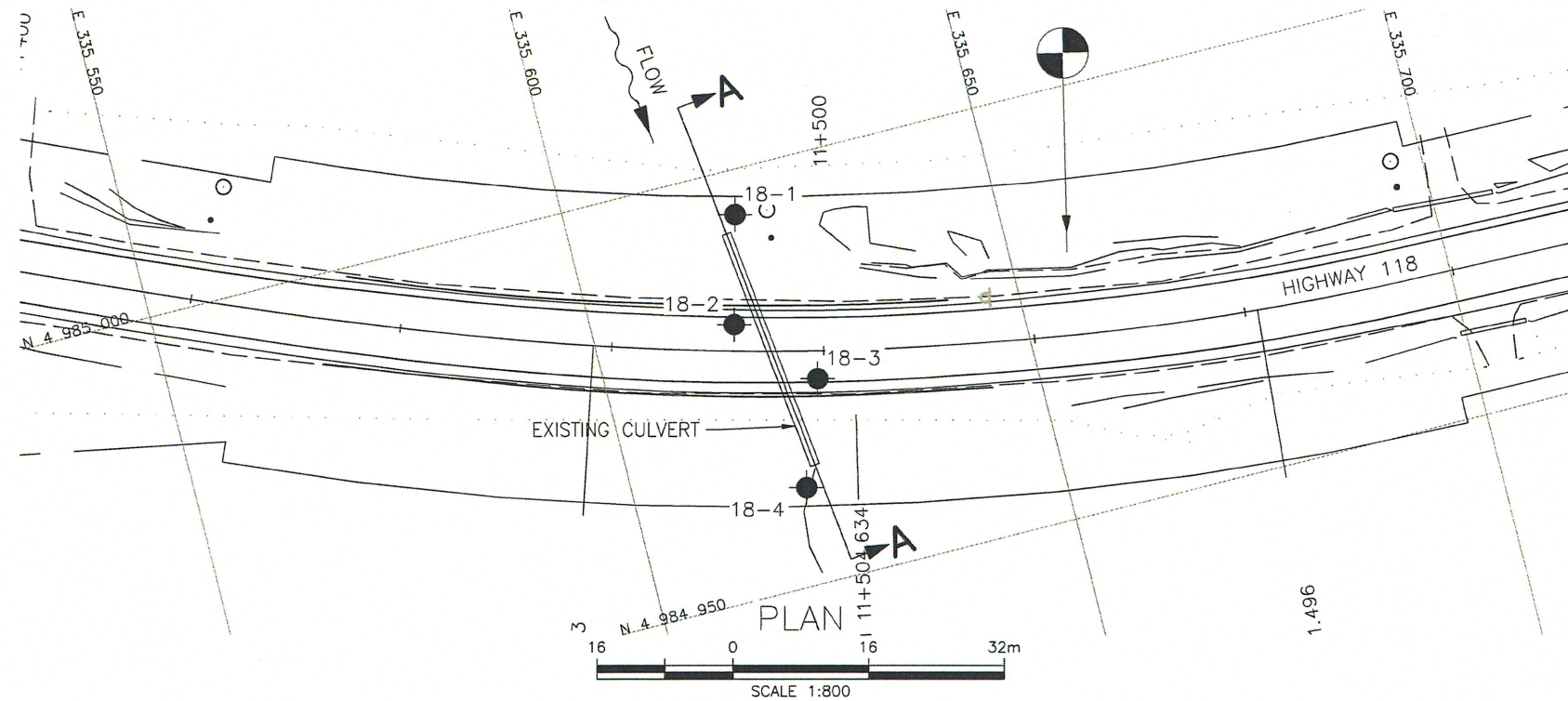


Dr. P.K. Chatterji, P.Eng.
Review Principal
Senior Geotechnical Engineer

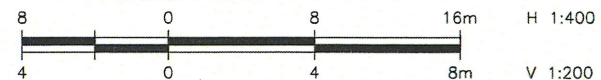


Appendix A.

Borehole Location Plan and Stratigraphic Drawing



SECTION A-A



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



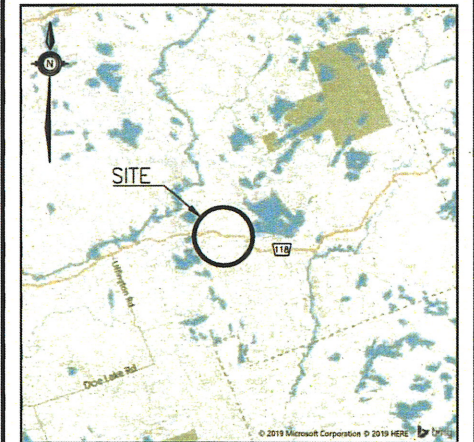
CONT No
GWP No 5287-14-00

HIGHWAY 118
STATION 11+494
CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

McINTOSH PERRY








THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
18-1	322.3	4 984 994.7	335 619.8
18-2	326.7	4 984 982.2	335 616.5
18-3	327.2	4 984 973.6	335 624.5
18-4	321.0	4 984 961.5	335 620.1

-NOTES-

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- 3) Coordinate system is MTM NAD 83 Zone 10.

GEOCRES No. 31E-397

[illegible]



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
COARSE GRAINED SOIL	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	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 of silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of high plasticity, organic silts.
HIGHLY ORGANIC SOILS		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# 5287-14-00 LOCATION Lat: 45.004269°, Long: -79.109051°
St. 11+494 N 4 984 994.7 E 335 619.8 ORIGINATED BY SOB
HWY 118 BOREHOLE TYPE Portable NWT Washboring COMPILED BY AC
DATUM Geodetic DATE 16.09.2018 - 17.09.2018 CHECKED BY KE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
								20 40 60 80 100	○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE			W _P W W _L				
322.9																
0.0	STAND															
322.3																
0.6	SILTY SAND (SM) with organics very loose to compact brown		1	SS	2		322								0 65 30 5 non-plastic	
			2	SS	5											
			3	SS	13											
320.8	SAND (SP) compact to dense brown														0 97 3 (SI+CL)	
2.1			4	SS	22		320									
			5	SS	42											
			6	SS	24		319									
318.3			7	SS	100/											
4.6	SAND TILL cobbles and boulders very dense grey															
			8	NQ	-		318									
							317									
316.6																
6.3	BEDROCK GRANITE fresh medium to coarse grained strong grey with red seams		1	RUN			316								RUN #1 TCR=100% SCR=100% RQD=100% RUN #2 TCR=94% SCR=79% RQD=70% UCS=88.4MPa RUN #3 TCR=98% SCR=87% RQD=98%	
			2	RUN			315									
			3	RUN			314									
313.1																
9.8	End of Borehole															

DOUBLE LINE ST 11+490.GPJ 2012TEMPLATE(MTO).GDT 21/8/19

Continued Next Page

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

RECORD OF BOREHOLE No 18-1

2 OF 2

METRIC

GWP# 5287-14-00 LOCATION Lat: 45.004269°, Long: -79.109051°
St. 11+494 N 4 984 994.7 E 335 619.8 ORIGINATED BY SOB
HWY 118 BOREHOLE TYPE Portable NWT Washboring COMPILED BY AC
DATUM Geodetic DATE 16.09.2018 - 17.09.2018 CHECKED BY KE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page																
	A half-weight (32 kg) drop hammer was used to advance the split-spoon sampler. The N values presented have been adjusted to provide an equivalent N value that would have been obtained with a standard 64 kg hammer.																

DOUBLE LINE ST 11+490.GPJ 2012TEMPLATE(MTO).GDT 21/8/19

RECORD OF BOREHOLE No 18-2

1 OF 2

METRIC

GWP# 5287-14-00 LOCATION Lat: 45.004157°, Long: -79.109093° St. 11+494 N 4 984 982.2 E 335 616.5 ORIGINATED BY AC
 HWY 118 BOREHOLE TYPE NW Washboring COMPILED BY AC
 DATUM Geodetic DATE 16.09.2018 - 16.09.2018 CHECKED BY KE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				GR	SA	SI	CL
326.7								20	40	60	80	100							
0.0																			
0.1	ASPHALT (100 mm)																		
	SAND with gravel to GRAVEL with sand very dense brown to grey-brown FILL		1	SS	65														
325.7			2	SS	100/														
1.0	ROCKFILL 0.9 m boulder at 1 m				230 mm														
			3	NQ	-														
			4	SS	100/														
					100 mm														
			5	NQ	-														
322.5																			
4.2	SAND with silt and gravel occasional cobbles and boulders very loose red-brown FILL		6	SS	3														
322.0																			
4.7	SAND (SP-SM) with silt very dense red-brown																		
			7	SS	75														
			8	SS	74														
319.1																			
7.6	SAND (SP) compact grey to grey-brown		9	SS	12														
			10	SS	16														
			</																

Continued Next Page

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

RECORD OF BOREHOLE No 18-2

2 OF 2

METRIC

GWP# 5287-14-00 LOCATION Lat: 45.004157°, Long: -79.109093°
St. 11+494 N 4 984 982.2 E 335 616.5 ORIGINATED BY AC
HWY 118 BOREHOLE TYPE NW Washboring COMPILED BY AC
DATUM Geodetic DATE 16.09.2018 - 16.09.2018 CHECKED BY KE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
	Continued From Previous Page													
316.0	SAND (SP) compact grey to grey-brown													
10.7	SANDY SILT (ML) trace organics very dense													
315.7	grey		11	SS	64									
11.0	SAND (SP-SM) with silt and gravel TILL very dense													
314.9	grey													
11.8	BEDROCK GRANITE fresh medium grained strong grey with black and pink		1	RUN										
			2	RUN										
			3	RUN										
311.5														
15.2	End of Borehole													

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

RECORD OF BOREHOLE No 18-3

1 OF 2

METRIC

GWP# 5287-14-00 LOCATION Lat: 45.004081°, Long: -79.108992°
St. 11+494 N 4 984 973.6 E 335 624.5 ORIGINATED BY AC
HWY 118 BOREHOLE TYPE NW Washboring COMPILED BY AC
DATUM Geodetic DATE 15.09.2018 - 15.09.2018 CHECKED BY KE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				GR	SA	SI	CL
								20 40 60 80 100				w _p w w _L							
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE											
327.2																			
0.0																			
0.1																			

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 18-3

2 OF 2

METRIC

GWP# 5287-14-00 LOCATION Lat: 45.004081°, Long: -79.108992° St. 11+494 N 4 984 973.6 E 335 624.5 ORIGINATED BY AC
 HWY 118 BOREHOLE TYPE NW Washboring COMPILED BY AC
 DATUM Geodetic DATE 15.09.2018 - 15.09.2018 CHECKED BY KE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	W _P W W _L	WATER CONTENT (%)						
								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								
	Continued From Previous Page							20 40 60 80 100				20 40 60		GR SA SI CL		
315.0	SAND (SP-SM) with silt compact to dense brown to grey		14	SS	15		317							FI	11 73 16 (SI+CL)	
							316									
12.2			SILTY SAND (SM) some gravel TILL compact grey		15	SS	25		315							
314.2																
13.0	BEDROCK GRANITE fresh to slightly weathered medium to coarse grained strong grey with black and pink		1	RUN			314						5	RUN #1 TCR=100% SCR=89% RQD=74%		
							313						1			
													3			
													2			
					2	RUN		312							2	
311.0													0	RUN #2 TCR=100% SCR=90% RQD=90%		
												0				
												0				
16.2	End of Borehole															





DOUBLE LINE ST 11+490.GPJ 2012TEMPLATE(MTO).GDT 21/8/19

RECORD OF BOREHOLE No 18-4

1 OF 2

METRIC

GWP# 5287-14-00 LOCATION Lat: 45.003971°, Long: -79.109048°
St. 11+494 N 4 984 961.5 E 335 620.1 ORIGINATED BY SOB
HWY 118 BOREHOLE TYPE Portable NWT Washboring COMPILED BY AC
DATUM Geodetic DATE 28.09.2018 - 29.09.2018 CHECKED BY KE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100						
321.3														
0.0	STAND													
321.0														
0.3	SILTY SAND (SM) trace organics very loose brown		1	SS	4		321							0 69 25 6 non-plastic
320.4														
0.9	SAND (SP-SM) with silt compact to dense brown		2	SS	26		320							0 91 9 (SI+CL)
			3	SS	43									
			4	SS	26		319							
			5	SS	19		318							
							317							
316.4														
4.9	SILTY SAND (SM) TILL occasional cobbles and boulders compact grey		6	SS	18		316							0 81 19 (SI+CL)
315.4														
5.9	BEDROCK GRANITE fresh coarse grained strong grey and pink		1	RUN			315							RUN #1 TCR=100% SCR=100% RQD=100%
			2	RUN			314							RUN #2 TCR=100% SCR=100% RQD=100%
			3	RUN										RUN #3 TCR=100% SCR=100% RQD=100%
			4	RUN			313							RUN #4 TCR=100% SCR=100% RQD=100%
312.4														
8.9	End of Borehole													
	A half-weight (32 kg) drop hammer was used to advance the split-spoon sampler. The N values presented have been adjusted to provide an equivalent N value that would have been obtained with a standard 64 kg hammer.													

Continued Next Page

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

RECORD OF BOREHOLE No 18-4

2 OF 2

METRIC

GWP# 5287-14-00 LOCATION Lat: 45.003971°, Long: -79.109048°
St. 11+494 N 4 984 961.5 E 335 620.1 ORIGINATED BY SOB
HWY 118 BOREHOLE TYPE Portable NWT Washboring COMPILED BY AC
DATUM Geodetic DATE 28.09.2018 - 29.09.2018 CHECKED BY KE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
	Continued From Previous Page													
	Water level in 19 mm diameter standpipe: 29/09/2018 at 1.2 mbgs (el. 319.8 m)													

DOUBLE LINE ST 11+490.GPJ 2012TEMPLATE(MTO).GDT 21/8/19



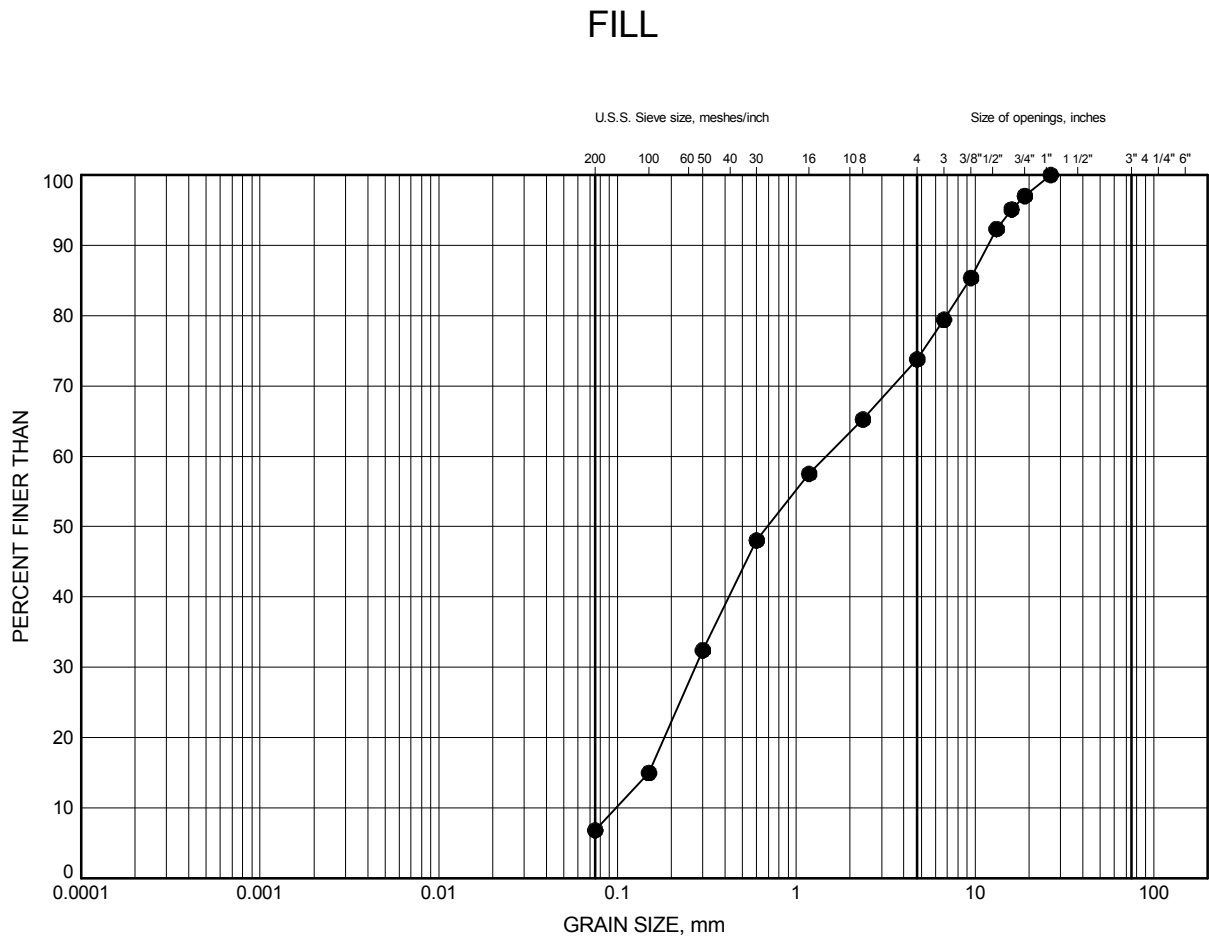
Appendix C.
Laboratory Testing



Appendix C.1
Particle Size Analysis Figures

HWY 118 Culverts Station 11+494 GRAIN SIZE DISTRIBUTION

FIGURE C1



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-3	3.5	323.7

Date ..October 2018.....
 GWP# ..5287-14-00.....

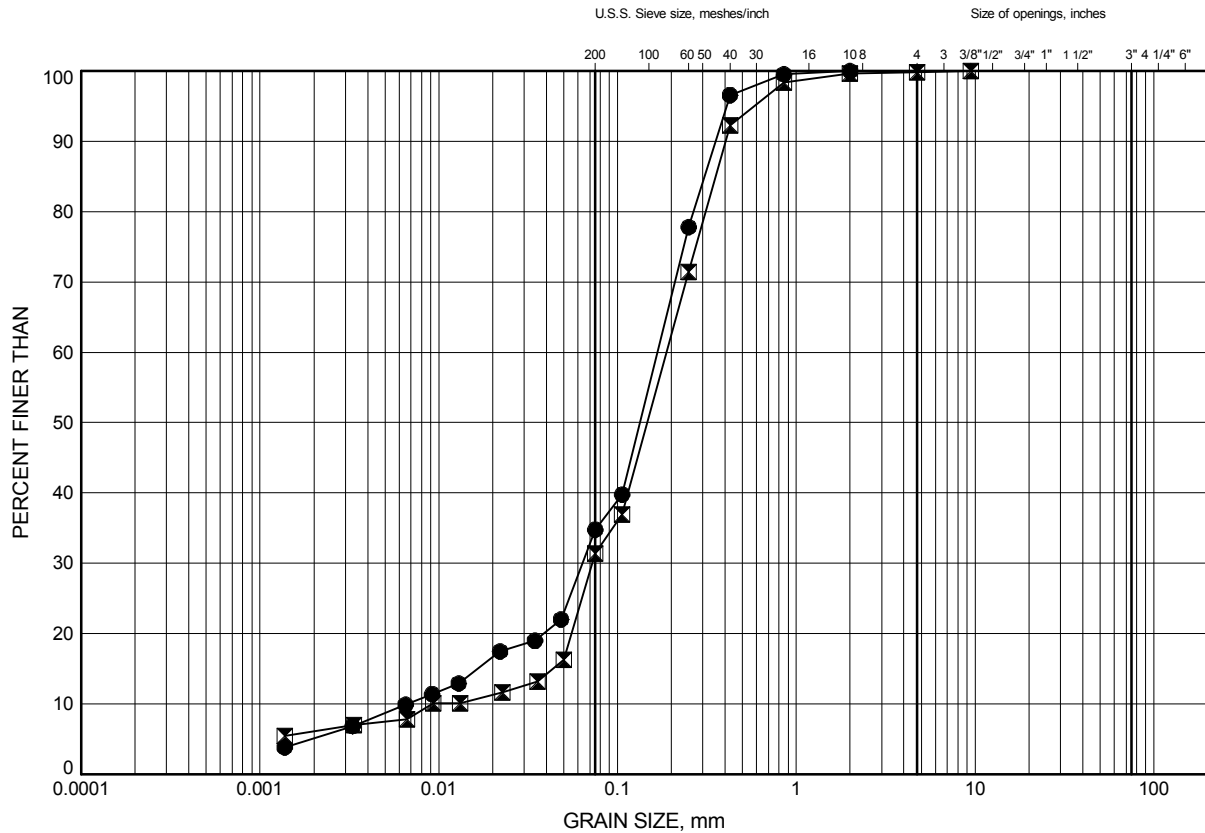


Prep'dAC.....
 Chkd.KE.....

HWY 118 Culverts Station 11+494 GRAIN SIZE DISTRIBUTION

FIGURE C2

SILTY SAND (SM) with organics



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-1	0.9	321.4
⊠	18-4	0.3	320.7

Date ..October 2018.....

GWP# ..5287-14-00.....



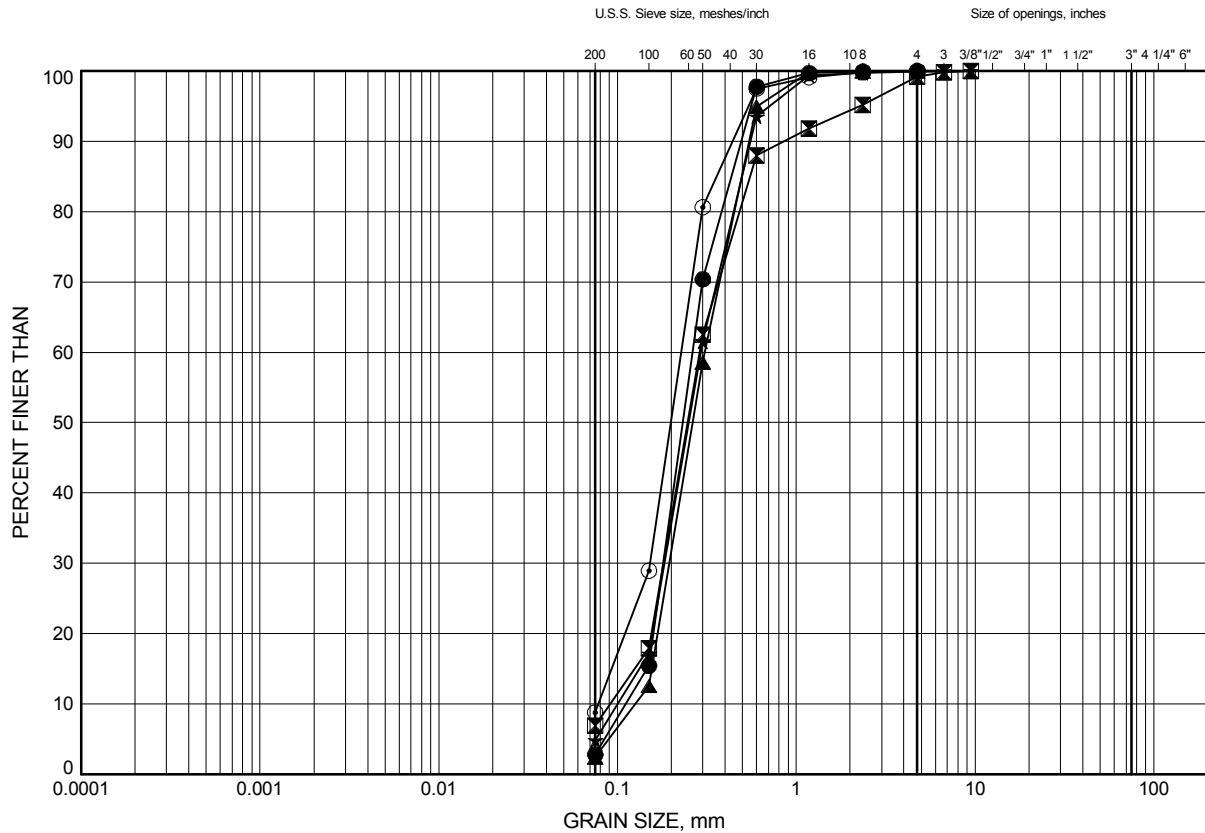
Prep'dAC.....

Chkd.KE.....

HWY 118 Culverts Station 11+494 GRAIN SIZE DISTRIBUTION

FIGURE C3

SAND (SP to SP-SM)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-1	2.9	319.4
⊠	18-2	5.6	321.1
▲	18-2	9.4	317.3
★	18-3	6.4	320.8
⊙	18-4	0.9	320.1

Date ..October 2018.....

GWP# ..5287-14-00.....



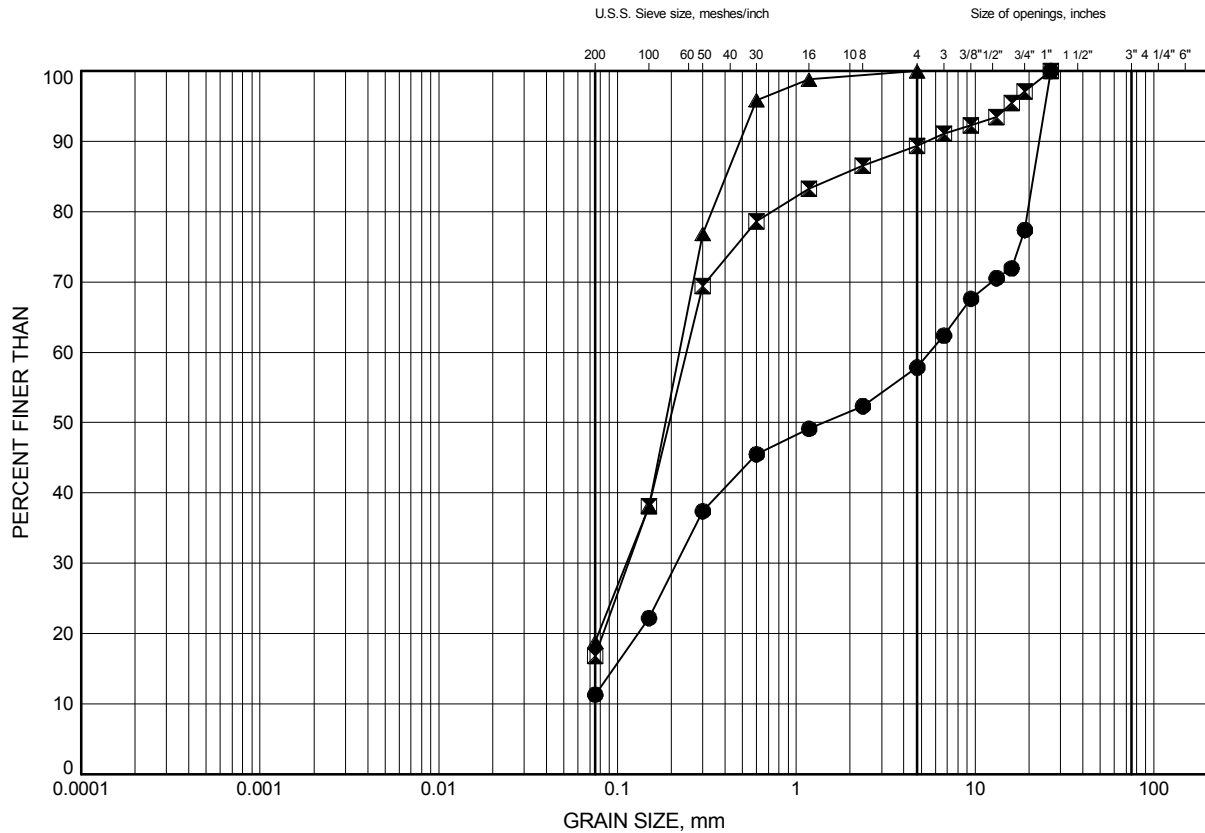
Prep'dAC.....

Chkd.KE.....

HWY 118 Culverts Station 11+494 GRAIN SIZE DISTRIBUTION

FIGURE C4

SAND (SP-SM) to SILTY SAND (SM) (TILL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-2	11.2	315.5
⊠	18-3	12.5	314.7
▲	18-4	4.9	316.1

Date ..October 2018.....
 GWP# ..5287-14-00.....



Prep'dAC.....
 Chkd.KE.....



Appendix C.2
Rock Core Photos
Rock Core Testing Results

Borehole 18-1
Run 1 to 3 (of 3)
Elevation 316.6 m to 313.2 m



THURBER ENGINEERING LTD.

Foundation Investigation
Hwy 118 Culverts St. 11+494
Foundations

GWP: 5287-14-00

Project No.: 20244

Borehole 18-2
Run 1 to 3 (of 3)
Elevation 314.9 m to 311.5 m



THURBER ENGINEERING LTD.

Foundation Investigation
Hwy 118 Culverts St. 11+494
Foundations

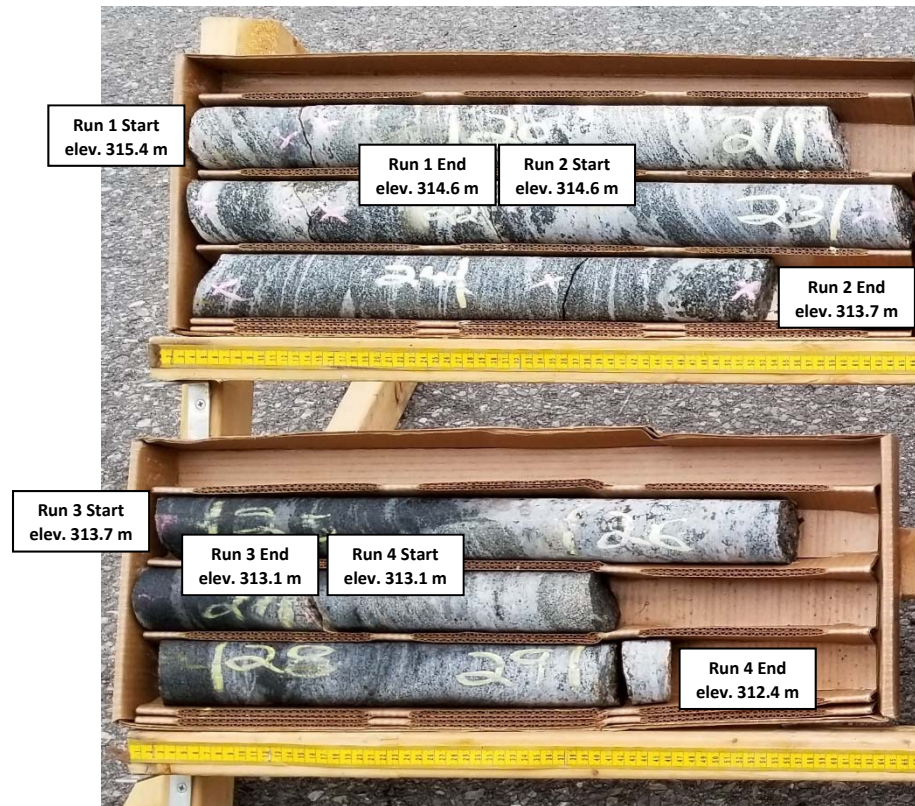
GWP: 5287-14-00

Project No.: 20244

Borehole 18-3
Run 1 to 2 (of 2)
Elevation 314.2 m to 311.0 m



Borehole 18-4
Run 1 to 4 (of 4)
Elevation 315.4 m to 312.4 m





Stantec

Stantec Consulting Ltd
2781 Lancaster Rd, Suite 100 A&B
Ottawa, ON K1B 1A7
Tel: (613) 738-6075
Fax: (613) 722-2799

October 17, 2018
File: 122410864

Attention: Thurber Engineering Ltd., File #20244

Reference: ASTM D7012, Method C, Unconfined Compressive Strength of Intact Rock Core

The table below summarizes five (5) rock core unconfined compressive strength results.

Location	Sample Depth	Compressive Strength (MPa)	Description of Break
18+550, 18-2 Run-1	26'1"-27'1"	115.0	Diagonal Fracture with no cracking through ends
18+550, 18-4 Run-1	11'6"-12'1"	141.6	Well-formed cone on one end. Vertical crack, no well-defined cone on the other end
18+875, 18-1 Run-2	7'7"-8'1"	127.8	Well-formed cone on one end. Vertical crack, no well-defined cone on the other end
18+875, 18-4 Run-1	7'2"-7'9"	76.2	Columnar vertical crack through both ends, no well-defined cones
11+490, 18-1 Run-2	23'7"-24'3"	88.4	Columnar vertical crack through both ends, no well-defined cones

Sincerely,

Stantec Consulting Ltd

Brian Prevost

Brian Prevost
Laboratory Supervisor
Tel: 613-738-6075
brian.prevost@stantec.com



Appendix C.3

Analytical Testing Results

Certificate of Analysis

Thurber Engineering Ltd.

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

Client PO: 20244
Project: Hwy 11+118
Custody: 39862

Report Date: 28-Sep-2018
Order Date: 24-Sep-2018

Order #: 1839096

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

Paracel ID	Client ID
1839096-01	18+250 18-1 SS3 6-8'
1839096-02	18+250 18-4 SS3 5'6"-7-6"
1839096-03	18+875 18-2 SS8 17'6"-19'6"
1839096-04	11+490 18-01 SS3B 7-8'

Depths provided in results are measured from the top of the drilling platform not shown in the Record of Borehole Sheets. Platform height measured 0.6 and 0.3 m for Boreholes 18-1 and 18-4, respectively.

Approved By:



Mark Foto, M.Sc.
Lab Supervisor

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 20244

Report Date: 28-Sep-2018
Order Date: 24-Sep-2018
Project Description: Hwy 11+118

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	26-Sep-18	26-Sep-18
Conductivity	MOE E3138 - probe @25 °C, water ext	27-Sep-18	27-Sep-18
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	27-Sep-18	27-Sep-18
Resistivity	EPA 120.1 - probe, water extraction	27-Sep-18	27-Sep-18
Solids, %	Gravimetric, calculation	27-Sep-18	27-Sep-18

Certificate of Analysis
 Client: Thurber Engineering Ltd.
 Client PO: 20244

Report Date: 28-Sep-2018

Order Date: 24-Sep-2018

Project Description: Hwy 11+118

Client ID:	18+250 18-1 SS3 6-8'	18+250 18-4 SS3 5'6"-7-6"	18+875 18-2 SS8 17'6"-19'6"	11+490 18-01 SS3B 7-8'
Sample Date:	09/12/2018 09:00	09/14/2018 09:00	09/19/2018 09:00	09/16/2018 09:00
Sample ID:	1839096-01	1839096-02	1839096-03	1839096-04
MDL/Units	Soil	Soil	Soil	Soil

Physical Characteristics

% Solids	0.1 % by Wt.	79.4	79.6	80.3	82.1
----------	--------------	------	------	------	------

General Inorganics

Conductivity	5 uS/cm	227	243	1340	383
pH	0.05 pH Units	5.86	5.11	4.82	5.32
Resistivity	0.10 Ohm.m	44.1	41.1	7.45	26.1

Anions

Chloride	5 ug/g dry	40	104	1260	236
Sulphate	5 ug/g dry	129	62	70	24

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 20244

Report Date: 28-Sep-2018
Order Date: 24-Sep-2018
Project Description: Hwy 11+118

Method Quality Control: Blank

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

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 20244

Report Date: 28-Sep-2018
Order Date: 24-Sep-2018
Project Description: Hwy 11+118

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	22.3	5	ug/g dry	23.2			4.1	20	
Sulphate	15.1	5	ug/g dry	15.6			3.3	20	
General Inorganics									
Conductivity	211	5	uS/cm	204			3.1	6.2	
pH	7.90	0.05	pH Units	7.93			0.4	10	
Resistivity	47.5	0.10	Ohm.m	48.9			3.1	20	
Physical Characteristics									
% Solids	79.2	0.1	% by Wt.	79.5			0.4	25	

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 20244

Report Date: 28-Sep-2018
Order Date: 24-Sep-2018
Project Description: Hwy 11+118

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	117	5	ug/g	23.2	93.8	78-113			
Sulphate	120	5	ug/g	15.6	104	78-111			

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 20244

Report Date: 28-Sep-2018
Order Date: 24-Sep-2018
Project Description: Hwy 11+118

Qualifier Notes:

None

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 EdneyTel: (613) 247-2121
Fax: (613) 247-2185Paracel Report No **1839096**Client Project(s): **Hwy 11+118**Client PO: **20244**Reference: **Standing Offer**CoC Number: **39862**Order Date: 24-Sep-18
Report Date: 27-Sep-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
1839096-01	18+250 18-1 SS3 6-8'	Sulphide, solid
1839096-02	18+250 18-4 SS3 5'6"-7-6"	Sulphide, solid
1839096-03	18+875 18-2 SS8 17'6"-19'6"	Sulphide, solid
1839096-04	11+490 18-01 SS3B 7-8'	Sulphide, solid

**SGS Canada Inc.**

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

Paracel Laboratories

Attn : Dale Robertson

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

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

27-September-2018

Date Rec. : 25 September 2018
LR Report: CA13421-SEP18
Reference: Project#: 1839096

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Sample ID	Sample Date & Time	Sulphide %
1: Analysis Start Date		27-Sep-18
2: Analysis Start Time		12:40
3: Analysis Completed Date		27-Sep-18
4: Analysis Completed Time		13:39
5: QC - Blank		< 0.02
6: QC - STD % Recovery		83%
7: QC - DUP % RPD		ND
8: RL		0.02
9: 18+250 18-1 SS3 6-8'	12-Sep-18	< 0.02
10: 18+250 18-4 SS3 5'6"-7-6"	14-Sep-18	< 0.02
11: 18+875 18-2 SS8 17'6-19'6"	19-Sep-18	< 0.02
12: 11+490 18-01 SS3B 7-8'	16-Sep-18	< 0.02

RL - SGS Reporting Limit
ND - Not Detected

Kimberley Didsbury
Project Specialist
Environmental Services, Analytical

Certificate of Analysis

Thurber Engineering Ltd.

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

Client PO: 20244
Project: HWY11+118
Custody: 39863

Report Date: 9-Oct-2018
Order Date: 2-Oct-2018

Order #: 1840220

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

Paracel ID	Client ID
1840220-01	18+550 18-1 SS3 5'6"-6'2"
1840220-02	18+550 18-4 SS2 3-5
1840220-03	18+875 18-4 SS1 2'6"-4'6"
1840220-04	11+490 18-4 SS3 5-7
1840220-05	22+590 18-1 SS2 4-6
1840220-06	22+590 18-4 SS3 6-8'

Depths provided in results are measured from the top of the drilling platform not shown in the Record of Borehole Sheets. Platform height measured 0.6 and 0.3 m for Boreholes 18-1 and 18-4, respectively.

Approved By:



Mark Foto, M.Sc.
Lab Supervisor

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 20244

Report Date: 09-Oct-2018

Order Date: 2-Oct-2018

Project Description: HWY11+118

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	5-Oct-18	5-Oct-18
Conductivity	MOE E3138 - probe @25 °C, water ext	4-Oct-18	5-Oct-18
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	5-Oct-18	5-Oct-18
Resistivity	EPA 120.1 - probe, water extraction	4-Oct-18	5-Oct-18
Solids, %	Gravimetric, calculation	3-Oct-18	3-Oct-18

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Client ID:	18+550 18-1 SS3 5'6"-6'2"	18+550 18-4 SS2 3-5	18+875 18-4 SS1 2'6"-4'6"	11+490 18-4 SS3 5-7
Sample Date:	09/23/2018 09:00	09/22/2018 09:00	09/20/2018 09:00	09/28/2018 09:00
Sample ID:	1840220-01	1840220-02	1840220-03	1840220-04
MDL/Units	Soil	Soil	Soil	Soil

Physical Characteristics

% Solids	0.1 % by Wt.	85.4	79.7	90.5	82.8
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General Inorganics

Conductivity	5 uS/cm	347	117	124	225
pH	0.05 pH Units	7.47	5.65	6.26	6.22
Resistivity	0.10 Ohm.m	28.8	85.1	80.9	44.5

Anions

Chloride	5 ug/g dry	211	55	19	124
Sulphate	5 ug/g dry	10	21	6	7

Client ID:	22+590 18-1 SS2 4-6	22+590 18-4 SS3 6-8'	-	-
Sample Date:	09/25/2018 09:00	09/26/2018 09:00	-	-
Sample ID:	1840220-05	1840220-06	-	-
MDL/Units	Soil	Soil	-	-

Physical Characteristics

% Solids	0.1 % by Wt.	86.5	85.5	-	-
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General Inorganics

Conductivity	5 uS/cm	302	15	-	-
pH	0.05 pH Units	6.44	5.59	-	-
Resistivity	0.10 Ohm.m	33.1	653	-	-

Anions

Chloride	5 ug/g dry	168	<5	-	-
Sulphate	5 ug/g dry	11	<5	-	-

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Method Quality Control: Blank

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

Certificate of Analysis
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Order Date: 2-Oct-2018

Project Description: HWY11+118

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	205	5	ug/g dry	211			2.7	20	
Sulphate	9.29	5	ug/g dry	9.98			7.2	20	
General Inorganics									
Conductivity	364	5	uS/cm	347			4.6	6.2	
pH	11.69	0.05	pH Units	11.61			0.7	10	
Resistivity	27.5	0.10	Ohm.m	28.8			4.6	20	
Physical Characteristics									
% Solids	90.9	0.1	% by Wt.	94.3			3.8	25	

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 20244

Report Date: 09-Oct-2018

Order Date: 2-Oct-2018

Project Description: HWY11+118

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	308	5	ug/g	211	97.2	78-113			
Sulphate	110	5	ug/g	9.98	100	78-111			

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 20244

Report Date: 09-Oct-2018
Order Date: 2-Oct-2018
Project Description: HWY11+118

Qualifier Notes:

None

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 **1840220**Client Project(s): **HWY11+118**Client PO: **20244**Reference: **Standing Offer**CoC Number: **39863**

Order Date: 02-Oct-18

Report Date: 9-Oct-18

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

Parcel ID	Client ID	Analysis
1840220-01	18+550 18-1 SS3 5'6"-6'2"	Sulphide, solid
1840220-02	18+550 18-4 SS2 3-5	Sulphide, solid
1840220-03	18+875 18-4 SS1 2'6"-4'6"	Sulphide, solid
1840220-04	11+490 18-4 SS3 5-7	Sulphide, solid
1840220-05	22+590 18-1 SS2 4-6	Sulphide, solid
1840220-06	22+590 18-4 SS3 6-8'	Sulphide, solid

**SGS Canada Inc.**

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

Paracel Laboratories

Attn : Dale Robertson

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

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

10-October-2018

Date Rec. : 04 October 2018
LR Report: CA12131-OCT18
Reference: Project#:1840220

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Sample ID	Sample Date & Time	Sulphide %
1: Analysis Start Date		05-Oct-18
2: Analysis Start Time		13:35
3: Analysis Completed Date		05-Oct-18
4: Analysis Completed Time		14:36
5: QC - Blank		< 0.02
6: QC - STD % Recovery		99%
7: QC - DUP % RPD		1%
8: RL		0.02
9: 18+550 18-1 SS3 5'6"-6'2"	23-Sep-18	< 0.02
10: 18+550 18-4 SS2 3-5	22-Sep-18	< 0.02
11: 18+875 18-4 SS1 2'6"-4'6"	20-Sep-18	< 0.02
12: 11+490 18-4 SS3 5-7	28-Sep-18	< 0.02
13: 22+590 18-1 SS2 4-6	25-Sep-18	< 0.02
14: 22+590 18-4 SS3 6-8'	26-Sep-18	< 0.02

RL - SGS Reporting Limit

Kimberley Didsbury
Project Specialist
Environmental Services, Analytical



Appendix D.

Site Photographs



Photo 1. Looking West along HWY 118 at St. 11+494 (2018/09/15)



Photo 2. Looking East along HWY 118 at St. 11+494 (2018/09/15)



Photo 3. St. 11+494 - Looking Southwest at Culvert Inlet (2018/09/11)



Photo 4. Looking East along northern embankment of HWY 118 (2018/09/11)



Photo 5. Drilling Platform Set Up for Borehole 18-1 at St. 11+494 (2018/09/16)



Photo 6. Looking North at Culvert Outlet at St. 11+494 (2018/09/11)