

**PRELIMINARY FOUNDATION INVESTIGATION REPORT
HIGHWAY 527 WABINOSH RIVER CULVERT
99.6 KM NORTH OF ON-811, THUNDER BAY UNORGANIZED
SITE NO.: 48C-124/C
ASSIGNMENT NO. 6017-E-0013**

G.W.P. 6829-14-00

Geocres No.: 52H-46

Report to:

Hatch Corporation

Latitude: 50.131523°
Longitude: -89.124399°

December 2018
Thurber File: 19773

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**G.W.P. 6829-14-00
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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 for Wabinoash River Culvert on Highway 527. The culvert is located approximately 99.6 km north of Tertiary Highway 811 within the Unorganized Thunder Bay District and conveys the Wabinoash River to between Nameiben Lake and Waweig Lake. Thurber Engineering Limited (Thurber) carried out the current investigation as a sub-consultant to Hatch Corporation (Hatch) under Assignment No. 6017-E-0013.

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.

2 SITE DESCRIPTION

The existing culvert, conveying the Wabinoash River under Highway 527 from Nameiben Lake to Waweig Lake, is a Steel Plate Corrugated Steel Pipe Arch (SPCSPA) culvert with an unknown construction date. A site survey plan from Hatch indicates that the culvert is approximately 6.3 m wide, 3.9 m high and approximately 18.9 m long at the obvert and 26.8 m long at the invert. The culvert alignment is generally northwest to southeast with the flow through the culvert toward the southeast.

At the location of the culvert, Highway 527 is a two-lane highway with a rural cross-section and narrow gravel shoulders. Steel cable guide rails are present along both sides of the highway in the area of the culvert. The embankment fill height above the culvert is approximately 1.6 m. The elevation of the road surface at the centreline is approximately 317.4 m. The existing embankment slopes are inclined approximately 1.9H:1V to 2H:1V. The land adjacent to the highway is undeveloped and densely vegetated with trees. The traffic volume for this section of Highway 527 is understood to be 230 AADT (2016).

Photographs showing the existing conditions in the area of the culvert are included in Appendix D for reference.

3 SITE INVESTIGATION AND FIELD TESTING

Thurber contacted Ontario One Call in advance of the field investigation to obtain utility locate clearances in the vicinity of the intended boreholes.

The site investigation and field testing program was carried out between June 9th and August 10th, 2018. The northing, easting and elevation of the boreholes are shown on the Borehole Location and Soil Strata Drawing No. 1 in Appendix A and are summarized in Table 3-1. The site is within MTM Zone 15.

Table 3-1: Borehole Summary

Borehole No.	Drilled Location	Northing (m)	Easting (m)	Ground Surface Elevation (m)	Termination Depth (m)
18-501	North of culvert – SB Lane	5 555 280.8	367 398.5	317.4	12.8
18-502	South of culvert – NB Lane	5 555 271.8	367 395.9	317.4	9.8
18-503	East end – culvert outlet	5 555 263.7	367 402.5	312.5	2.6
18-504*	West end – culvert inlet	5 555 301.1	367 390.4	313.7	1.4

** - Five attempts were made to drill this borehole due to the frequent boulders present. None of the other attempts penetrated deeper than 0.9 m.*

The drilling was carried out using a truck mounted CME 75 drill rig for on-road Boreholes 18-501 and 18-502 and portable drilling equipment for off-road Boreholes 18-503 and 18-504.

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). Borehole 18-503, which was drilled with portable equipment, utilized a quarter-weight hammer for SPT testing due to difficult site access conditions. The N-values presented on the Record of Borehole sheet for Borehole 18-503 have been corrected to provide an estimate of the N-value that would have been obtained with a standard 64 kg hammer. Borehole 18-504, which was also drilled with portable equipment, utilized a full-weight hammer for SPT testing.

A 19 mm diameter standpipe piezometer was installed in Borehole 18-503 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. All other boreholes were backfilled with a low-permeability mixture of cuttings and bentonite pellets in accordance with Ontario MOE Regulation 903 as amended. Boreholes advanced within paved areas were capped with granular fill followed by 150 mm of cold patch asphalt to reinstate the travelling surface. The piezometer installed during the investigation was decommissioned in accordance with Ontario MOE Regulation 903 on August 11th, 2018.

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

4 LABORATORY TESTING

Geotechnical laboratory testing consisted of natural moisture content determination and visual identification of all retained soil samples. Testing for grain size distribution was also carried out on selected samples to MTO and ASTM standards. Chemical analysis for determination of pH, conductivity, resistivity, sulphate and chloride concentrations was carried out on two soil samples. Chemical analysis for determination of sulphide concentration was carried out on one soil sample.

The results of the geotechnical tests are summarized on the Record of Borehole sheets included in Appendix B and all laboratory results are presented 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 Locations 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, subsurface conditions at the site consist of prime surface treatment and granular embankment fill overlying native glacial till.

5.1 Embankment Fill

5.1.1 Prime Surface Treatment

Boreholes 18-501 and 18-502 were drilled through the travelled lanes of the Highway 527 embankment and encountered a layer of prime surface treatment with a thickness of 20 mm.

5.1.2 Fill: Sand with Silt and Gravel to Gravel with Sand

Below the prime surface treatment in the on-road boreholes were layers of granular embankment fill ranging in composition from sand with silt and gravel to silty sand with gravel to gravel with sand. Frequent cobbles were noted to be present within the granular fill layers. The underside of the embankment fill ranged from 4.4 to 5.3 m below the existing roadway surface (elev. 312.1 to 313.0 m).

The SPT tests conducted in the fill gave N-values ranging from 8 blows for 300 mm of penetration to 100 blows for 125 mm of penetration indicating a relative density of loose to very dense, but typically compact to dense. Recorded moisture contents ranged from 5 to 9%.

Gradation analyses were completed on three samples of the granular fill. The grain size distribution curves for these samples are included in Figure C1 of Appendix C. The results of the tests are summarized in Table 5-1 below and are presented on the corresponding Record of Borehole sheets in Appendix B.

Table 5-1: Gradation Results for Granular Fill

Soil Particle	Percentage (%)
Gravel	30 to 64
Sand	35 to 56
Silt and Clay	1 to 14

5.2 Surficial Sand

A surficial sand deposit ranging in composition from sand some silt and gravel to sand with silt and gravel was encountered in Boreholes 18-503 and 18-504. Trace organics were noted in this layer in Borehole 18-504. The underside depths of this layer ranged from 0.4 to 2.4 m below ground surface (elev. 310.1 to 313.3 m).

SPT tests conducted in this deposit gave N-values ranging from 17 blows for 300 mm of penetration to 100 blows for 230 mm of penetration, indicating a relative density of compact to very dense. The recorded moisture contents ranged from 9 to 13%.

Gradation analyses were completed on two samples of the surficial sand layer. The grain size distribution curves are included in Figure C2 of Appendix C. The results of the tests are summarized in Table 5-2 below and are presented on the corresponding Record of Borehole sheets in Appendix B.

Table 5-2: Gradation Results for Surficial Sand

Soil Particle	Percentage (%)
Gravel	13 to 45
Sand	49 to 82
Silt and Clay	5 to 6

5.3 Gravel with Silt and Sand to Sand with Silt and Gravel (Glacial Till)

A deposit of glacial till was encountered below the embankment fill in Boreholes 18-501 and 18-502 and below the sand layer in Boreholes 18-503 and 18-504. The glacial till varies in composition from gravel with silt and sand, to gravel with sand some silt, to sand with silt and gravel. Cobbles and boulders were noted in the till in all boreholes.

Boreholes 18-502, 18-503 and 18-504 were terminated within the glacial till layer at base elevations ranging from 307.6 to 312.3 m. Within Borehole 18-501, the upper portion of glacial till consisted of gravel with silt and sand and contained frequent cobbles and boulders. This upper portion of glacial till had an underside depth of 10.1 m below the

existing ground surface (elev. 307.3 m) Below this depth the glacial till consisted of sand with silt and gravel and contained occasional cobbles. Borehole 18-501 was terminated within the lower glacial till at 12.8 m below ground surface (elev. 304.6 m).

SPT tests conducted in the upper portion of the glacial till deposit (above elev. 307.3 m) gave N-values ranging from 37 blows for 300 mm of penetration to 100 blows for 25 mm indicating a relative density of dense to very dense. Very poor sample recovery within the split spoon sampler was noted within this layer. SPT tests conducted in the glacial till below elevation 307.3 m gave N-values of 19 and 75 blows, indicating a relative density of compact to very dense. The recorded moisture contents ranged from 6 to 11%.

Gradation analyses were completed on two samples of the gravel till and two samples of the sand till. The grain size distribution curves are included in Figures C3 and C4 of Appendix C. The results of the tests are summarized in Table 5-3 below and are presented on the corresponding Record of Borehole sheets in Appendix B.

Table 5-3: Gradation Results for Glacial Till

Soil Particle	Percentage (%)	
	Gravel Till	Sand Till
Gravel	49 to 59	21 to 44
Sand	35 to 46	51 to 71
Silt	5 to 6	5 to 8

5.4 Groundwater

The water level was measured in the piezometer installed in Borehole 18-503 and in the open hole of Borehole 18-501. These measurements are presented in Table 5-4 below:

Table 5-4: Groundwater Level Observations

Borehole	Groundwater Level		Date of Measurement
	Depth (mbgs)	Elevation (m)	
18-501	4.4	313.0	June 10, 2018
18-503	0.0	312.5	August 12, 2018

The river water level was surveyed at the culvert inlet and outlet and the measured elevations are provided in Table 5-5 below:

Table 5-5: River Water Level Observations

Location	Surface Water Elevation (m)	Date of Measurement
Culvert Inlet	312.5	August 9, 2018
Culvert Outlet	312.5	August 9, 2018

These observations are considered short term and it should be noted that fluctuations of the river level and the groundwater level are to be expected. In particular, the water levels may be at a higher elevation after periods of significant and/or prolonged precipitation.

5.5 Analytical Testing

Two samples of soil were submitted to Paracel Laboratories in Ottawa, Ontario for analysis of pH, water soluble sulphate and chloride concentrations, resistivity and conductivity. One of the submitted samples was also tested for sulphide content. The analysis results are provided in Appendix C and are summarized in Table 5-6 below:

Table 5-6: Analytical Results Summary

Borehole	18-502	18-503
Sample	SS8	SS2
Depth (m)	5.3 – 5.9	0.6 – 1.2
Chloride (µg/g)	13	6
Sulphate (µg/g)	10	< 5
Sulphide (%)	< 0.02	-
pH (-)	7.1	7.4
Resistivity (Ohm-cm)	21,300	16,600
Conductivity (uS/cm)	47	60

6 MISCELLANEOUS

Borehole locations were selected in consultation with Hatch and the Ministry of Transportation relative to the existing culvert and the existing site features. The as-drilled locations and ground surface elevations were surveyed by Thurber.

George Downing Estate Drilling Ltd. of Hawkesbury, Ontario and CCC Drilling of Ottawa, Ontario supplied and operated the drilling equipment for the on-road and off-road boreholes respectively, to carry out the drilling, soil sampling, in-situ testing, piezometer installation and borehole decommissioning. Traffic control signage was provided by Thurber Engineering. The field investigation was supervised on a full-time basis by Mr. Nick Weil and Mr. Sean O'Bryan, C.E.T., of Thurber. Overall supervision of the investigation program was conducted by Mr. Stephen Dunlop, P.Eng.

Routine geotechnical laboratory testing was completed by Thurber'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 Mr. Christopher Murray, P.Eng. and Mr. Stephen Dunlop, P.Eng. The report was reviewed by Dr. Fred Griffiths, P.Eng., a Designated Principal Contact for MTO Foundation Projects.



Christopher Murray, M.A.Sc., P.Eng.
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Appendix A.

Borehole Location Plan and Stratigraphic Drawing

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

CONT No	(
GWP No 6829-14-00)



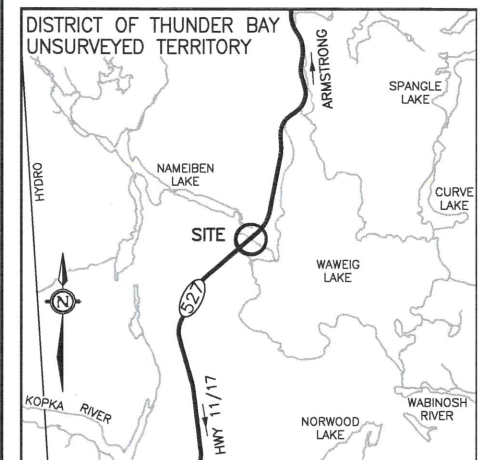
SHEET

HIGHWAY 527
WABINOSH RIVER CULVERT
REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

HATCH








THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

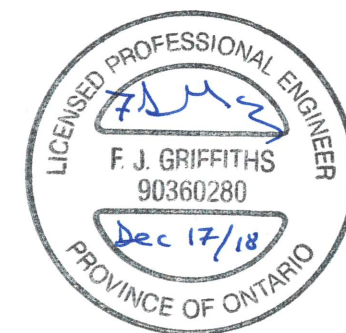
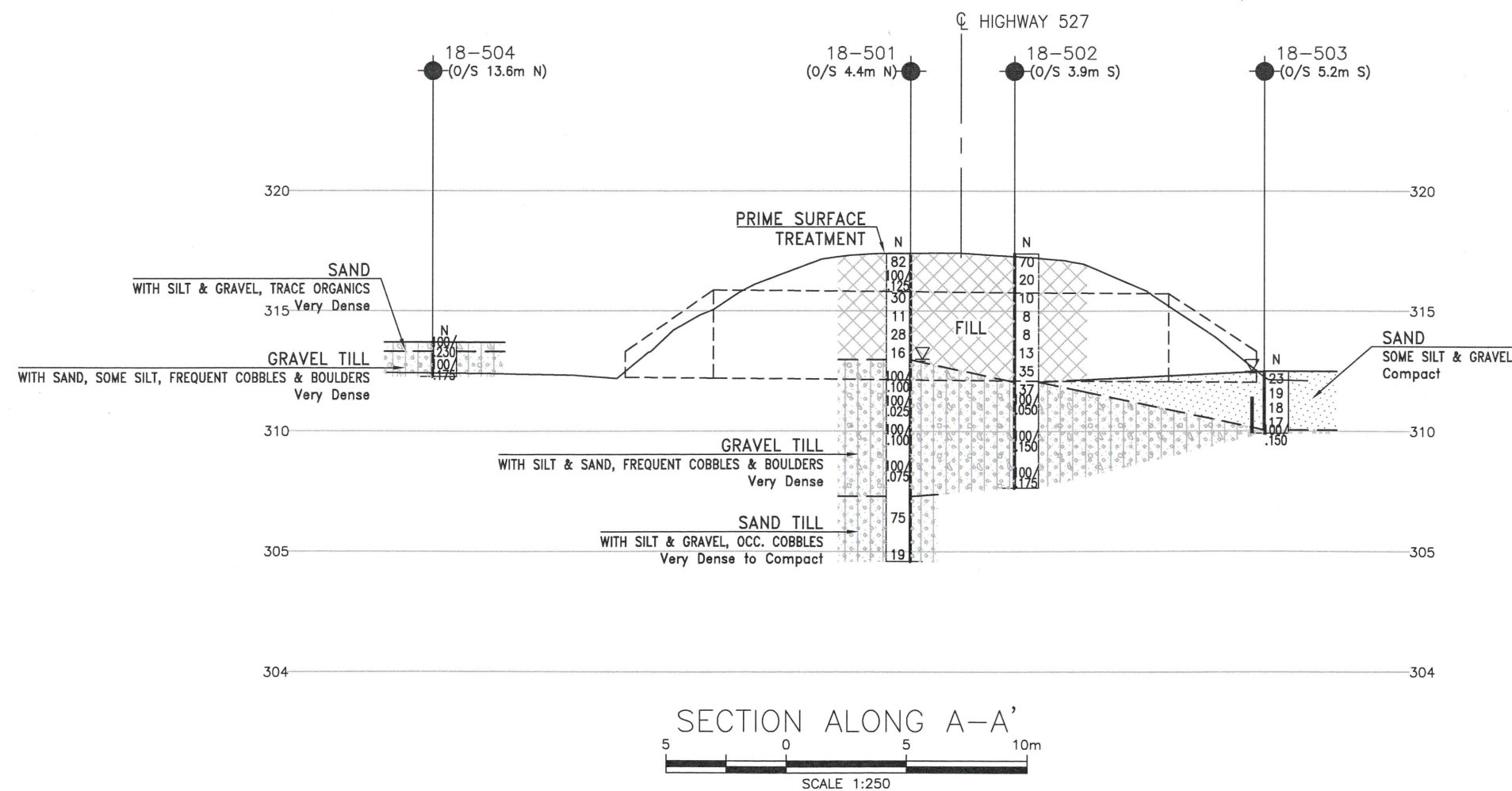
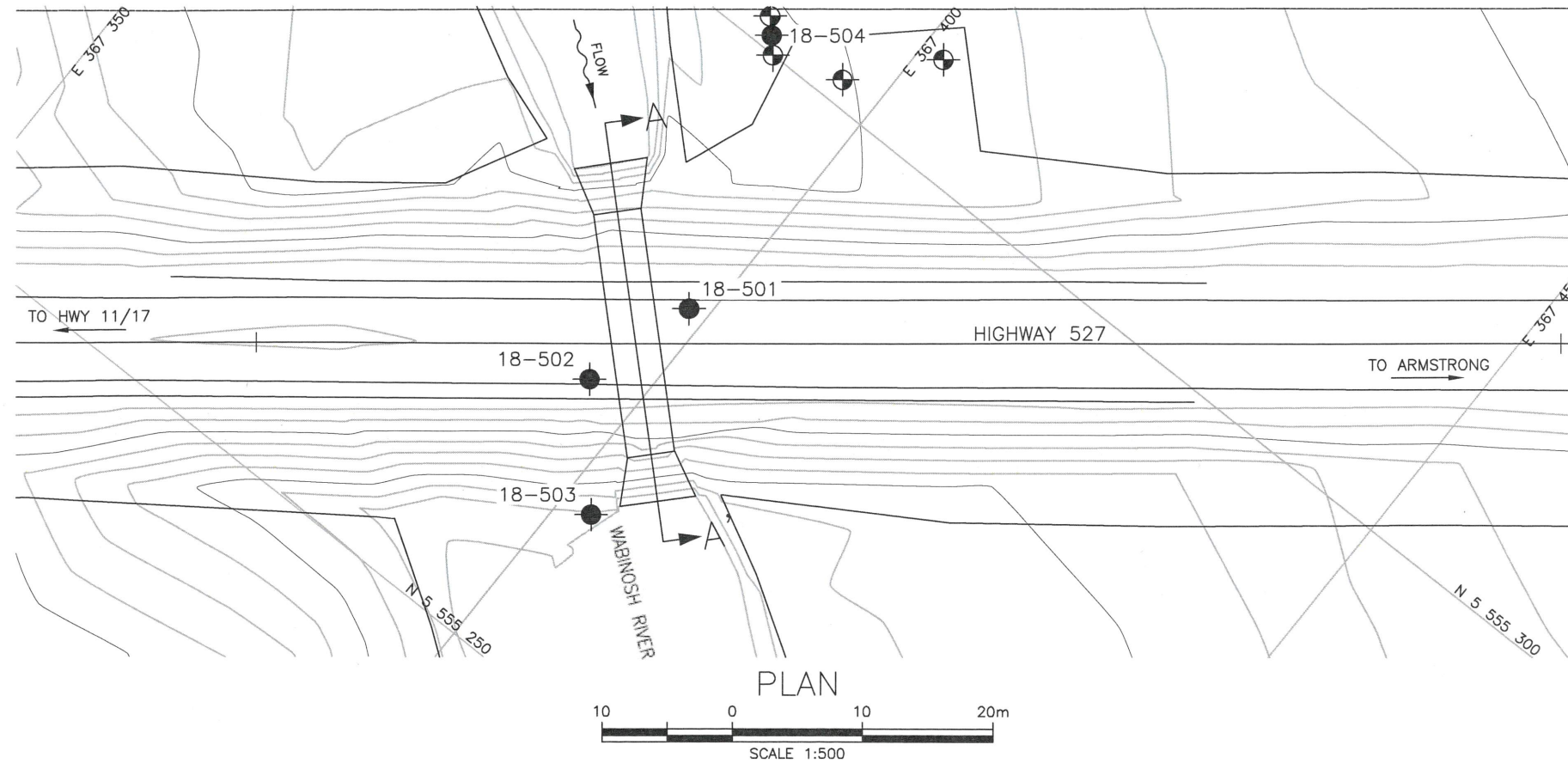
	Borehole
	Failed Borehole Attempt (Shallow Refusal)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60' Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
18-501	317.4	5 555 280.8	367 398.5
18-502	317.4	5 555 271.8	367 395.9
18-503	312.5	5 555 263.7	367 402.5
18-504	313.7	5 555 301.1	367 390.4

-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 15.

GEOCRES No. 52H-46

[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).

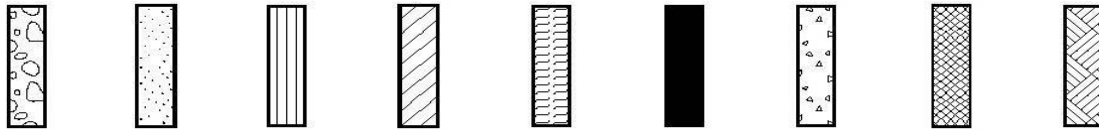
DYNAMIC CONE PENETRATION TEST (DCPT):

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 18-501

1 OF 2

METRIC

GWP# 6829-14-00 LOCATION Lat: 50.131459°, Long: -89.124404° Wabinoish River Culvert, MTM z15: N 5 555 280.8 E 367 398.5 ORIGINATED BY NW
 HWY 527 BOREHOLE TYPE NW Casing COMPILED BY SOB
 DATUM Geodetic DATE 2018.06.09 - 2018.06.10 CHECKED BY SD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				W P W W L							
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	WATER CONTENT (%)										
317.4							20 40 60 80 100												
0.0	20mm Prime Surface Treatment																		
	SAND with Silt and Gravel, frequent Cobbles, FILL Very Dense to Compact Brown		1	SS	82								○						
			2	SS	100/ 125mm														
	- 90 mm and 75 mm Cobbles cored between 1.2 and 1.5 m																		
			3	SS	30														
	- 150 mm Cobble cored at 2.1 m																		
			4	SS	11								○						
314.4																			
3.0	Silty SAND with Gravel, frequent Cobbles, FILL Compact Brown		5	SS	28								○						
			6	SS	16														
313.0																			
4.4	GRAVEL (GW) with Silt and Sand, frequent Cobbles and Boulders, TILL Very Dense Brown - 200 mm Boulder cored at 4.5 m																		
			7	SS	100/ 100mm								○						
			8	SS	100/ 25mm								○						
	- Several Cobbles cored between 6.3 and 7.6 m																		
			9	SS	100/ 100mm								○						
	- 260 mm Boulder cored at 8.5 m																		
			10	SS	100/ 75mm														
	- Several Cobbles cored between 9.2 and 10.1 m																		


Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

METRIC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE LIQUID CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				WATER CONTENT (%) W _p W W _L					
307.3	Continued From Previous Page																
10.1	SAND (SP) with Silt and Gravel, occasional Cobbles, TILL Very Dense to Compact Brown		11	SS	75									○	44 51 5 (SI+CL)		
304.6			12	SS	19									○	21 71 8 (SI+CL)		
12.8	End of Borehole - Advanced past refusal Water at 4.4 m B.G.S. (elev. 313.0 m) on completion of drilling																

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 18-502

1 OF 1

METRIC

GWP# 6829-14-00 LOCATION Lat: 50.131378°, Long: -89.124442° Wabinoth River Culvert, MTM z15: N 5 555 271.8 E 367 395.9 ORIGINATED BY NW
 HWY 527 BOREHOLE TYPE NW Casing COMPILED BY SOB
 DATUM Geodetic DATE 2018.06.12 - 2018.06.12 CHECKED BY SD

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							
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							
				WATER CONTENT (%)				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _P W W _L							
317.4															
0.0	20mm Prime Surface Treatment														
	SAND with Silt and Gravel, frequent Cobbles, FILL Very Dense to Compact Brown - 75 mm Cobble cored at 0.6 m		1	SS	70		317								41 49 10 (SI+CL)
			2	SS	20										
			3	SS	10		316								
315.3															
2.1	GRAVEL with Sand, frequent Cobbles, FILL Loose to Dense Brown - 90 mm Cobble cored at 2.9 m		4	SS	8		315								
			5	SS	8		314								
	- 75 mm Cobble cored at 3.7 m		6	SS	13										
	- 90 mm Cobble cored at 4.4 m		7	SS	35		313								64 35 1 (SI+CL)
312.1	- 80 mm Cobble cored at 5.2 m														
5.3	GRAVEL (GW) with Silt and Sand, frequent Cobbles and Boulders, TILL Dense to Very Dense Brown		8	SS	37		312								
			9	SS	100/ 50mm		311								
			10	SS	100/ 150mm		310								
							309								
307.6							308								
9.8	End of Borehole - Refusal														

DOUBLE LINE 19773 WABINOSH RIVER.GPJ 2012TEMPLATE(MTO).GDT 17/12/18

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 18-503

1 OF 1

METRIC

GWP# 6829-14-00 LOCATION Lat: 50.131304°, Long: -89.124351° Wabinoah River Culvert, MTM z15: N 5 555 263.7 E 367 402.5 ORIGINATED BY SOB
 HWY 527 BOREHOLE TYPE Portable, 1/4 weight hammer COMPILED BY AC
 DATUM Geodetic DATE 2018.08.09 - 2018.08.09 CHECKED BY SD

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	W _P	W		
312.5	SAND (SP) some Silt and Gravel Compact Brown		1	SS	23										13 82 5 (SI+CL)	
0.0				2	SS		19									
				3	SS		18									
				4	SS		17									
310.1	GRAVEL (GW) with Silt and Sand, frequent Cobbles and Boulders, TILL Very Dense Brown		5	SS	100/											
308.9																
2.6	End of Borehole - Refusal on Boulder															
	DATE DEPTH (m) ELEV. (m) 2018.08.12 0.0 312.5															
	Note: A quarter-weight (16kg) drop hammer was used to advance the split-spoon sampler. The "N" values presented above have been corrected to provide an estimate of the "N" value that would have been obtained with a standard 64kg hammer															

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 18-504

1 OF 1

METRIC

GWP# 6829-14-00 LOCATION Lat: 50.131642°, Long: -89.124514° Wabinoah River Culvert, MTM z15: N 5 555 301.1 E 367 390.4 ORIGINATED BY SOB
 HWY 527 BOREHOLE TYPE Portable COMPILED BY AC
 DATUM Geodetic DATE 2018.08.09 - 2018.08.10 CHECKED BY SD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT							PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												WATER CONTENT (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
313.7								20	40	60	80	100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												</

Appendix C.

Laboratory Testing

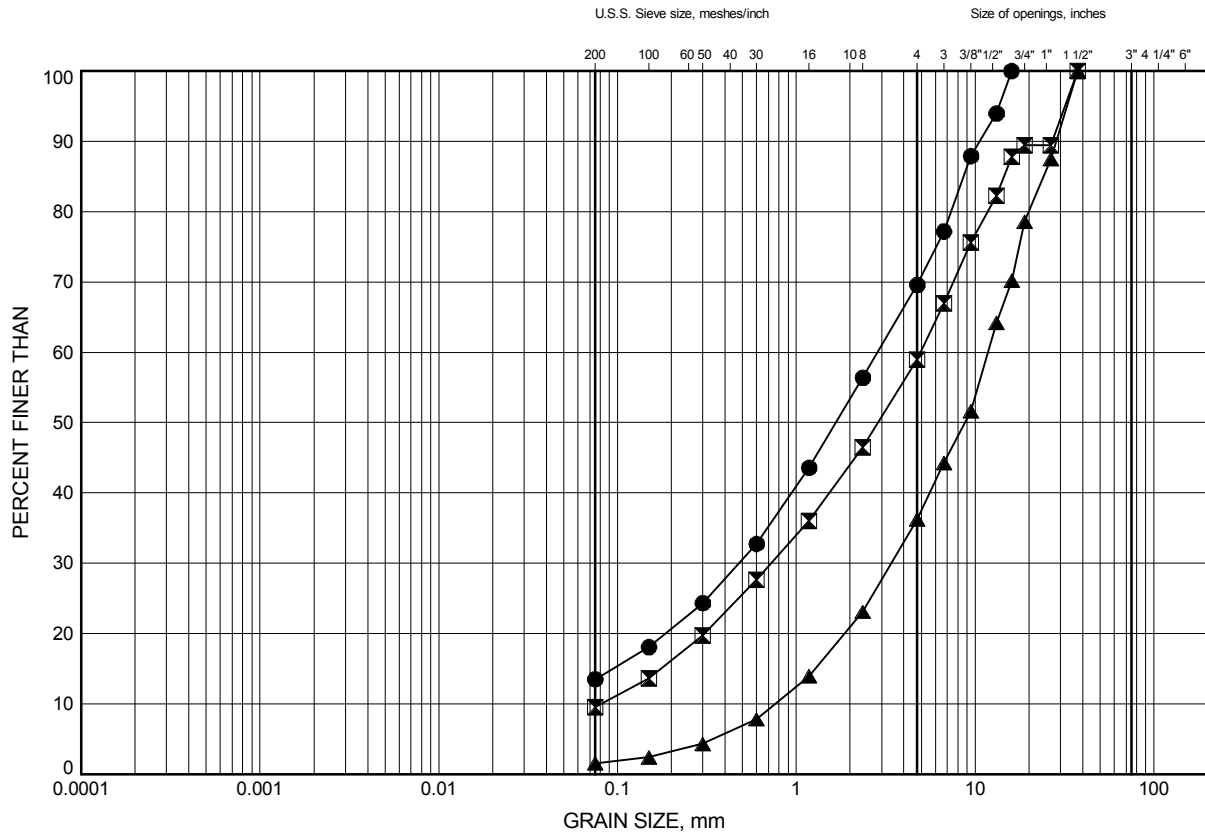
Appendix C.1

Particle Size Analysis Figures

Wabinoash River Culvert GRAIN SIZE DISTRIBUTION

FIGURE C1

Embankment Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-501	3.35	314.05
◻	18-502	0.33	317.07
▲	18-502	4.11	313.29

Date December 2018

GWP# 6829-14-00



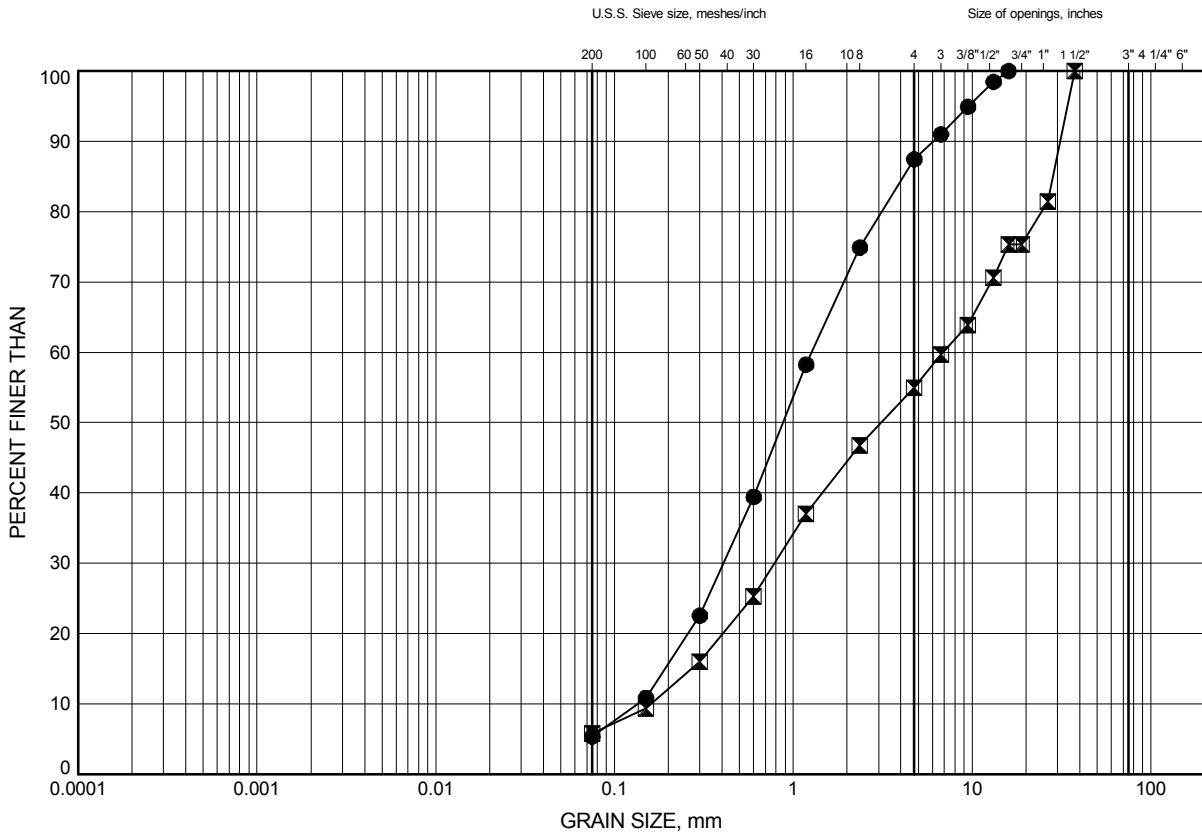
Prep'd CM

Chkd. SD

Wabinoash River Culvert GRAIN SIZE DISTRIBUTION

FIGURE C2

Surficial Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-503	1.52	310.98
⊠	18-504	0.19	313.51

Date December 2018

GWP# 6829-14-00



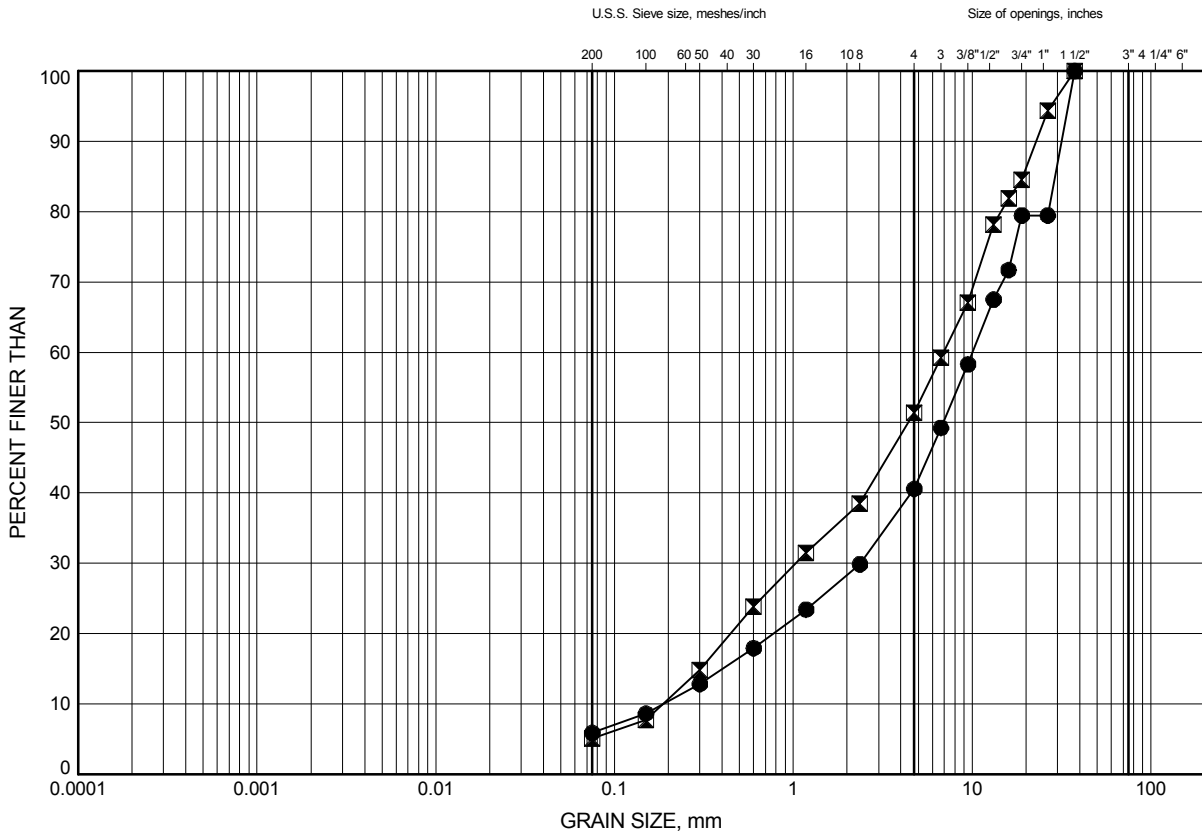
Prep'd CM

Chkd. SD

Wabinoash River Culvert GRAIN SIZE DISTRIBUTION

FIGURE C3

Gravel Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-501	5.46	311.94
⊠	18-504	1.17	312.53

Date December 2018

GWP# 6829-14-00



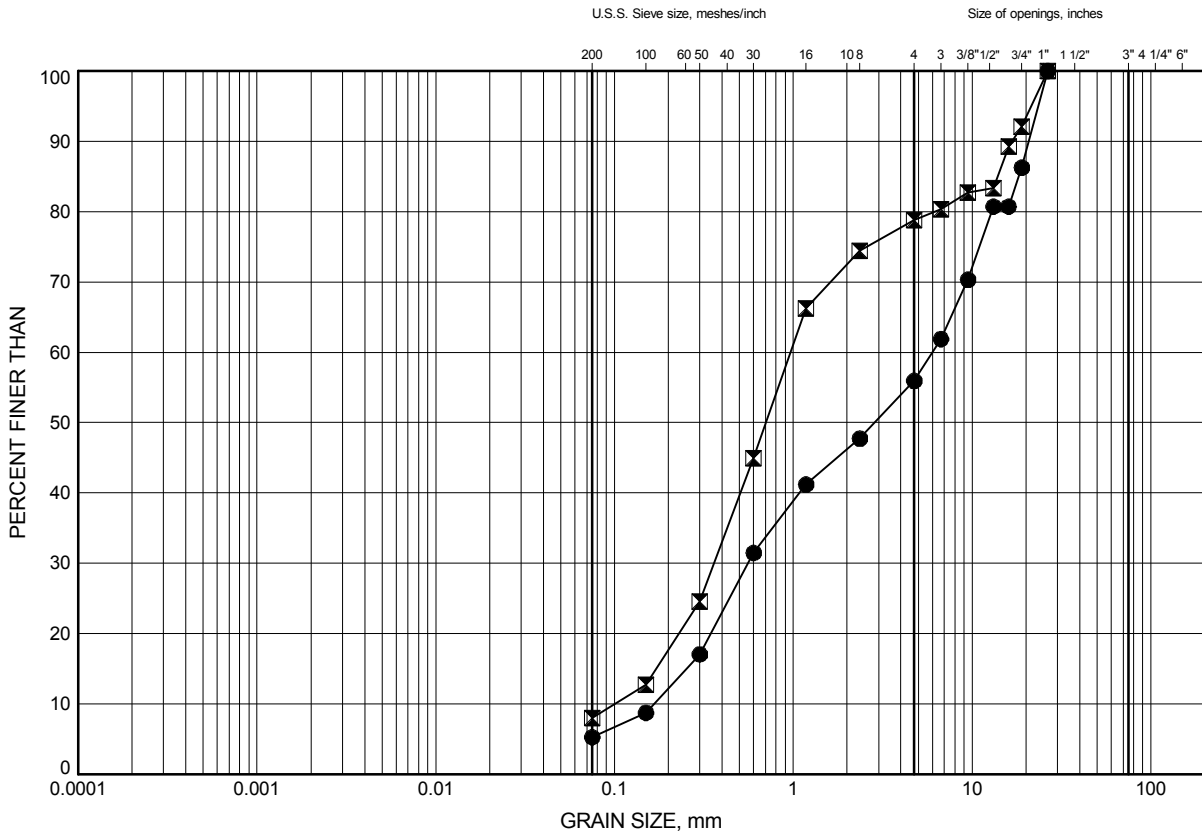
Prep'd CM

Chkd. SD

Wabinoash River Culvert GRAIN SIZE DISTRIBUTION

FIGURE C4

Sand Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-501	10.97	306.43
⊠	18-501	12.50	304.90

Date December 2018

GWP# 6829-14-00



Prep'd CM

Chkd. SD

Appendix C.2

Analytical Testing Results

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

Report Date: 26-Jun-2018

Order Date: 20-Jun-2018

Project Description: 19773

Client ID:		18-101, SS6, 12'6"-14'6"	18-203, SS3, 5'10"-7'10"	18-204, SS4, 10'4"-12'4"	18-401, SS5, 10'-12'
Sample Date:		05/30/2018 11:00	06/12/2018 14:30	06/13/2018 09:45	06/07/2018 13:30
Sample ID:		1825441-01	1825441-02	1825441-03	1825441-04
MDL/Units		Soil	Soil	Soil	Soil
Physical Characteristics					
% Solids	0.1 % by Wt.	80.0	88.0	89.3	92.4
General Inorganics					
Conductivity	5 uS/cm	135	156	98	90
pH	0.05 pH Units	7.81	7.76	7.76	7.56
Resistivity	0.10 Ohm.m	74.3	64.3	102	111
Anions					
Chloride	5 ug/g dry	9	25	29	9
Sulphate	5 ug/g dry	16	46	7	28
Client ID:		18-502, SS8, 17'6"-19'6"	18-301, SS8A, 17'6"-19'4"	-	-
Sample Date:		06/12/2018 11:15	06/05/2018 15:30	-	-
Sample ID:		1825441-05	1825441-06	-	-
MDL/Units		Soil	Soil	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	89.9	90.0	-	-
General Inorganics					
Conductivity	5 uS/cm	47	50	-	-
pH	0.05 pH Units	7.14	7.38	-	-
Resistivity	0.10 Ohm.m	213	198	-	-
Anions					
Chloride	5 ug/g dry	13	19	-	-
Sulphate	5 ug/g dry	10	6	-	-

**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,

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

28-June-2018

Date Rec. : 22 June 2018
LR Report: CA12773-JUN18
Reference: Project#:1825441

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Sample ID	Sample Date & Time	Sulphide %
1: Analysis Start Date		28-Jun-18
2: Analysis Start Time		13:23
3: Analysis Completed Date		28-Jun-18
4: Analysis Completed Time		14:45
5: QC - Blank		< 0.02
6: QC - STD % Recovery		105%
7: QC - DUP % RPD		ND
8: RL		0.02
9: 18-101,SS6, 12'6"-14'16"	30-May-18	< 0.02
10: 18-204,SS4, 10'4"-12'4"	13-Jun-18	< 0.02
11: 18-401,SS5, 10'-12'	07-Jun-18	< 0.02
12: 18-502,SS8, 17'6"-19'6"	12-Jun-18	< 0.02
13: 18-301,SS8A, 17'6"-19'4"	05-Jun-18	< 0.02

RL - SGS Reporting Limit
ND - Not Detected

Kimberley Didsbury
Project Specialist
Environmental Services, Analytical

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

Report Date: 17-Aug-2018

Order Date: 13-Aug-2018

Project Description: 19773

Client ID:	18-503, SS2, 2' - 4'	-	-	-
Sample Date:	08/09/2018 09:00	-	-	-
Sample ID:	1833093-01	-	-	-
MDL/Units	Soil	-	-	-

Physical Characteristics

% Solids	0.1 % by Wt.	88.6	-	-	-
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General Inorganics

Conductivity	5 uS/cm	60	-	-	-
pH	0.05 pH Units	7.42	-	-	-
Resistivity	0.10 Ohm.m	166	-	-	-

Anions

Chloride	5 ug/g dry	6	-	-	-
Sulphate	5 ug/g dry	<5	-	-	-

Appendix D.

Site Photographs



Photo 1. Looking southeast toward culvert inlet (2018/08/10)



Photo 2. Looking northwest toward culvert outlet (2018/08/10)



Photo 3. Looking north along Highway 527 overtop of culvert (2018/08/10)



Photo 4. Looking south along Highway 527 overtop of culvert (2018/08/10)