



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION REPORT
HIGHWAY 527 MAX CREEK CULVERT
89 KM NORTH OF HIGHWAY 11/17, THUNDER BAY UNORGANIZED
SITE NO.: 48C-222/C
ASSIGNMENT NO. 6017-E-0013**

G.W.P. 6827-14-00

Geocres No.: 52H-45

Report to:

Hatch Corporation

Latitude: 49.170657°
Longitude: -89.352638°

December 2018
Thurber File: 19773

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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 Max Creek Culvert on Highway 527. The culvert is located approximately 89 km north of Highway 11/17 within the Unorganized Thunder Bay District. 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 Max Creek under Highway 527, is a twin corrugated steel pipe (CSP) culvert constructed in 1984. A site survey plan from Hatch indicates that each CSP has a diameter of 2.4 m and is approximately 20.7 m long. The culvert alignment is generally southwest to northeast with the flow through the culvert toward the northeast.

At the location of the culvert, Highway 527 is a two-lane highway with a rural cross-section, narrow gravel shoulders and cable guiderail on both sides. The embankment fill height above the culvert is approximately 1.0 m. The elevation of the road surface at the centreline is approximately 439.1 m. The existing embankment slopes are inclined between approximately 2.4H:1V and 3.1H:1V. The land adjacent to the highway and waters edge is undeveloped and densely vegetated with trees. Traffic volumes on this section of Highway 527 are understood to be between 170 and 420 AADT (2016).

An OSIM report for the culverts dated Friday October 30th, 2015 indicated some transverse and longitudinal cracking of the pavement north of the culverts and some longitudinal cracking south of the culverts. Further, the report commented on signs of settlement of the foundation below both culverts. Minor settlement of the north culvert barrel was also indicated. A visual inspection of the pavement in the vicinity of the culvert completed in June 2018 does not suggest poor pavement performance (i.e. no bumps or sagging of the pavement). 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 2nd and June 14th, 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)
18-201	South of culvert – SB Lane	5448248.6	352006.3	439.0	12.3
18-202	Bypass culvert – NB Lane	5448282.5	351978.8	439.2	9.4
18-203	East end – culvert outlet	5448261.1	352014.8	436.9	5.7
18-204	West end – culvert inlet	5448246.8	351993.8	437.0	5.5

The drilling was carried out using NW casing with a truck mounted CME 75 drill rig for on-road Boreholes 18-201 and 18-202 and portable drilling equipment for off-road Boreholes 18-203 and 18-204. The off-road boreholes were advanced from the water surface on a raft.

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). It is noted that the split spoon sampler has an inside diameter of 35 mm; therefore, larger size particles of gravel, cobbles and boulders, which are known to be present, were not represented in the grain size analyses. Boreholes 18-203 and 18-204, which were drilled with portable equipment, utilized a full-weight hammer for SPT testing. Bedrock was cored and collected in Boreholes 18-201 and 18-202 using NQ coring equipment.

Open-hole groundwater levels were measured within the on-road boreholes upon completion of drilling. All 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 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. All rock cores were photographed and their total core recovery (TCR), solid core recovery (SCR) and rock quality designation (RQD) were measured. Chemical analysis for determination of pH, conductivity, resistivity, sulphate and chloride concentrations was carried out on two soil samples and one surface water sample. Chemical analysis for determination of sulphide concentration was carried out on one soil sample. Organic content testing was carried out on two samples.

The results of the geotechnical tests are summarized on the Record of Borehole sheets included in Appendix B and all laboratory results are presented on the figures included 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, the site was found to be underlain by pavement structure and granular embankment fill overlying deposits of organic silt and cohesionless till over bedrock.

5.1 Embankment Fill

5.1.1 Asphalt

Boreholes 18-201 and 18-202 were drilled through the existing Highway 527 embankment and encountered a layer of asphalt with a thickness of 75 mm.

5.1.2 Granular Fill

Below the asphalt pavement within the on-road boreholes and below the creek bed was a layer of granular fill ranging in composition from gravel with sand, to sand with gravel, to sand with silt and gravel, to silty sand with gravel, to sandy silt with gravel. The underside of the granular fill was at 4.6 to 6.1 m below the existing ground/raft surface (elev. 431.9 to 434.6 m). Cobbles ranging from 75 mm to 150 mm in size were cored in this layer in Boreholes 18-201, 18-202 and 18-203. Boulders were noted in Borehole 18-203. A 0.7 m thick layer of lumber with a creosote odor was encountered in the fill in Borehole 18-202 with an underside depth of 3.7 m (elev. 435.5 m). Given that Borehole 18-202 was drilled on what appears to be to be an old creek alignment and an old design drawing indicates an old timber culvert in this area, this lumber is suspected to be part of the old timber culvert.

The SPT tests conducted in the fill typically gave N-values ranging from 3 to 92 blows indicating a loose to very dense relative density. Higher N-values ranging from 100 blows

per 25 mm to 100 blows per 175 mm were recorded on inferred cobbles and boulders. Recorded moisture contents ranged from 2% to 22%.

Gradation analyses were completed on six 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 Embankment Fill

Soil Particle	Percentage (%)
Gravel	21 to 57
Sand	32 to 72
Silt and Clay	4 to 12

5.2 Organic Silt

A layer of organic silt was encountered below the fill in Boreholes 18-201, 18-202 and 18-204. The layer had a thickness ranging from 0.1 m to 1.5 m with an underside depth that ranged from 5.2 to 7.2 m below the existing ground/raft surface (elev. 431.8 to 433.1 m).

SPT tests conducted in the organic silt gave N-values ranging from 2 to 4 blows, recognizing that correlations to relative density are not applicable to organic soils. Very poor sample recovery within the split spoon sampler was noted within this layer. The moisture content of the organic silt was measured to range from 117% to 157%. The organic content on two samples of this layer was measured to range from 13.8% to 20.8%.

5.3 Cobbles, Boulders and Gravel

A layer of cobbles and boulders with gravel to gravel with sand was encountered below the organic silt in Boreholes 18-201 and 18-204. Where fully penetrated by coring in Borehole 18-201, the thickness of this layer was 0.7 m with an underside depth of 7.9 m below the existing ground surface (elev. 431.1 m). Borehole 18-204 was terminated within this layer on inferred cobbles and boulders at a depth of 5.5 m below the raft surface (elev. 431.5 m). Cobbles and boulders cored in this layer ranged from 75 mm to 260 mm in size.

One SPT test conducted in this layer gave an N-value of 100 blows per 175 mm penetration indicating a very dense relative density; however, this blow count could represent the presence of cobbles or a boulder rather than the state of packing of the soil matrix. One recorded moisture content was 19%.

5.4 Sand with Silt and Gravel

A layer of sand with silt and gravel was encountered below the fill in Borehole 18-203. The borehole was terminated upon casing refusal on an inferred boulder in this layer at 5.7 m below the raft surface (elev. 431.2 m). This layer contained trace organics. One 50 mm particle was cored in this layer.

SPT tests conducted in this layer gave N-values ranging from 64 blows per 300 mm penetration to 100 blows per 100 mm penetration indicating a very dense relative density; however, the high blow counts could represent the presence of cobbles or a boulder rather than the state of packing of the soil matrix. The recorded moisture contents ranged from 15 to 18%.

A gradation analysis was completed on one sample of the sand layer. The grain size distribution curve is included in Figure C2 of Appendix C. The results of the test are summarized in Table 5-2 below and are presented on the corresponding Record of Borehole sheet in Appendix B.

Table 5-2: Gradation Results for Sand with Silt and Gravel

Soil Particle	Percentage (%)
Gravel	34
Sand	59
Silt and Clay	7

5.5 Silty Sand Till

A layer of silty sand till with some gravel and frequent cobbles/boulders was encountered below the layer of cobbles and boulders in Borehole 18-201. The thickness of the till was 1.0 m with an underside depth of 8.9 m below the existing ground surface (elev. 430.1 m). Cobbles cored in this layer ranged from 160 mm to 180 mm in size.

SPT tests conducted in this layer gave N-values ranging from 34 blows per 300 mm penetration to 100 blows for 25 mm of penetration indicating a dense to very dense relative density; however, the high blow counts could represent the presence of cobbles or a boulder rather than the state of packing of the soil matrix. The recorded moisture contents ranged from 9 to 11% within the till layer.

A gradation analysis was completed on one sample of the till. The grain size distribution curve is included in Figure C3 of Appendix C. The results of the test are summarized in Table 5-3 below and are presented on the corresponding Record of Borehole sheet in Appendix B.

Table 5-3: Gradation Results for Till

Soil Particle	Percentage (%)
Gravel	10
Sand	43
Silt and Clay	47

5.6 Refusal and Bedrock

Practical refusal to advancement of the portable drilling equipment was encountered at off-road Borehole 18-203 in the very dense sand with silt and gravel layer and at Borehole 18-204 within the gravel with sand layer.

Bedrock was proven by coring in on-road Boreholes 18-201 and 18-202. Information on the confirmed bedrock surface is summarized in Table 5-4 below:

Table 5-4: Summary of Bedrock Depth / Elevation

Borehole No.	Depth to Bedrock Surface (mbgs)	Bedrock Surface Elevation (m)
18-201	8.9	430.1
18-202	6.1	433.1

The bedrock encountered within Boreholes 18-201 and 18-202 consisted of fresh, banded, light to dark grey, fine to medium grained gneiss. The Total Core Recovery (TCR) measured on the recovered bedrock core was 100%, the Solid Core Recovery (SCR) ranged from 92 to 100% and the Rock Quality Designation (RQD) ranged from 57 to 100%. Based on the measured RQD values, the bedrock is classified as fair to excellent quality. The gneiss bedrock is estimated to be very strong. Photographs of the bedrock core are provided in Appendix C.

5.7 Groundwater

It is expected that the groundwater level at the site will correspond to the water level in the creek. The creek water level was surveyed at the culvert inlet and outlet and the measured elevations are provided in Table 5-5 below:

Table 5-5: Creek Water Level Observations

Location	Surface Water Elevation (m)	Date of Measurement
Culvert Inlet	436.9	June 4, 2018
	436.9	June 13, 2018
Culvert Outlet	436.9	June 4, 2018
	436.8	June 13, 2018

Water level readings were taken upon completion of drilling in Boreholes 18-201 (open borehole) and 18-202 (casing). Although water was introduced for coring, the water levels correspond relatively well to the surface water elevation at the time of drilling. A summary of the measured elevations are provided in Table 5-6 below:

Table 5-6: Open-hole Groundwater Levels

Location	Depth (mbgs)	Groundwater Elevation (m)	Date of Measurement
18-201	2.2	436.8	June 4, 2018
18-202*	2.0	437.3	June 4, 2018

Note: (*) : this borehole is located north of the existing culvert

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

5.8 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. The analysis results are provided in Appendix C and are summarized in Table 5-7 below:

Table 5-7: Analytical Results Summary (Soil)

Borehole	18-203	18-204
Sample	SS3	SS4
Depth (m)	1.8* – 2.4*	3.1* – 3.8*
Chloride (µg/g)	25	29
Sulphate (µg/g)	46	7
Sulphide (%)	-	< 0.02
pH (-)	7.76	7.76
Resistivity (Ohm-cm)	6430	10200
Conductivity (µS/cm)	156	98

Note: (*) depth relative to top of raft at time of drilling.

A surface water sample was obtained on November 30, 2018 upstream of the existing culvert and was submitted to Paracel Laboratories in Ottawa, Ontario for analysis of conductivity, pH, resistivity, chloride and sulphate. The analysis results are provided in Appendix C and are summarized in Table 5-8 below.

Table 5-8: Analytical Results Summary (Surface Water)

Parameter	Result
Conductivity (µS/cm)	74
pH (-)	7.4
Resistivity (Ohm-cm)	13500
Chloride (mg/L)	2
Sulphate (mg/L)	1

6 MISCELLANEOUS

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

George Downing Estate Drilling Ltd. of Hawkesbury, Ontario and OGS Drilling of Almonte, 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 and borehole decommissioning. Traffic control was provided by NC Traffic Management Inc. of Kirkland Lake, Ontario. 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. Organic content testing was completed by Stantec Consulting 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 Ms. Deanna Pizycki and Mr. Stephen Dunlop, P.Eng. The report was reviewed by Dr. Fred Griffiths, P.Eng. a Designated Principal Contact for MTO Foundation Projects.


Dec 13/18

Deanna Pizycki, M.Eng.
Geotechnical EIT



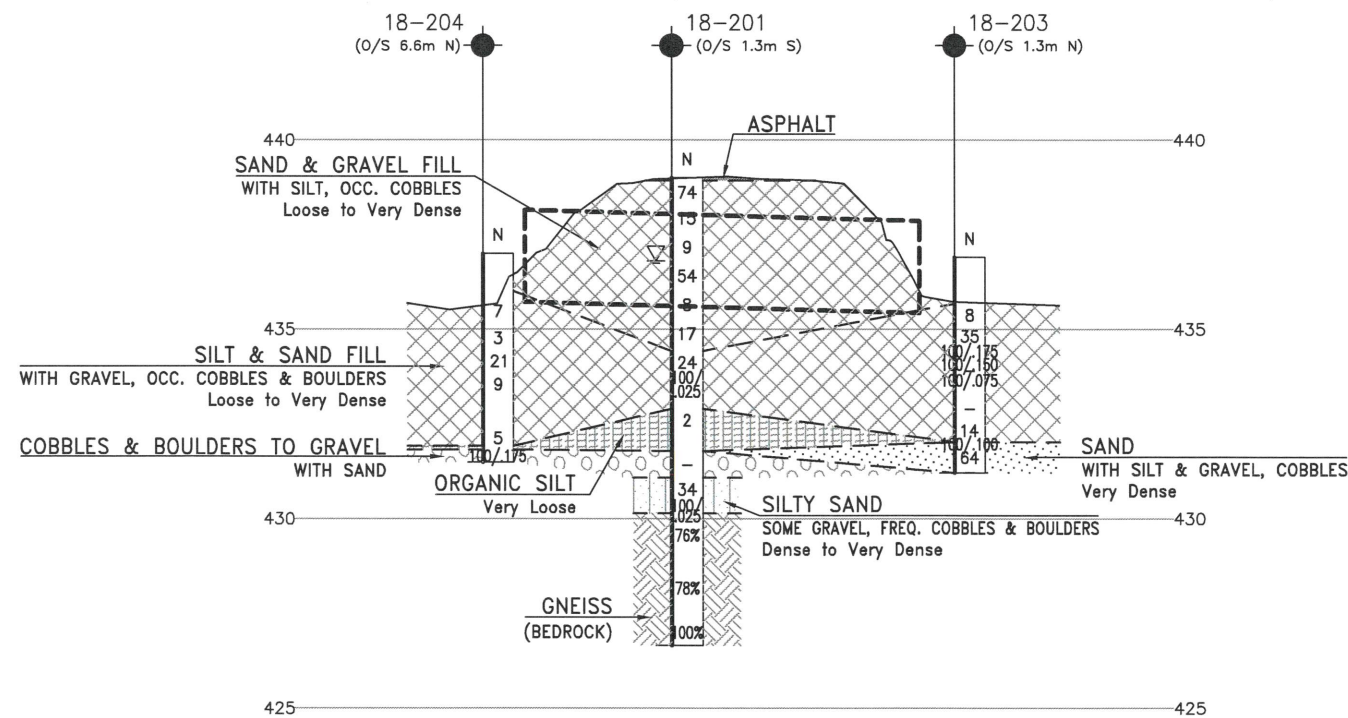
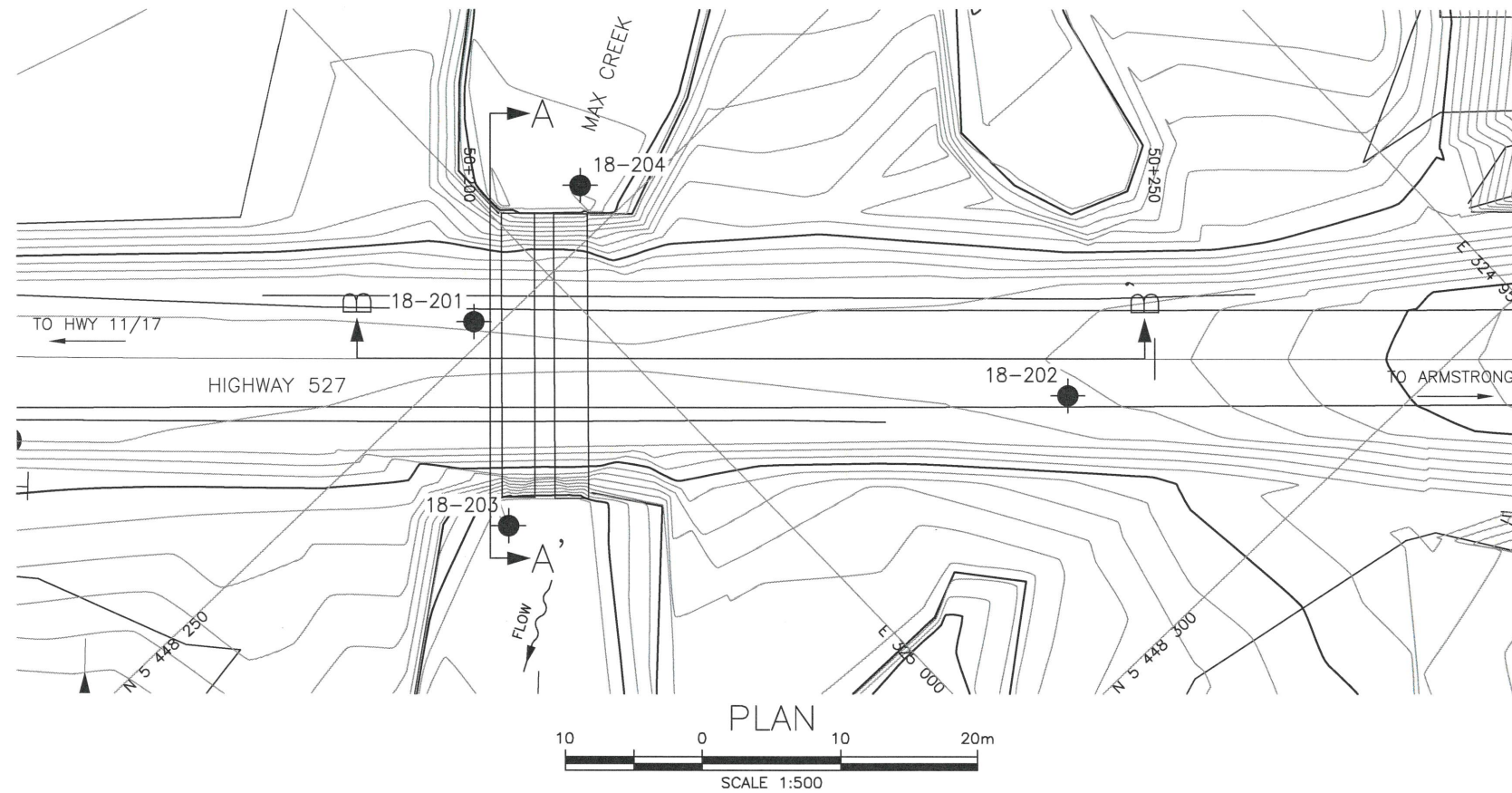
Stephen Dunlop, M.A.Sc., P.Eng.
Senior Geotechnical Engineer



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

Appendix A.

Drawings



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

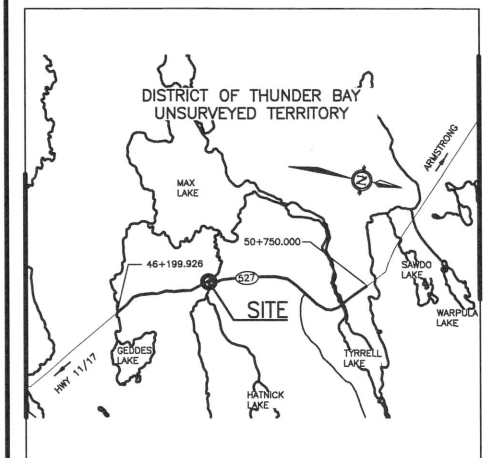
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HIGHWAY 527
MAX CREEK CULVERT
REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

HATCH



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LEGEND

	Borehole
	Borehole & Cone
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

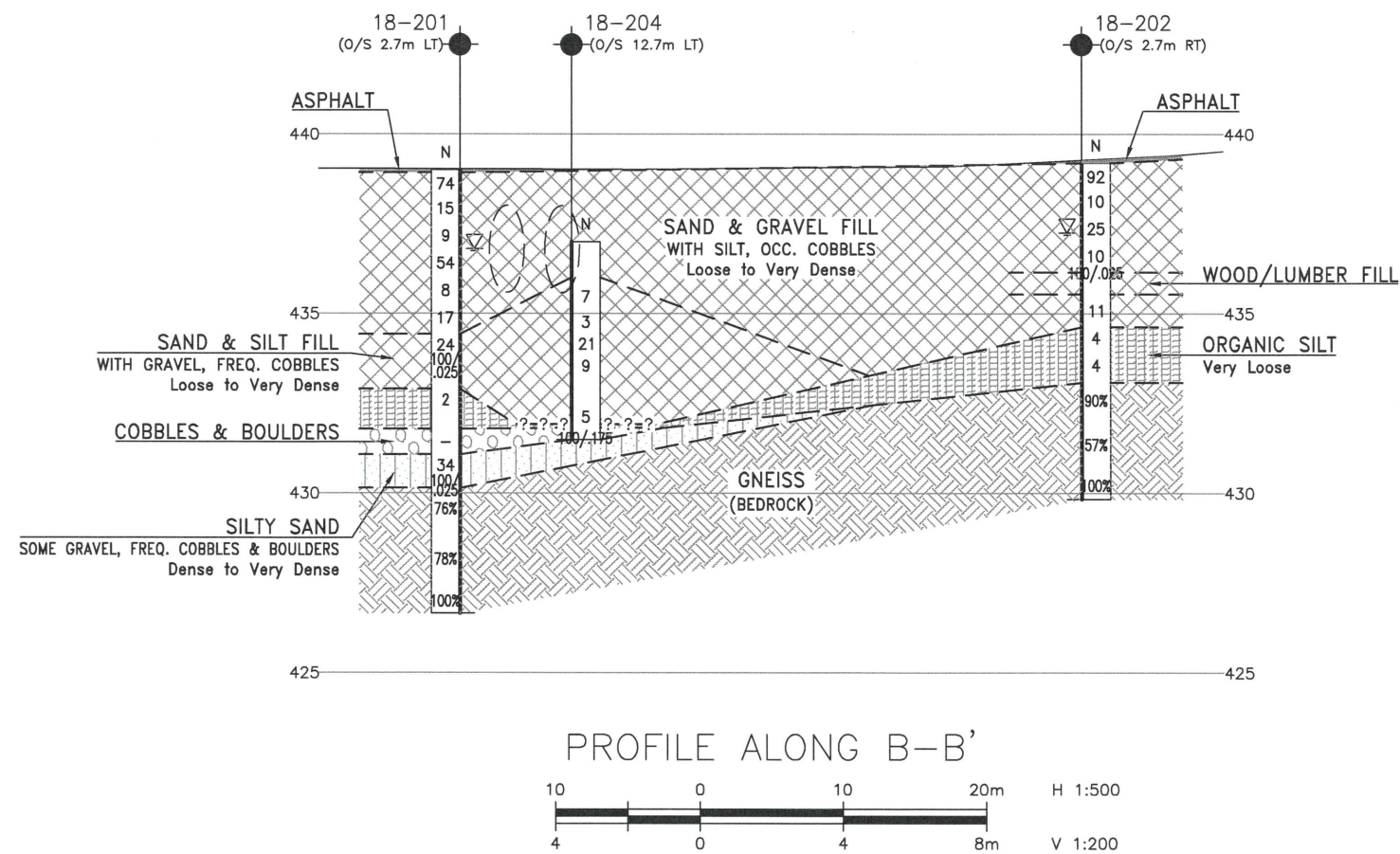
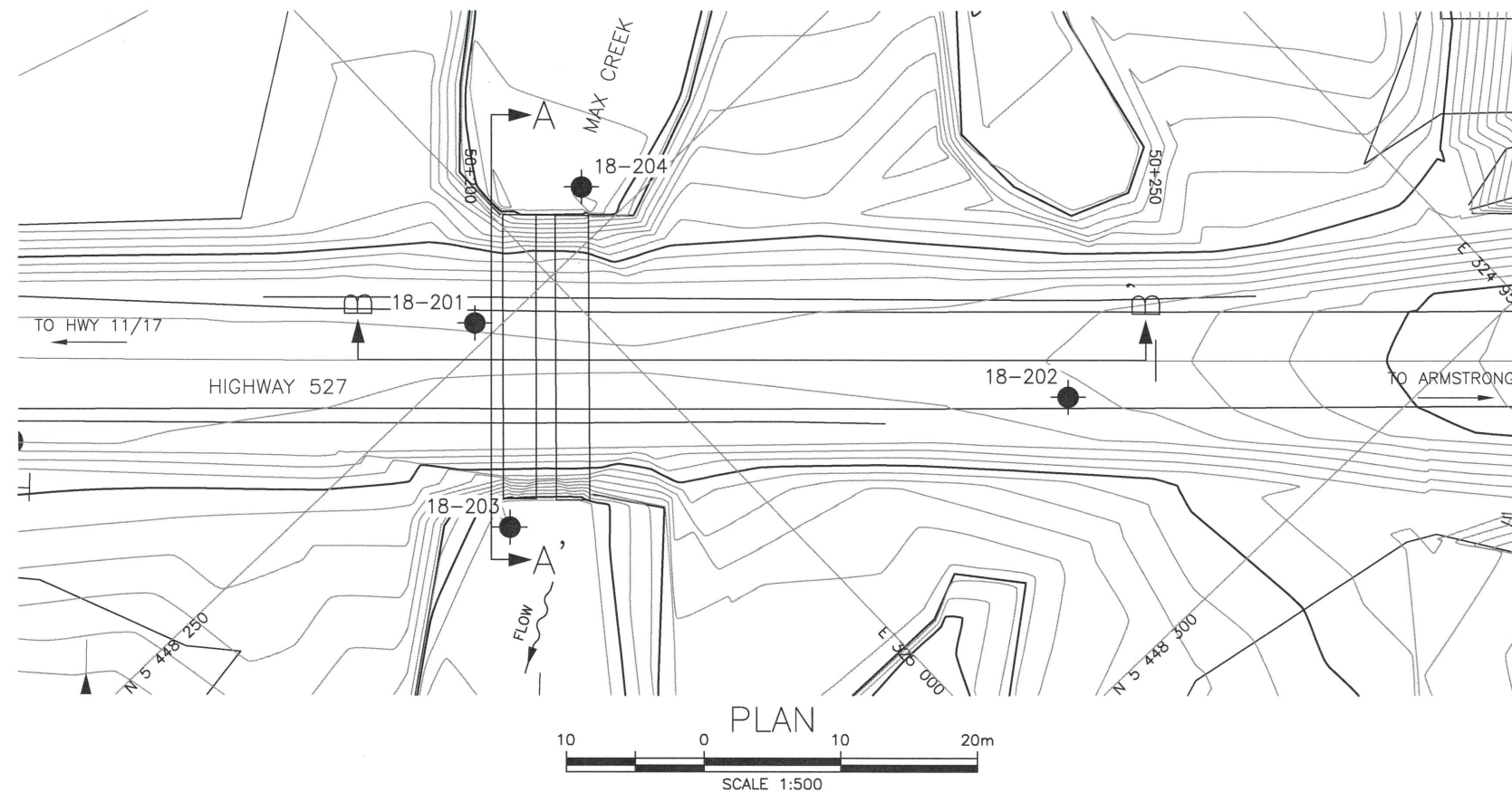
NO	ELEVATION	NORTHING	EASTING
18-201	439.0	5 448 248.6	352 006.3
18-202	439.2	5 448 282.5	351 978.8
18-203	436.9	5 448 261.1	352 014.8
18-204	437.0	5 448 246.8	351 993.8

-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 15.

GEOCRES No. 52H-45

DATE	BY	DESCRIPTION
DESIGN DP	CHK SP	CODE
DRAWN AN	CHK DP	SITE
		LOAD
		STRUCT
		DATE DEC 2018
		DWG 1



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

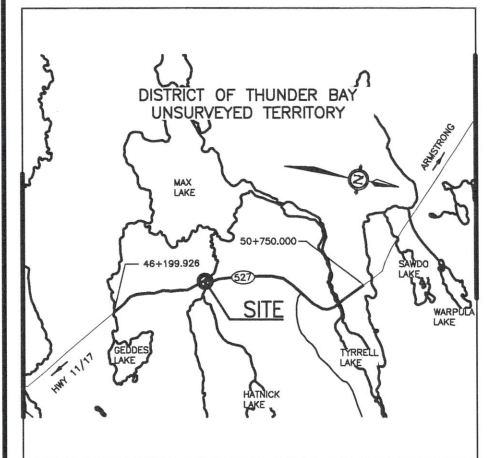
CONT No
GWP No 6827-14-00

HIGHWAY 527
MAX CREEK CULVERT
REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

HATCH



THURBER ENGINEERING LTD.



LEGEND

●	Borehole
⊙	Borehole & Cone
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
18-201	439.0	5 448 248.6	352 006.3
18-202	439.2	5 448 282.5	351 978.8
18-203	436.9	5 448 261.1	352 014.8
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GEOCRES No. 52H-45



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	DP	CHK SP	CODE
DRAWN	AN	CHK DP	SITE
			LOAD
			STRUCT
			DWG 2
			DATE DEC 2018

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).

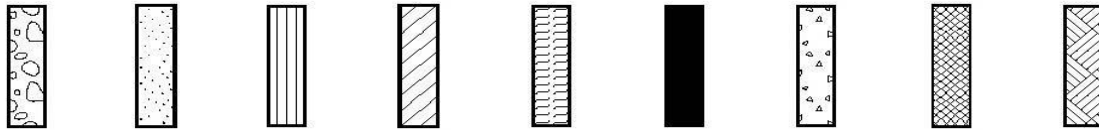
DYNAMIC CONE PENETRATION TEST (DCPT):

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 18-201

1 OF 2

METRIC

GWP# 6827-14-00 LOCATION Lat: 49.1705225°, Long: -89.3525775° Max Creek Culvert, MTM z15: N 5 448 248.6 E 352 006.3 ORIGINATED BY NW
HWY 527 BOREHOLE TYPE NW Casing/ NQ Coring COMPILED BY SOB
DATUM Geodetic DATE 2018.06.02 - 2018.06.04 CHECKED BY DJP

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						
439.0														
0.0 0.1	75 mm ASPHALT													
	GRAVEL with Sand, FILL Very Dense to Compact Brown		1	SS	74									52 44 4 (SI+CL)
			2	SS	15		438							
437.5														
1.5	SAND with Gravel to GRAVEL with Silt and Sand, Occasional Cobbles, FILL Loose to Very Dense Brown		3	SS	9		437							
			4	SS	54									
			5	SS	8		436							
	- 120 mm Cobble cored while advancing from 3.8 m to 4.6 m		6	SS	17		435							57 32 11 (SI+CL)
434.4														
4.6	Sandy SILT with Gravel, Frequent Cobbles, FILL Compact to Very Dense Brown		7	SS	24		434							
	- 100 mm and 140 mm Cobbles cored while advancing from 4.6 m to 6.1 m		8	SS	100/ 25mm									
432.9							433							
6.1	Organic SILT (OL)		9	SS	2									13.8% organic content
							432							
431.8														
7.2	Cobbles and Boulders with Gravel - 75 mm to 260 mm Cobbles / Boulders cored		9A	NQ	-									
431.1							431							
7.9	Silty SAND (SM), some Gravel, Frequent Cobbles and Boulders, TILL Dense Grey - 160 mm and 180 mm Cobbles cored while advancing from 7.9 m to 8.9 m		10	SS	34									10 43 47 (SI+CL)
430.1			11	SS	100/ 25mm		430							
8.9	Gneiss BEDROCK Fresh Banded Light to Dark Grey Fine to Medium Grained Verv Strong		1	RUN										RUN #1 TCR=100% SCR=100% RQD=76%

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

DOUBLE LINE 19773 MAX CREEK.GPJ 2012TEMPLATE(MTO).GDT 10/12/18

METRIC

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 18-202

1 OF 1

METRIC

GWP# 6827-14-00 LOCATION Lat: 49.1708293°, Long: -89.3529502°
Max Creek Culvert, MTM z15: N 5 448 282.5 E 351 978.8 ORIGINATED BY NW
HWY 527 BOREHOLE TYPE NW Casing/ NQ Coring COMPILED BY SOB
DATUM Geodetic DATE 2018.06.04 - 2018.06.04 CHECKED BY DJP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								WATER CONTENT (%)					
439.2													
0.0	75 mm ASPHALT												
0.1	SAND with Silt and Gravel, FILL Very Dense to Compact Brown		1	SS	92								34 56 10 (SI+CL)
			2	SS	10								
			3	SS	25								
			4	SS	10								44 48 8 (SI+CL)
436.2	WOOD/LUMBER, Creosote Odour, FILL		5	SS	100/25mm								
435.5	SAND with Gravel, FILL Compact Brown		6	SS	11								
434.6	Organic SILT (OL)		7	SS	4								
			8	SS	4								
433.1	- 60 mm Particle cored at 6.0 m												
6.1	Gneiss BEDROCK Fresh Banded Light to Dark Grey Fine to Medium Grained Very Strong		1	RUN									RUN #1 TCR=100% SCR=100% RQD=90%
			2	RUN									RUN #2 TCR=100% SCR=92% RQD=57%
			3	RUN									RUN #3 TCR=100% SCR=100% RQD=100%
429.8	End of Borehole Water level in casing at 2.0 m BGS (Elev. 437.3 m) upon completion of drilling.												
9.4													

DOUBLE LINE 19773 MAX CREEK.GPJ 2012TEMPLATE(MTO).GDT 10/12/18

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 18-203

1 OF 1

METRIC

GWP# 6827-14-00 LOCATION Lat: 49.1706344° Long: -89.352459° Max Creek Culvert, MTM z15: N 5 448 261.1 E 352 014.8 ORIGINATED BY SOB
HWY 527 BOREHOLE TYPE Portable / NW Casing / NQ Coring COMPILED BY SOB
DATUM Geodetic DATE 2018.06.12 - 2018.06.13 CHECKED BY DJP

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								
436.9	RAFT (Drilling Platform) WATER															
0.0 0.1																
435.7	Silty SAND with Gravel, Frequent Cobbles and Boulders FILL Loose to Very Dense Grey - 150 mm Cobble cored at 1.6 m (NQ2) - 150 mm Cobble cored at 2.7 m - 50 mm Particle cored at 4.0 m		1	SS	8											
			3	SS	35											
			4	SS100/175mm												
			5	SS100/150mm												
			6	NQ	-											
			7	SS 100/75mm												
			8	NQ	-											
			9	SS	14											
432.0	SAND (SP-SM) with Silt and Gravel, trace Organics, Frequent Cobbles Very Dense Brown		10	SS100/100mm												
4.9																
			11	SS	64											
431.2	- 50 mm Particle cored at 5.6 m End of Borehole Casing refusal on inferred Boulder.															
5.7																

DOUBLE LINE 19773 MAX CREEK.GPJ 2012TEMPLATE(MTO).GDT 10/12/18

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

RECORD OF BOREHOLE No 18-204

1 OF 1

METRIC

GWP# 6827-14-00 LOCATION Lat: 49.1705069°, Long: -89.3527489° Max Creek Culvert, MTM z15: N 5 448 246.8 E 351 993.8 ORIGINATED BY SOB
 HWY 527 BOREHOLE TYPE Portable / NW Casing / NQ Coring COMPILED BY SOB
 DATUM Geodetic DATE 2018.06.13 - 2018.06.14 CHECKED BY DJP

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				WATER CONTENT (%) W P W W L					GR	SA
437.0 0.0 0.1	RAFT (Drilling Platform) WATER																	
436.0 1.0	SAND with Silt and Gravel FILL Loose to Compact Grey																	
			1	SS	7													
			2	SS	3													
			3	SS	21													
			4	SS	9													
			5	SS	5													
431.9 431.8 5.2 431.5 5.5	Organic SILT (OL) GRAVEL with Sand Very Dense Grey End of Borehole Casing refusal on inferred cobbles / boulders.																	
			6	SS100/175mm														

DOUBLE LINE 19773 MAX CREEK.GPJ 2012TEMPLATE(MTO).GDT 10/12/18

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

Appendix C.

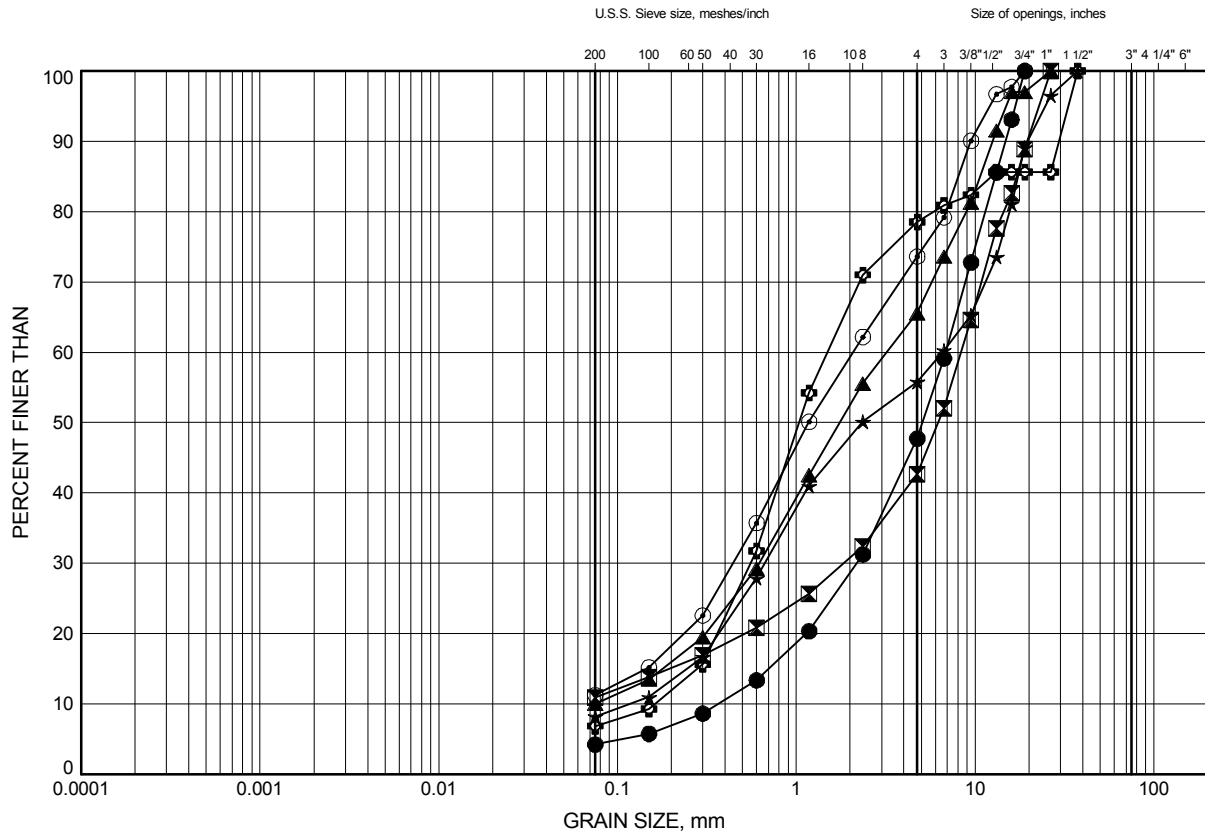
Laboratory Testing

Appendix C.1
Particle Size Analysis Figures

Max Creek Culvert GRAIN SIZE DISTRIBUTION

FIGURE C1

Sand and Gravel Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-201	0.38	438.62
⊠	18-201	4.11	434.89
▲	18-202	0.38	438.82
★	18-202	2.59	436.61
⊙	18-203	2.48	434.42
⊕	18-204	2.84	434.16

Date August 2018
GWP# 6827-14-00

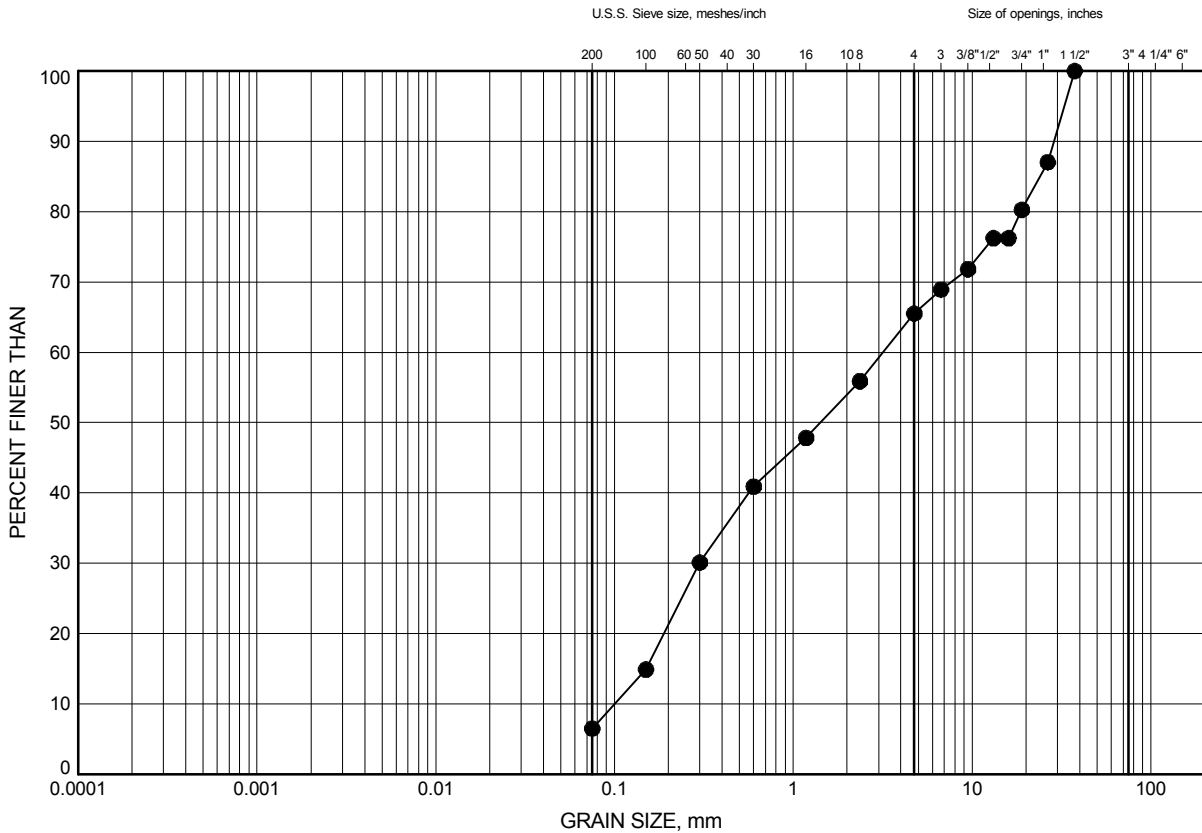


Prep'd DJP
Chkd. SD

Max Creek Culvert GRAIN SIZE DISTRIBUTION

FIGURE C2

Sand with Silt and Gravel



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-203	5.28	431.62

Date August 2018
GWP# 6827-14-00

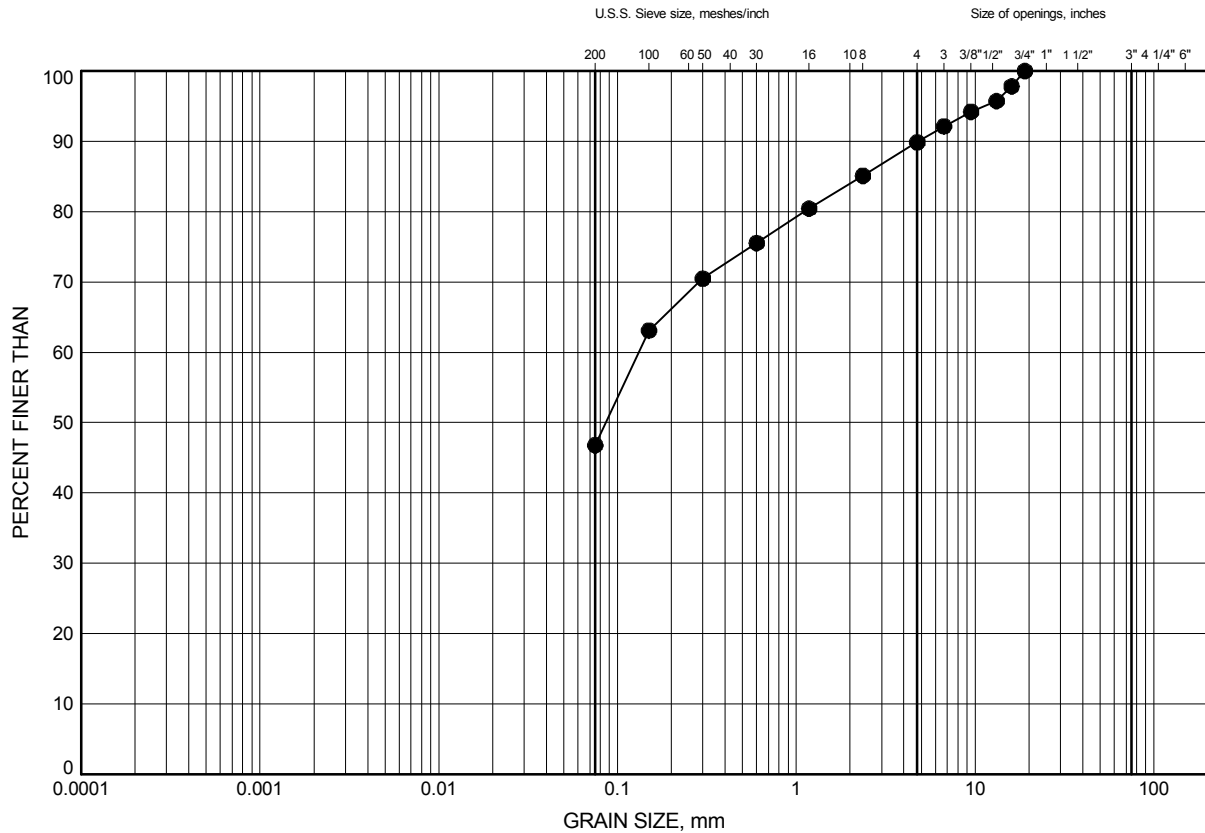


Prep'd DJP
Chkd. SD

Max Creek Culvert GRAIN SIZE DISTRIBUTION

FIGURE C3

Silty Sand Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-201	8.23	430.77

Date August 2018
GWP# 6827-14-00



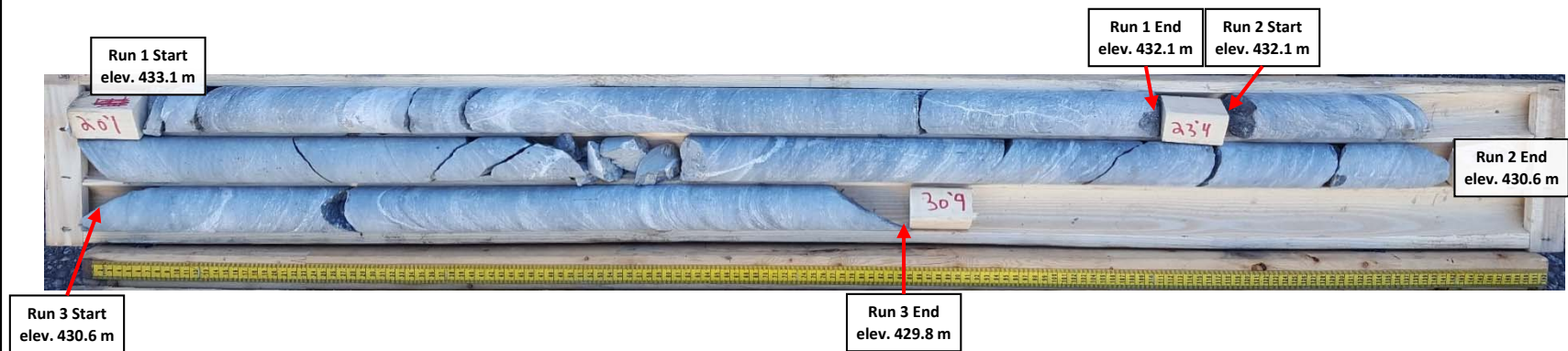
Prep'd DJP
Chkd. SD

Appendix C.2
Rock Core Photos

Borehole 18-201
Run 1 to 3 (of 3)
Elevation 430.1 to 426.7 m



Borehole 18-202
Run 1 to 3 (of 3)
Elevation 433.1 m to 429.8 m



THURBER ENGINEERING LTD.

Foundation Investigation
Max Creek Culvert Replacement
Site No.: 48C-222/C
Highway 527

GWP 6827-14-00

Project No.: 19773

Appendix C.3
Analytical Testing Results



Stantec

Stantec Consulting Ltd
100 A&B – 2781 Lancaster Rd
Ottawa, ON K1B 1A7
Tel: (613) 738-6075
Fax: (613) 738-6067

June 29, 2018
File: 122410864

Attention: Thurber Engineering, File #19773

Reference: ASTM D2974 Organic Matter of Peat & Other Soils

The table below summarizes test results for Organic Matter of Peat and Other Soils.

Source	Depth	Location	Organic Content
BH18-201 SS9	20'-22'	Highway 527 Culverts	13.8%
BH18-204 SS5B	16'8"-17'	Highway 527 Culverts	20.8%
BH18-301 SS7B	15'4"-16'2"	Highway 527 Culverts	13.0%

Sincerely,

Stantec Consulting Ltd.

Brian Prevost

Brian Prevost
Laboratory Supervisor
Tel: 613-738-6075
Fax: 613-738-6067
brian.prevost@stantec.com

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	-	-
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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: 07-Dec-2018

Order Date: 3-Dec-2018

Project Description: 19773

Client ID:	Rousseau	Max	Rinker	Wabikon
Sample Date:	11/30/2018 12:00	11/30/2018 11:45	11/30/2018 11:30	11/30/2018 11:00
Sample ID:	1849062-01	1849062-02	1849062-03	1849062-04
MDL/Units	Water	Water	Water	Water

General Inorganics

Conductivity	5 uS/cm	125	74	52	84
pH	0.1 pH Units	7.5	7.4	7.3	7.5
Resistivity	0.01 Ohm.m	79.9	135	193	119

Anions

Chloride	1 mg/L	7	2	1	4
Sulphate	1 mg/L	1	1	1	1

Client ID:	Waweig	-	-	-
Sample Date:	11/30/2018 10:00	-	-	-
Sample ID:	1849062-05	-	-	-
MDL/Units	Water	-	-	-

General Inorganics

Conductivity	5 uS/cm	56	-	-	-
pH	0.1 pH Units	7.4	-	-	-
Resistivity	0.01 Ohm.m	180	-	-	-

Anions

Chloride	1 mg/L	1	-	-	-
Sulphate	1 mg/L	<1	-	-	-

Appendix D.

Site Photographs



Photo 1. Looking northward at culvert inlets (2018/08/12)



Photo 2. Looking northward at culvert outlets (2018/08/12)



Photo 3. Looking north along Highway 527 (2018/08/12)



Photo 4. Looking south along Highway 527 (2018/08/12)



Photo 5. Looking east at Max Creek culvert outlets (2018/08/12)



Photo 6. Looking west at Max Creek culvert inlets (2018/08/12)



Photo 7. Transverse cracking near north culvert (2018/08/12)