THURBER ENGINEERING LTD.

FOUNDATION INVESTIGATION REPORT
KEKWANZIK LAKE CULVERT REPLACEMENT
HIGHWAY 599, SITE No. 48W-243/C
TOWNSHIP OF IGNACE
ONTARIO
G.W.P. No. 6836-14-00

GEOCRES Number: 52G-17

Latitude 49.439045 ° , Longitude -91.625972 °

Report

to

HATCH Corporation

Date: February 8, 2018
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PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the proposed replacement of the Kekwanzik Lake Culvert on Highway 599, located in the Township of Ignace Ontario.

The purpose of this investigation was to explore the subsurface conditions at the culvert site and, based on the data obtained, to provide a borehole location plan, stratigraphic profile, records of boreholes, laboratory test results, and a written description of the subsurface conditions.

Thurber was retained by Hatch Corporation (Hatch) to carry out this foundation investigation under the Ministry of Transportation Ontario (MTO) Agreement Number 6016-E-0030.

2. SITE DESCRIPTION

The site is located on Highway 599, approximately 4.0 km north of the intersection of Highway 599 and Highway 17 in Ignace, Ontario. The key plan showing the general location of the culvert site is presented on the Borehole Location and soil Strata Drawings in Appendix D.

Highway 599 runs in a general southwest-northeast direction with the culvert perpendicular to the centreline of the highway. The culvert allows a tributary of the Kekwanzik Lake to flow in a northwest direction beneath the highway.

The Ontario Structural Inspection Manual (OSIM) prepared by MTO dated November 2, 2015 indicates that the existing structure is a 27-m long, three span open footing, timber structure culvert. Each span is 1.8 m wide, resulting in a total culvert width of 5.4 m. The culvert is 2.1 m

in height. The grade level of Highway 599 at the existing culvert is at an approximate Elevation of 420.8 m. The height of the existing fill cover is approximately 2.0 m. The culvert invert is at approximately Elevation 416.8 m at the inlet and 416.7 m at the outlet. The upstream and downstream water levels at Kekwanzik Lave were measured at Elevations 417.7and 416.8, respectively, in April 2016, as shown on drawings provided by Hatch.

The lands surrounding the Kekwanzik Lake Culvert site predominantly consist of heavily forested areas with occasional marsh lands and lakes. Local topography is generally of low relief and consists of organic terrain. Beaver dam activities were noted near the culvert inlet. Photographs of the culvert and surrounding area are presented in Appendix C.

Based on published geological information, the subsurface soils at the site generally consist of outwash plains of sand and gravel with organic deposits of peat located near by. Bedrock in the area has been identified as granodiorite to granite bedrock.

3. INVESTIGATION PROCEDURES

The borehole investigation and field testing program for this project was carried out between June 9 and August 1, 2017, and consisted of drilling and sampling ten (10) boreholes, designated as Boreholes KE17-01A, KE17-01B, KE17-01C, and KE17-02 to KE17-08. Three attempts were made to advance Borehole KE17-01 to an appropriate depth and are designated as KE17-01A to KE17-01C.

Boreholes KE17-01A to KE17-01C and KE17-02 to KE17-04 were drilled along the culvert alignment. Boreholes KE17-01A to KE17-01C were drilled at the outlet and terminated at depths raging from 1.8 m to 7.3 m (Elevations 415.2 to 410.9). Boreholes KE17-02 and KE17-03 were drilled through the highway embankment. Borehole KE17-04 was drilled at the inlet. Borehole KE17-03 was terminated at 14.2 m (Elevation 406.4). Bedrock was proved by NQ size diamond in Boreholes KE17-02 and KE17-04, and advanced 3.0 m and 3.1 m into bedrock. Both boreholes were terminated at 16.8 m and 11.9 m depth (Elevations 404.0 and 406.6).

Boreholes KE17-05 to KE17-08 were drilled through the paved section of Highway 599, to the west and east of the existing culvert, at approximately 10.0 m intervals. These boreholes were advanced to assess the existence and extents of any frost taper near the culvert. Boreholes KE17-05 to KE17-08 were terminated at depths ranging from 1.2 m to 8.2 m (Elevations 419.7 to 412.6). Borehole KE17-06 was located 10.4 m west of the existing culvert centreline, near the alignment of the proposed diversion pipe.

The boreholes on the highway platform and at the inlet, were drilled using a rubber track mounted drill rig equipped with continuous flight hollow and solid stem augers. The boreholes drilled at the outlet were advanced using tripod equipment. NQ coring methods were used to advance Boreholes KE17-02 and KE17-04 into the bedrock. Samples of the overburden soils were obtained from the boreholes at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). A Dynamic Cone Penetration Test (DCPT) was carried out in proximity to Borehole KE17-02 to further assess the subsurface/soil conditions. This DCPT was conducted from 3.0 m (Elevation 417.8) depth to refusal reached at 13.4 m depth (Elevation 407.4).

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

All rock cores were logged, and the Total Core Recovery (TCR), Rock Quality Designation (RQD) and the Fracture Indices (FI) were determined. Photos of the rock cores are included in Appendix B.

Groundwater conditions in the open boreholes were observed throughout the drilling operations and upon completion of drilling. A piezometer was installed in Borehole KE17-04 on June 11, 2017, and a piezometer reading was taken on June 13, 2017. The piezometer was decommissioned on June 13, 2017. The boreholes were backfilled in general accordance with Ontario Regulation 903. Completion details of the boreholes are summarized in Table 3.1.

Table 3.1 – Borehole Completion Details

Borehole Number	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
KE17-01A	1.8 / 415.7	None installed	Borehole backfilled with bentonite holeplug to surface.
KE17-01B	2.4 / 415.2	None installed	Borehole backfilled with bentonite holeplug to surface
KE17-01C	7.3 / 410.9	None installed	Borehole backfilled with bentonite holeplug to surface
KE17-02	16.8 / 404.0	None installed	Borehole backfilled with auger cuttings/slough to 5.5 m, bentonite holeplug to 0.2 m, then asphalt patch to surface.

Borehole Number	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
KE17-03	14.2 / 406.4	None installed	Borehole backfilled with auger cuttings/slough to 5.9 m, gravel to 0.2 m, then asphalt patch to surface.
KE17-04	11.9 / 406.6	8.8 / 409.7	Bentonite holeplug from 11.9 m to 8.8 m, screened depth from 8.8 m to 5.8 m, sand from 5.8 m to surface
KE17-05	1.2 / 419.7	None installed	Borehole backfilled with auger cuttings to 0.2 m, then asphalt to surface.
KE17-06	8.2 / 412.6	None installed	Borehole backfilled with auger cuttings to 0.9 m, concrete to 0.2 m, then asphalt to surface.
KE17-07	3.7 / 417.0	None installed	Borehole backfilled with auger cuttings to 0.9 m, concrete to 0.2 m, then asphalt to surface.
KE17-08	3.7 / 417.0	None installed	Borehole backfilled with auger cuttings to 0.9 m, concrete to 0.2 m, then asphalt to surface.

4. LABORATORY TESTING

All recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size distribution analyses (sieve and/or hydrometer) where appropriate. The results of this laboratory testing program are shown on the Record of Borehole sheets included in Appendix A and on the figures included in Appendix B.

Point load tests were carried out on selected samples of intact bedrock upon arrival at the laboratory to assist in evaluation of the compressive strength of the bedrock. Results of point load tests on the rock core samples are included in Appendix B and on the Record of Borehole sheets in Appendix A.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for corrosion associated with the structure, a sample of the existing native soil, and a sample of the surface water from the upstream of the existing culvert were collected. The samples were submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield,

Ontario, for analytical testing of corrosivity parameters and sulphate content. The results of the analytical testing are summarized in Section 6 and are presented in Appendix B.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets 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 and should be used for interpretation of site conditions. It must be recognized and expected that soil conditions may vary between and beyond the borehole locations.

In general, the subsurface conditions encountered in the boreholes below the existing embankment fill typically consist of gravelly sand to sand overlying layers of native sand, gravelly sand, silt and, sand and silt, which were further underlain by gravel, cobbles and boulders. The native soils are underlain by granite bedrock. Descriptions of the individual strata are presented below.

5.1 Topsoil and Organics

Topsoil was encountered at the surface in Boreholes KE17-01B and KE17-01C. The thickness of the topsoil was 50 mm. The topsoil thickness may vary between and beyond the borehole locations and the data is not intended for the purpose of estimating quantities.

Organics were encountered beneath the fill in Boreholes KE17-04 and KE17-06 at 2.7 m and 4.6 m depth (Elevations 415.8 and 416.2), respectively. The thickness of organics ranged from 50 mm to 300 mm.

Measured moisture contents in the organics were 25 percent to 42 percent.

5.2 Asphalt

The boreholes drilled through the paved portion of Highway 599 encountered approximately 25 mm of asphalt at the ground surface. The ground surface elevations of the boreholes drilled on the highway platform ranged from 420.6 to 420.9.

5.3 Embankment Fill

Embankment fill was encountered below the asphalt in all boreholes drilled on Highway 599 platform. The embankment fill generally consisted of sand containing trace to some silt, trace to some gravel and trace clay. Where fully penetrated, the embankment fill typically extended to depths of approximately 3.3 m to 4.6 m (Elevations 416.2 m to 417.4 m) below the existing road surface. Fill was also encountered at the outlet and inlet, in Boreholes KE17-01A and KE17-04 and extended to depths of 0.6 m and 2.7 m (Elevations 415.8 m and 416.9 m), respectively.

Boreholes KE17-05 and KE17-08 were terminated within the fill at 1.2 m and 3.7 m depth (Elevations 419.7 and 417.0), respectively.

SPT 'N' values in the granular fill ranged from 2 to 21 blows for 0.3 m penetration, indicating a very loose to compact relative density. Measured moisture contents ranged from 4 percent to 13 percent.

The results of grain size distribution analyses conducted on samples of the fill are presented on the Record of Borehole sheets included in Appendix A and are summarized in the following table. The results are also presented on Figure B1 in Appendix B.

Soil Particle	Fill (percent)
Gravel	3 to 20
Sand	70 to 81
Silt	12 to 15
Clay	3 to 4
Silt & Clay	10 to 15

5.4 Gravelly Sand

Native, brown gravelly sand containing trace to some silt and clay, was contacted below the fill and topsoil in Boreholes KE17-01A and KE17-01B, near the culvert outlet.

Boreholes KE17-1A and KE17-01B were terminated at 1.8 m and 2.4 m depth (Elevations 415.7 and 415.2), upon refusal.

A lower unit of grey gravelly sand was encountered in Borehole KE17-04 at 7.6 m (Elevation410.9), above the bedrock. The thickness of the lower gravelly sand layer was 1.2 m.

SPT 'N' values recorded in the gravelly sand ranged from 10 to 87 blows for 0.3 m penetration, indicating a compact to very dense state. Measured moisture contents in the gravelly sand ranged from 6 percent to 17 percent.

The results of grain size distribution analyses conducted on samples of the gravelly sand are presented on the Record of Borehole sheets included in Appendix A and are summarized in the following table. The results are also presented on Figure B2 in Appendix B.

Soil Particle	Gravelly Sand (percent)
Gravel	22 to 29
Sand	64 to 70
Silt & Clay	7 to 10

5.5 Sand

Brown to grey sand containing some gravel, some silt and trace to some clay, was contacted in Borehole KE17-01C below the topsoil and also below the silt at 4.9 m depth (Elevation 413.3), and in Boreholes KE17-02 to KE17-04 at depths ranging from 2.7 m to 9.7 m (Elevations 415.8 to 410.9). The thickness of the sand varied from 0.8 m to 2.6 m.

The depth to the base of the sand was 3.5 m (Elevation 415.0) in Borehole KE17-04, and 12.2 m and 11.9 m (Elevations 408.6 and 408.7), in Boreholes KE17-02 and KE17-03, respectively.

Borehole KE17-01C was terminated within the sand layer at 7.3 m depth (Elevation 410.9).

SPT 'N' values recorded in the sand ranged from 7 to 25 blows for 0.3 m penetration, indicating a loose to compact relative density. Measured moisture contents in the sand deposits ranged from 10 percent to 23 percent.

The results of grain size distribution analyses conducted on samples of the sand are presented on the Record of Borehole sheets included in Appendix A and are summarized in the following table. The results are also presented on Figure B3 in Appendix B.

Soil Particle	Sand (percent)
Gravel	0 to 16
Sand	59 to 81
Silt	17
Clay	2
Silt & Clay	25

5.6 Silt to Sand and Silt

Layers of brown to grey silt to sand and silt were encountered in Boreholes KE17-01C, KE17-02 to KE17-04, KE17-06 and KE17-07 beneath the fill or native sand, at depths ranging from 0.7 m to 4.9 m (Elevations 417.5 to 415.0). The silt to sand and silt generally contains trace to some sand, trace clay. The thickness of the silt and, silt and sand layers ranged from 4.1 m to 6.2 m.

The silt to sand and silt generally extended to depths ranging between 4.9 m and 9.7 m (Elevations 413.3and 410.9).

Boreholes KE17-06 and KE17-07 were terminated within the silt/sand and silt at 8.2 m and 3.7 m depth (Elevations 412.6 and 417.0), respectively.

SPT 'N' values recorded in the silt to sand and silt ranged from 1 to 37 blows for 0.3 m penetration, indicating a very loose to dense relative density. The loose to very loose conditions were noted within approximate Elevations 415.0 to 411.5, and may have been the result of hydraulic ground disturbance during drilling operations. Measure moisture contents in the silt to sand and silt ranged from 6 percent to 28 percent.

The results of grain size analyses conducted on samples of the silt to sand and silt are provided on the Record of Borehole sheets in Appendix A, and illustrated in Figure B4 of Appendix B. The results are summarized as follows:

Soil Particle	Silt, Sand and Silt (percent)
Gravel	0
Sand	7 to 65
Silt	32 to 85
Clay	2 to 8

5.7 Gravel, Cobbles and Boulders

Cobbles and boulders were encountered in Borehole KE17-02 at 12.2 m depth (Elevation 408.6). The cobbles and boulders generally contained some sand and gravel and trace silt. The cobbles and boulders were proved by coring. The layer of the cobbles and boulders was 1.6 m thick.

The depth to the base of the cobbles and boulders was 13.8 m (Elevation 407.0).

A layer of gravel containing some sand, was contacted at 13.7 m depth (Elevation 406.9) in Borehole KE17-03. Borehole KE17-03 was terminated within the gravel layer at 14.2 m (Elevation 406.4).

A SPT 'N' value recorded in the gravel layer was 107 blows for 0.3 m penetration, indicating a very dense state. Measured moisture contents in the gravel, cobbles and boulders layers were 5 percent and 10 percent.

5.8 Bedrock

The overburden soils described above are underlain by granite bedrock. The bedrock was grey with occasional pink bands. Occasional mechanical breaks were noted throughout the bedrock cores. The bedrock is generally described as highly to moderately weathered. Bedrock was proved by coring in Boreholes KE17-02 and KE17-04. Table 5.1 summarizes depths and elevations to the top of bedrock.

Table 5.1 – Depths and Elevations of Top of Bedrock

Borehole	Top of Bedrock	
	Depth (m)	Elevation (m)
KE17-02(1)	13.8	407.0
KE17-04(1)	8.8	409.7

(1) Proved by coring.

Total Core Recovery (TCR) in the bedrock ranged from 93% to 100% with Solid Core Recovery (SCR) ranging from 23% to 88%. The Rock Quality Designation (RQD) determined from the recovered cores generally ranged from 0% to 82%, indicating very poor to good rock quality.

The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, ranged from 1 to greater than 10.

Average unconfined compressive strengths (UCS) of the rock ranged between 30 MPa and 224 MPa, indicating the rock is medium strong to very strong. These estimated rock strength values are interpreted from point load tests that were conducted on rock cores recovered from the boreholes. A summary of the Point Load Test Results and photographs of bedrock cores are presented in Appendix B.

5.9 Groundwater Conditions

Groundwater conditions were observed during drilling operations and groundwater levels were measured in the open boreholes upon completion of drilling. A piezometer was also installed in Borehole KE17-04. The groundwater levels measured in the open boreholes and the piezometer are summarized in Table 5.2 below.

Table 5.2 – Groundwater Measurements

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
KE17-01A	June 16, 2017	1.2	416.3	Open borehole
KE17-01B	June 16, 2017	1.2	416.4	Open borehole
KE17-01C	June 17, 2017	0.7	417.5	Open borehole
KE17-02	June 13, 2017	3.9	416.9	Open borehole
KE17-03	June 15, 2017	3.5	417.1	Open borehole
KE17-04	June 13, 2017	1.0	417.5	Piezometer
KE17-05	June 09, 2017	Dry	-	Open borehole
KE17-06	June 16, 2017	3.9	416.9	Open borehole
KE17-07	June 14, 2017	3.0	417.7	Open borehole
KE17-08	June 14, 2017	Dry	-	Open borehole

The above groundwater levels are short-term readings and seasonal fluctuations of the groundwater levels are to be expected. In particular, the groundwater levels may be at a higher elevation during spring and after periods of significant or prolonged precipitation. The groundwater level should be assumed to reflect the local lake level.

6. CORROSIVITY AND SULPHATE TEST RESULTS

A sample of the native sandy silt from Borehole KE17-03, and a sample of the lake water, taken from the inlet area, were submitted for analytical testing of corrosivity parameters and sulphate. The results of the analytical tests are shown in Table 6.1. The laboratory certificates of analysis are presented in Appendix B.

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Table 6.1 – Analytical Test Results

Parameter	Units (Soil)	Units (Water)	Test Results	
			KE17-03 SS5	Kekwanzik Lake
			(Sandy Silt)	(Lake Water)
Sulphide	%	mg/L	<0.02	<0.006
Chloride	µg/g	mg/L	240	8.8
Sulphate	µg/g	mg/L	10	2.0
pH	No unit	No unit	6.40	7.38
Electrical Conductivity	µS/cm	µS/cm	269	67
Resistivity	Ohms.cm	Ohms.cm	3720	15000
Redox Potential	mV	mV	338	312

7. MISCELLANEOUS

Thurber obtained subsurface utility clearances prior to drilling. Thurber obtained the northing and easting coordinates and ground surface elevations from measurements taken in the field relative to the topographic plans provided by Hatch.

RPM Drilling Inc. of Thunder Bay, Ontario supplied and operated the drilling, sampling and in-situ testing equipment for the field investigation. The field investigation was supervised on a full time basis by Mr. Ryan McCourt, P. Geo of Thurber. Overall supervision of the field program was provided by Mr. Cory Zanatta, EIT of Thurber.

Geotechnical laboratory testing was carried out at Thurber's geotechnical laboratory. Analytical laboratory testing was carried out by SGS Canada Inc. Interpretation of the field data and preparation of this report was carried out by Mr. Cory Zanatta, EIT and Ms. R. Palomeque Reyna, The report was reviewed by Mr. Jason Lee, P.Eng and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT[(1)] 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

1) Laboratory Triaxial Testing
2) Field Insitu Vane Testing
3) Laboratory Vane Testing
4) SPT value
5) Pocket Penetrometer

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample		TP Thin Wall Piston Sample
	PH Sampler Advanced by Hydraulic Pressure		PM Sampler Advanced by Manual Pressure
	WH Sampler Advanced by Self Static Weight	RC Rock Core	SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$

▼ Water Level

C_{pen} Shear Strength Determination by Pocket Penetrometer

(1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.

(2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

EXPLANATION OF ROCK LOGGING TERMS

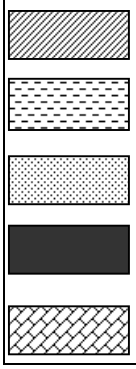
ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.
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 structure are preserved.

DISCONTINUITY SPACING

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

SYMBOLS



CLAYSTONE

SILTSTONE

SANDSTONE

COAL

BEDROCK

STRENGTH CLASSIFICATION

Rock Strength	**Approximate Uniaxial Compressive Strength (MPa)**	**(psi)**	**Field Estimation of Hardness***
Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

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 0.1m in length or larger as a % of total core run length.
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen
Fracture Index:(FI)	Frequency of natural fractures per 0.3m of core run.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	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	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and 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. ($W_L < 30\%$).
		CI	Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

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THURBER

RECORD OF BOREHOLE No KE17-01A 1 OF 1 METRIC

GWP# 6836-14-00 LOCATION Kekwanzik Lake Culvert, MTM NAD 83 Zone 16 N 5 478 833.0 E 404 445.2 ORIGINATED BY BRM

HWY 599 BOREHOLE TYPE Tripod - Wash Boring COMPILED BY AN

DATUM Geodetic DATE 2017.06.16 - 2017.06.16 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100) ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
417.5	GROUND SURFACE										
0.0	**SAND**, trace gravel, occasional organics Compact Brown Moist (FILL)		1	SS	21		417	○	○		
416.9											
0.6	Gravelly **SAND**, trace to some silt and clay Dense to Very Dense Brown Wet		2	SS	30	▽		○	○		
			3	SS	87		416	○	○		22 68 10 (SI+CL)
415.7											
1.8	END OF BOREHOLE AT 1.8m UPON CASING REFUSAL. WATER LEVEL MEASURED AT 1.2m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.										

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

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THURBER

RECORD OF BOREHOLE No KE17-01B 1 OF 1 METRIC

GWP# 6836-14-00 LOCATION Kekwanzik Lake Culvert, MTM NAD 83 Zone 16 N 5 478 834.2 E 404 446.0 ORIGINATED BY BRM

HWY 599 BOREHOLE TYPE Tripod - Wash Boring COMPILED BY AN

DATUM Geodetic DATE 2017.06.16 - 2017.06.16 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
417.6	GROUND SURFACE										
0.0 / 0.0	**TOPSOIL:** (50mm)										
	Gravelly **SAND**, trace silt and clay Compact to Very Dense Brown Moist to Wet		1	SS	10		417		○		
			2	SS	24	▽			○		
			3	SS	55		416		○		
415.2			4	SS	16				○		29 64 7 (SI+CL)
2.4	END OF BOREHOLE AT 2.4m UPON CASING REFUSAL. WATER LEVEL MEASURED AT 1.2m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.										

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

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THURBER

RECORD OF BOREHOLE No KE17-01C 1 OF 1 METRIC

GWP# 6836-14-00 LOCATION Kekwanzik Lake Culvert, MTM NAD 83 Zone 16 N 5 478 820.2 E 404 435.8 ORIGINATED BY BRM

HWY 599 BOREHOLE TYPE Tripod - Wash Boring COMPILED BY AN

DATUM Geodetic DATE 2017.06.17 - 2017.06.17 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
418.2	GROUND SURFACE										
0.0	**TOPSOIL:** (50mm)						418				
0.0	**SAND**, trace gravel Compact Brown		1	SS	16	▽			○		
417.5	Moist										
0.7	**SILT**, trace to some sand, trace clay Dense to Compact Brown to Grey Moist to Wet		2	SS	10		417		○		
			3	SS	33				○		
			4	SS	23		416		○		0 7 85 8
			5	SS	12				○		
			6	SS	11		415		○		0 17 76 7
			7	SS	14				○		
			8	SS	16		414		○		
413.3											
4.9	**SAND**, some silt, trace clay Compact to Loose Grey Moist		9	SS	19		413		○		0 81 17 2
			10	SS	25				○		
			11	SS	7		412				
			12	SS	10				○		
410.9							411				
7.3	END OF BOREHOLE AT 7.3m UPON CASING REFUSAL. WATER LEVEL MEASURED AT 0.7m UPON COMPLETION OF BOREHOLE. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.										

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

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THURBER

RECORD OF BOREHOLE No KE17-02 1 OF 2 METRIC

GWP# 6836-14-00 LOCATION Kekwanzik Lake Culvert, MTM NAD 83 Zone 16 N 5 478 815.9 E 404 445.7 ORIGINATED BY BRM

HWY 599 BOREHOLE TYPE Hollow Stem Augers/Coring COMPILED BY AN

DATUM Geodetic DATE 2017.06.13 - 2017.06.13 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
420.8	GROUND SURFACE										
0.0	**ASPHALT:** (25mm)										
0.0	**SAND**, some silt, trace clay, trace gravel Very Loose to Loose Brown Moist (FILL)		1	GS					○		
			2	GS			420		○		
			1	SS	3		419		○		3 81 12 4
			2	SS	9		418		○		
417.4			3	SS	6				○		
3.4	**SAND** and **SILT**, trace clay Loose to Very Loose Grey Moist					▽	417				
			4	SS	7		416		○		
			5	SS	2		415		○		
	Low SPT "N" values due to hydraulic ground disturbance from approx. elevation 415.0m to 411.0m						414				
			6	SS	1		413		○		0 47 49 4
			7	SS	1		412		○		
411.2							411				
9.6	**SAND**, trace to some gravel, some silt and clay										

Continued Next Page

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

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THURBER

RECORD OF BOREHOLE No KE17-02 2 OF 2 METRIC

GWP# 6836-14-00 LOCATION Kekwanzik Lake Culvert, MTM NAD 83 Zone 16 N 5 478 815.9 E 404 445.7 ORIGINATED BY BRM

HWY 599 BOREHOLE TYPE Hollow Stem Augers/Coring COMPILED BY AN

DATUM Geodetic DATE 2017.06.13 - 2017.06.13 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	SAND, some gravel, some silt and clay Compact Grey Wet						410		○		
			8	SS	15						16 59 25 (SI+CL)
408.6							409				
12.2	**COBBLES** and **BOULDERS**, some sand, some gravel								○		
			1	RUN			408				RUN #1 TCR=62%
407.0									○		
13.8	**BEDROCK GRANITE**, highly weathered, pink and grey, mechanical breaks						407			FI	
			2	RUN						6 5 1 2	RUN #2 TCR=93% SCR=45% RQD=20% UCS=188MPa (Average)
							406			1	
			3	RUN			405			3 3	RUN #3 TCR=97% SCR=88% RQD=82% UCS=212MPa (Average)
404.0	Slightly weathered						404			0	
16.8	END OF BOREHOLE AT 16.8m. WATER LEVEL AT 3.9m UPON COMPLETION. BOREHOLE BACKFILLED WITH SLOUGH TO 5.5m, BENTONITE HOLEPLUG TO 0.2m, THEN ASPHALT TO SURFACE.										

$+^3$, $\times^3$: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

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THURBER

RECORD OF BOREHOLE No KE17-03 1 OF 2 METRIC

GWP# 6836-14-00 LOCATION Kekwanzik Lake Culvert, MTM NAD 83 Zone 16 N 5 478 821.6 E 404 454.6 ORIGINATED BY BRM

HWY 599 BOREHOLE TYPE Hollow Stem Augers/Dynamic Cone Penetration Test COMPILED BY AN

DATUM Geodetic DATE 2017.06.15 - 2017.06.15 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
420.6	GROUND SURFACE										
0.0	**ASPHALT:** (25mm)										
	SAND, some silt, trace gravel, trace clay Very Loose to Loose Brown Moist (FILL)		1	GS			420		○		
			1	SS	5				○		
			2	SS	3		419		○		6 78 13 3
			3	SS	7		418		○		
			4	SS	8	▽	417		○		
416.6											
4.0	**SILT**, some sand, trace clay Compact to Very Loose Brown Moist		5	SS	10		416		○		
	Brown to Grey Wet		6	SS	7		415		○		0 18 77 5
			7	SS	3		414		○		
	Dense		8	SS	37		413		○		
410.9							412				
9.7	**SAND**, trace gravel Compact						411				

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+ ^{3}, × ^{3}: Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

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THURBER

RECORD OF BOREHOLE No KE17-03 2 OF 2 METRIC

GWP# 6836-14-00 LOCATION Kekwanzik Lake Culvert, MTM NAD 83 Zone 16 N 5 478 821.6 E 404 454.6 ORIGINATED BY BRM

HWY 599 BOREHOLE TYPE Hollow Stem Augers/Dynamic Cone Penetration Test COMPILED BY AN

DATUM Geodetic DATE 2017.06.15 - 2017.06.15 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
408.7	**SAND**, trace gravel Compact Grey Wet		9	SS	17		410 409				
11.9 406.9	End of sampling at 11.9m and start DCPT						408 407				
13.7 406.4	**GRAVEL**, some sand Very Dense Brown Moist		10	SS	107						
14.2	END OF BOREHOLE AT 14.2m. WATER LEVEL MEASURED AT 3.5m UPON COMPLETION. BOREHOLE WAS WASH BORED FROM 11.9m TO 13.7m. BOREHOLE BACKFILLED WITH SLOUGH TO 5.9m, GRAVEL TO 0.2m, THEN ASPHALT TO SURFACE.										

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L

WATER CONTENT (%): 20 40 60

+ ³, × ³: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No KE17-04 1 OF 2 METRIC

GWP# 6836-14-00 LOCATION Kekwanzik Lake Culvert, MTM NAD 83 Zone 16 N 5 478 802.5 E 404 453.6 ORIGINATED BY BRM

HWY 599 BOREHOLE TYPE Hollow Stem Augers/Coring COMPILED BY AN

DATUM Geodetic DATE 2017.06.11 - 2017.06.11 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
418.5	GROUND SURFACE										
0.0	**SAND**, some silt, trace gravel, trace clay Very Loose Brown Moist (FILL)		1	GS					○		
			1	SS	3	▼	418		○		
			2	SS	2		417		○		
415.8			3	SS	2		416		○		
415.8 2.7	**ORGANICS** Dark Brown Wet (50mm)										
415.0 3.5	**SAND**, trace gravel Very Loose to Loose Grey Wet		4	SS	7		415		○		
	SAND and **SILT**, trace clay Very Loose Brown to Grey Moist to Wet										
	Low SPT "N" values due to hydraulic ground disturbance from approx. elevation 414.5m to 412.5m		5	SS	1		414		○		0 49 49 2
	Grey Wet		6	SS	4		413		○		
410.9							412				
7.6	Gravelly **SAND**, trace silt and clay Compact Grey Wet		7	SS	11		411		○		
409.7			8	SS	50/ 0.150		410		○		22 70 8 (SI+CL)
8.8	**BEDROCK GRANITE**, moderately weathered, pink, blue and grey, mechanical breaks		1	RUN			409			FI 3 >10 8 5	RUN #1 TCR=100% SCR=42% RQD=0% UCS=224MPa (Average)

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No KE17-04 2 OF 2 METRIC

GWP# 6836-14-00 LOCATION Kekwanzik Lake Culvert, MTM NAD 83 Zone 16 N 5 478 802.5 E 404 453.6 ORIGINATED BY BRM

HWY 599 BOREHOLE TYPE Hollow Stem Augers/Coring COMPILED BY AN

DATUM Geodetic DATE 2017.06.11 - 2017.06.11 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	BEDROCK GRANITE, moderately weathered, pink, blue and grey, mechanical and sub-vertical breaks									7	
							408			8	
			2	RUN						>10	
										4	RUN #2 TCR=100% SCR=23% RQD=0% UCS=30MPa (Average)
							407			5	
406.6										5	
11.9	END OF BOREHOLE AT 11.9m. Well installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.										
	WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2017.06.13 1.0 417.5										

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No KE17-05 1 OF 1 METRIC

GWP# 6836-14-00 LOCATION Kekwanzik Lake Culvert, MTM NAD 83 Zone 16 N 5 478 801.9 E 404 437.0 ORIGINATED BY BRM

HWY 599 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.06.09 - 2017.06.09 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
420.9	GROUND SURFACE										
0.0	**ASPHALT:** (25mm)										
	SAND, some silt and clay, trace gravel Light Brown Moist (FILL)		1	GS					○		
			2	GS			420		○		8 77 15 (SI+CL)
419.7											
1.2	END OF BOREHOLE AT 1.2m UPON AUGER REFUSAL. BOREHOLE DRY UPON COMPLETION. BOREHOLE BACKFILED WITH AUGER CUTTINGS TO 0.2m, THEN ASPHALT TO SURFACE.										

$+^3$, $\times^3$: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

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THURBER

RECORD OF BOREHOLE No KE17-06 1 OF 1 METRIC

GWP# 6836-14-00 LOCATION Kekwanzik Lake Culvert, MTM NAD 83 Zone 16 N 5 478 810.4 E 404 442.8 ORIGINATED BY BRM

HWY 599 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.06.16 - 2017.06.16 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
420.8	GROUND SURFACE										
0.0	**ASPHALT:** (25mm)										
0.0	**SAND**, some silt, trace gravel, trace clay Compact to Very Loose Brown Moist (FILL)		1	GS					○		
			1	SS	13		420		○		
			2	SS	6		419		○		
			3	SS	3				○		4 78 15 3
			4	SS	6		418		○		
416.2						▽	417				
4.6	**ORGANICS**, trace gravel Dark Brown Wet		5	SS	10		416		○		
415.9											
4.9	(300mm)										
	SAND and **SILT**, trace clay Loose Grey Wet		6	SS	6		415		○		
			7	SS	5		414		○		0 65 32 3
412.6							413				
8.2	END OF BOREHOLE AT 8.2m. WATER LEVEL MEASURED AT 3.9m UPON COMPLETION. BOREHOLE BACKFILLED WITH AUGER CUTTINGS TO 0.9m, CEMENT TO 0.2m, THEN ASPHALT TO SURFACE.										

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

20
15 5
10
(%) STRAIN AT FAILURE

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THURBER

RECORD OF BOREHOLE No KE17-07 1 OF 1 METRIC

GWP# 6836-14-00 LOCATION Kekwanzik Lake Culvert, MTM NAD 83 Zone 16 N 5 478 827.4 E 404 458.6 ORIGINATED BY BRM

HWY 599 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.06.14 - 2017.06.14 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
420.7	GROUND SURFACE										
0.0	**ASPHALT:** (25mm)										
	SAND, some silt and clay, trace gravel Brown Moist (FILL)		1	GS			420		○		
			2	GS					○		
			3	GS			419		○		8 80 12 (SI+CL)
			4	GS		▽	418		○		
417.4											
3.3	**SILT**, some clay, occasional organics Loose Dark Brown Wet		1	SS	4				○		
417.0											
3.7	END OF BOREHOLE AT 3.7m. WATER LEVEL MEASURED AT 3.0m UPON COMPLETION. BOREHOLE BACKFILLED WITH AUGER CUTTINGS TO 0.9m, CONCRETE TO 0.2m, THEN ASPHALT TO SURFACE.										

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

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THURBER

RECORD OF BOREHOLE No KE17-08 1 OF 1 METRIC

GWP# 6836-14-00 LOCATION Kekwanzik Lake Culvert, MTM NAD 83 Zone 16 N 5 478 835.7 E 404 464.5 ORIGINATED BY BRM

HWY 599 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.06.14 - 2017.06.14 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
420.7	GROUND SURFACE										
0.0	**ASPHALT:** (25mm)										
	SAND, some gravel, trace to some silt and clay Loose Brown Moist (FILL)		1	GS			420		○		
			2	GS					○		
			3	GS			419		○		
			4	GS			418		○		
417.0			1	SS	7				○		20 70 10 (SI+CL)
3.7	END OF BOREHOLE AT 3.7m. BOREHOLE DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH AUGER CUTTINGS TO 0.9m, CONCRETE TO 0.2m, THEN ASPHALT TO SURFACE.										

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE

ONTMT4S MTO-17077.GPJ 2017TEMPLATE(MTO).GDT 1/29/18

THURBER

Appendix B

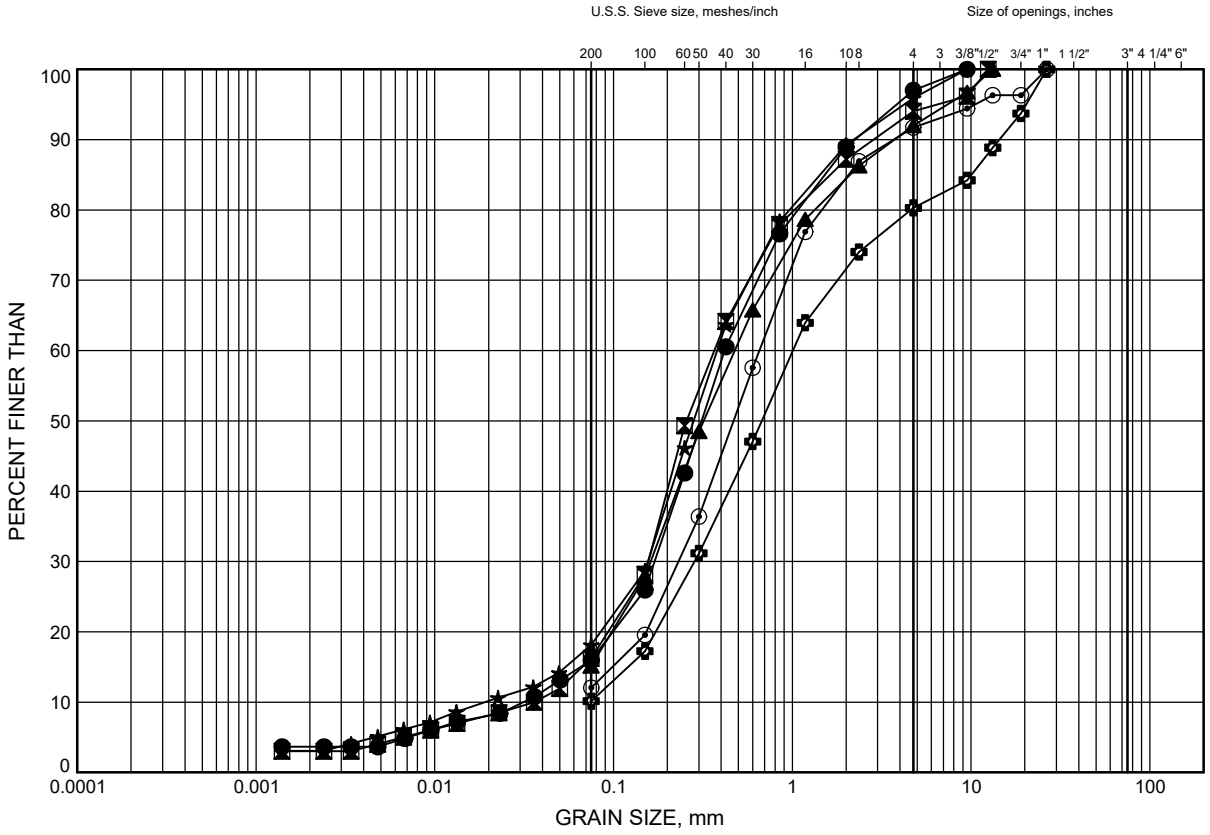
Geotechnical and Analytical Laboratory Test Results
And Rock Core Photos

Kekwanzik Lake Culvert

GRAIN SIZE DISTRIBUTION

FIGURE B1

SAND FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	KE17-02	1.8	419.0
⊠	KE17-03	1.8	418.8
▲	KE17-05	0.9	416.9
★	KE17-06	2.6	418.2
⊙	KE17-07	1.8	418.9
✿	KE17-08	3.4	417.3

Date September 2017

GWP# 6836-14-00

THURBER

Prep'd AN

Chkd. RPR

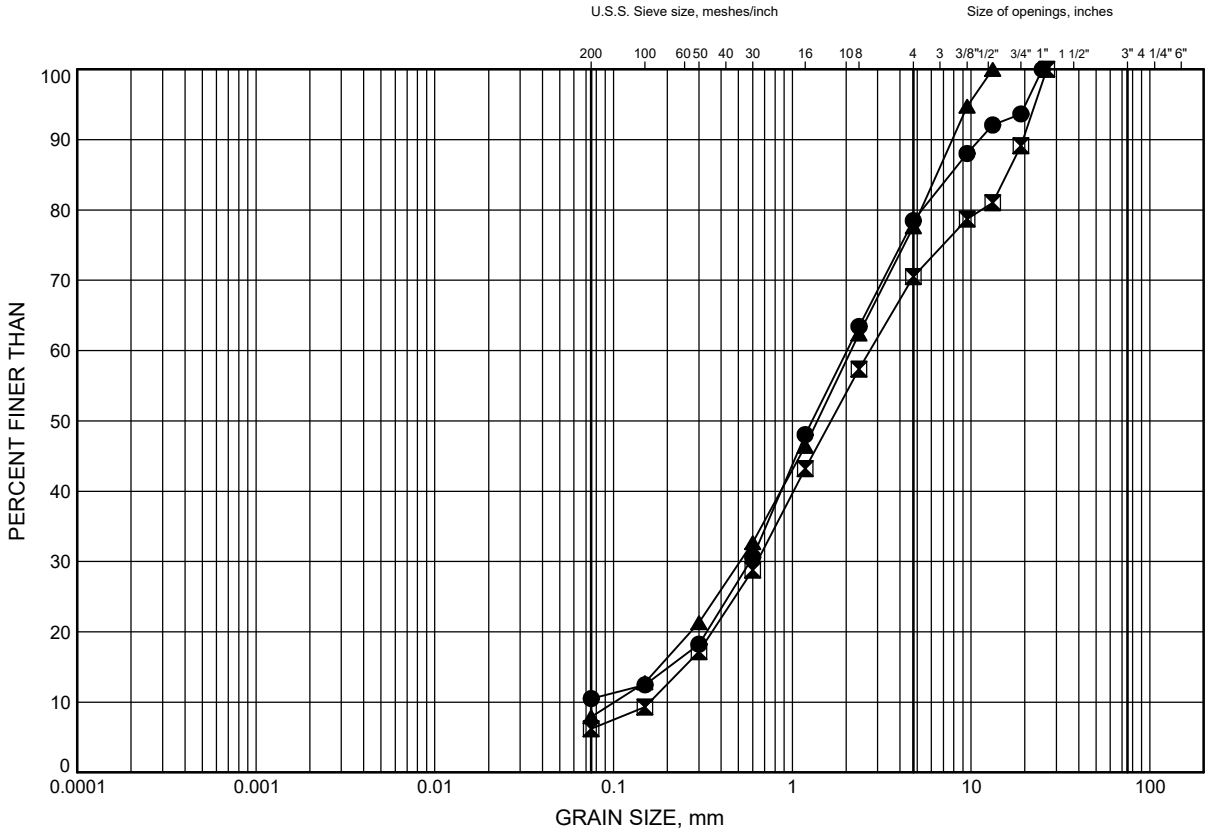
GRAIN SIZE DISTRIBUTION - THURBER MTO-17077.GPJ 9/7/17

Kekwanzik Lake Culvert

GRAIN SIZE DISTRIBUTION

FIGURE B2

Gravelly SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	KE17-01A	1.5	416.0
⊠	KE17-01B	2.1	415.5
▲	KE17-04	8.7	409.8

Date September 2017

GWP# 6836-14-00

THURBER

Prep'd AN

Chkd. RPR

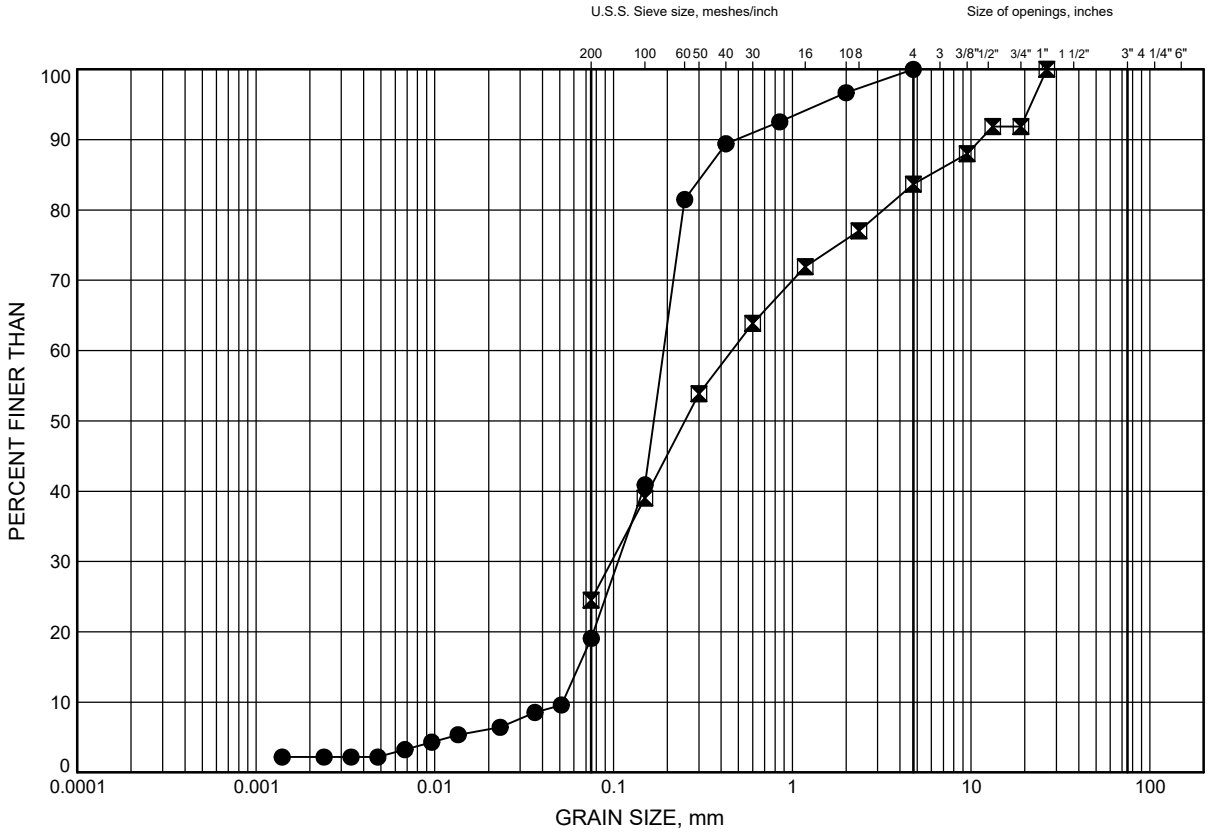
GRAIN SIZE DISTRIBUTION - THURBER MTO-17077.GPJ 9/7/17

Kekwanzik Lake Culvert

GRAIN SIZE DISTRIBUTION

FIGURE B3

SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	KE17-01C	5.2	413.0
⊠	KE17-02	11.0	409.8

Date September 2017

GWP# 6836-14-00

THURBER

Prep'd AN

Chkd. RPR

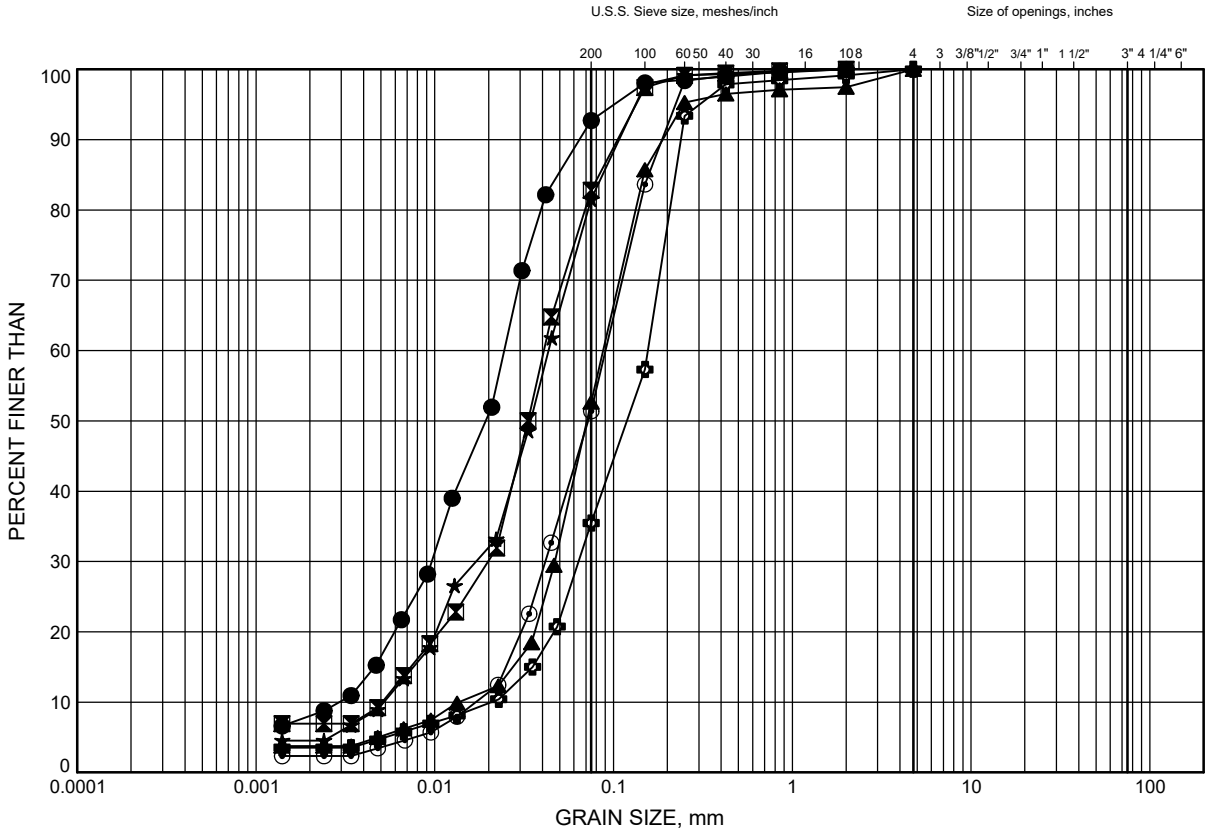
GRAIN SIZE DISTRIBUTION - THURBER MTO-17077.GPJ 9/7/17

Kekwanzik Lake Culvert

GRAIN SIZE DISTRIBUTION

FIGURE B4

SILT to SAND and SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	KE17-01C	2.1	416.1
⊠	KE17-01C	3.4	414.8
▲	KE17-02	7.9	412.9
★	KE17-03	6.4	414.2
⊙	KE17-04	4.9	413.6
✿	KE17-06	7.9	412.9

Date September 2017

GWP# 6836-14-00

THURBER

Prep'd AN

Chkd. RPR

GRAIN SIZE DISTRIBUTION - THURBER MTO-17077.GPJ 9/7/17

THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No:	17077	**Date Drilled:**	11-Jun-17
Client:	HATCH	**Date Tested:**	26-Jun-17
Project Name:	Kekwanzik Lake Culvert	**Tester:**	ISP
Core Size:	NQ **BH No :** 17-04	**Reviewed by:**	CZ

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	9.9	A	27.6	47.0	60.0	7.9	189.5	Granite	Very Strong
2	1	10.2	D	25.8	47.0	154.0	10.8	258.6	Granite	Extremely Strong
3	2	11.1	A	4.5	47.0	63.0	1.3	30.1	Granite	Medium Strong
4										
5										
6										
7										
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35										

* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have 0.7 x D on either side of test point.

* Correlation factor to obtain UCS values is 24.

THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No:	17077	**Date Drilled:**	11-Jun-17
Client:	HATCH	**Date Tested:**	26-Jun-17
Project Name:	Kekwanzik Lake Culvert	**Tester:**	ISP
Core Size:	NQ **BH No :** 17-02	**Reviewed by:**	CZ

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	6.9	A	20.9	47.0	75.4	5.0	120.6	Granite	Very Strong
2	1	7.2	D	24.3	47.0	195.1	10.1	243.2	Granite	Very Strong
3	1	7.5	A	25.1	47.0	57.7	7.4	177.6	Granite	Very Strong
4	2	7.6	D	19.7	47.0	139.6	8.2	197.7	Granite	Very Strong
5	2	7.9	A	22.8	47.0	61.6	6.4	153.4	Granite	Very Strong
6	2	8.4	D	21.2	47.0	154.5	8.9	212.8	Granite	Very Strong
7	3	8.7	A	30.2	47.0	63.2	8.3	199.1	Granite	Very Strong
8	3	9.0	D	22.5	47.0	154.5	9.4	225.4	Granite	Very Strong
9										
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35										

* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have 0.7 x D on either side of test point.

* Correlation factor to obtain UCS values is 24.

Core Photo 1: Borehole KE17-02 Run 1 to Run 3 (12.2 m to 16.8 m)

Core Photo 2: Borehole KE17-04 Run 1 to Run 2 (8.8 m to 11.9 m)

SGS Canada Inc.
185 Concession St. Box 4300
Lakefield,Ont.,Canada,
K0L 2H0

Attention: Cory Zanatta
Project#: 17077

Client Thurber Engineering Ltd.
SGS LIMS Number CA15302-AUG17
Analysis Package: **Corrosivity (Soil)**

Sample ID	Unit	PR17-02 SS7	KE 17-03 SS5	ME 17-03 SS3	TU 17-02 SPT5	CO 17-03 SS4	AG 147-02 SS4
Sample Date/Time		30-Jul-17	30-Jul-17	30-Jul-17	30-Jul-17	30-Jul-17	30-Jul-17
Moisture	%	15.6	7.0	7.7	22.2	15.6	21.0
pH	no unit	8.25	6.40	8.27	8.14	8.65	8.33
Corrosivity Index	none	4.5	1.0	1.0	1.0	4.0	1.0
Soil Redox Potential	mV	325	338	303	301	295	290
Sulphide	mg/L	0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Chloride	mg/L	6.9	240	2.4	25	1.2	150
Sulphate	mg/L	26	10	10	1.2	46	6.1
Conductivity	uS/cm	49	269	35	81	83	213
Resistivity (calculated)	ohms.cm	20300	3720	28700	12400	12000	4690

Corrosivity Scale according to AWWA C-105.
An index greater than 10 indicates the
soil matrix may be corrosive to cast iron alloys.

Deanna Edwards

Deanna Edwards B.Sc., C.Chem
Project Specialist
Environment, Health and Safety

Certificate of Analysis

SGS Canada Inc.
185 Concession St. Box 4300
Lakefield, Ont.,Canada,K0L 2H0

Attention: Cory Zanatta
Project#: 17077 Hwy 599

Client Thurber Engineering Ltd.
SGS LIMS Number CA15314-JUN17
Analysis Package: Corrosivity (Solution)

Sample ID	Unit	RL	Tug Creek	Pratt Creek	Mile Creek	Cobb Bay	Kekwanzik Lake	Agimak River
Sample Date/Time			10-Jun-17 12:10	10-Jun-17 12:30	10-Jun-17 10:40	10-Jun-17 11:20	10-Jun-17 12:45	10-Jun-17 13:10
Temperature Upon Receipt	°C		10.0	10.0	10.0	10.0	10.0	10.0
Soil Redox Potential	mV		334	272	352	301	312	345
Sulphide	mg/L	0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
pH	no unit	0.05	7.78	7.81	7.62	7.70	7.38	7.26
Chloride	mg/L	0.04	2.1	2.9	2.7	1.7	8.8	7.8
Sulphate	mg/L	0.04	0.3	1.2	0.8	0.6	2.0	1.9
Conductivity	µS/cm	2	100	78	63	78	67	56
Resistivity (calculated)	ohms.cm		9990	12700	15800	12800	15000	17700

Corrosivity Index is based on the AWWA Corrosivity Scale according to AWWA C-105. An index greater than 10 indicates the soil matrix may be corrosive to cast iron alloys.

Deanna Edwards B.Sc., C.Chem
Project Specialist
Environment, Health and Safety

THURBER

Appendix C

Selected Site Photographs

Photo 1: Highway 599 at Kekwanzik Creek Culvert looking north

Photo 2: Highway 599 at Kekwanzik Creek Culvert looking south

Photo 3: Kekwanzik Creek Culvert outlet

Photo 4: Kekwanzik Creek Culvert inlet

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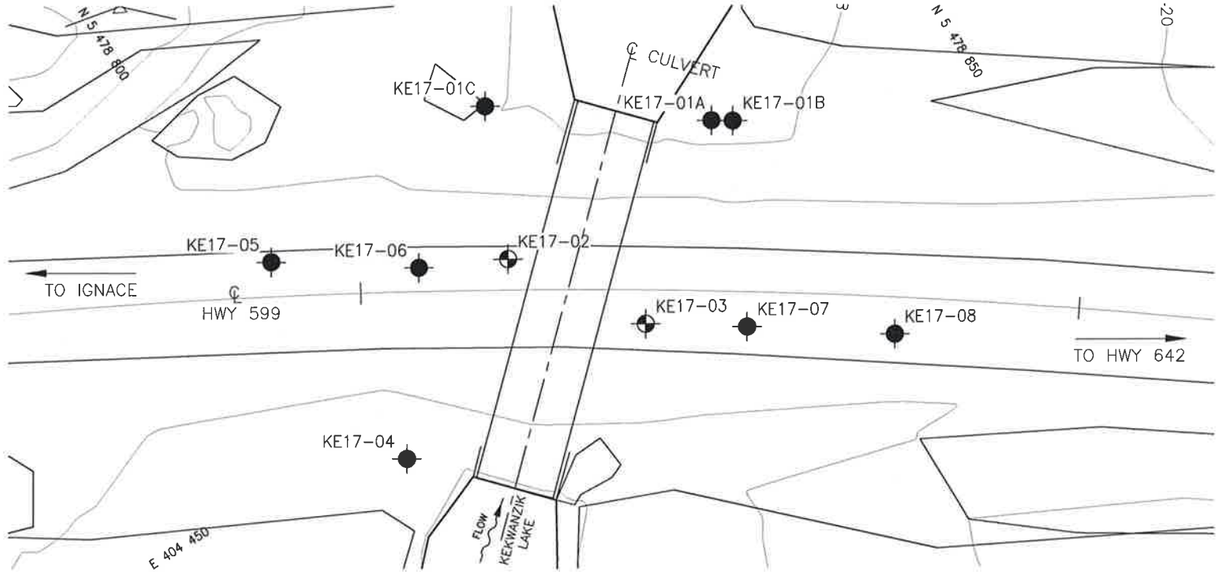
Appendix D

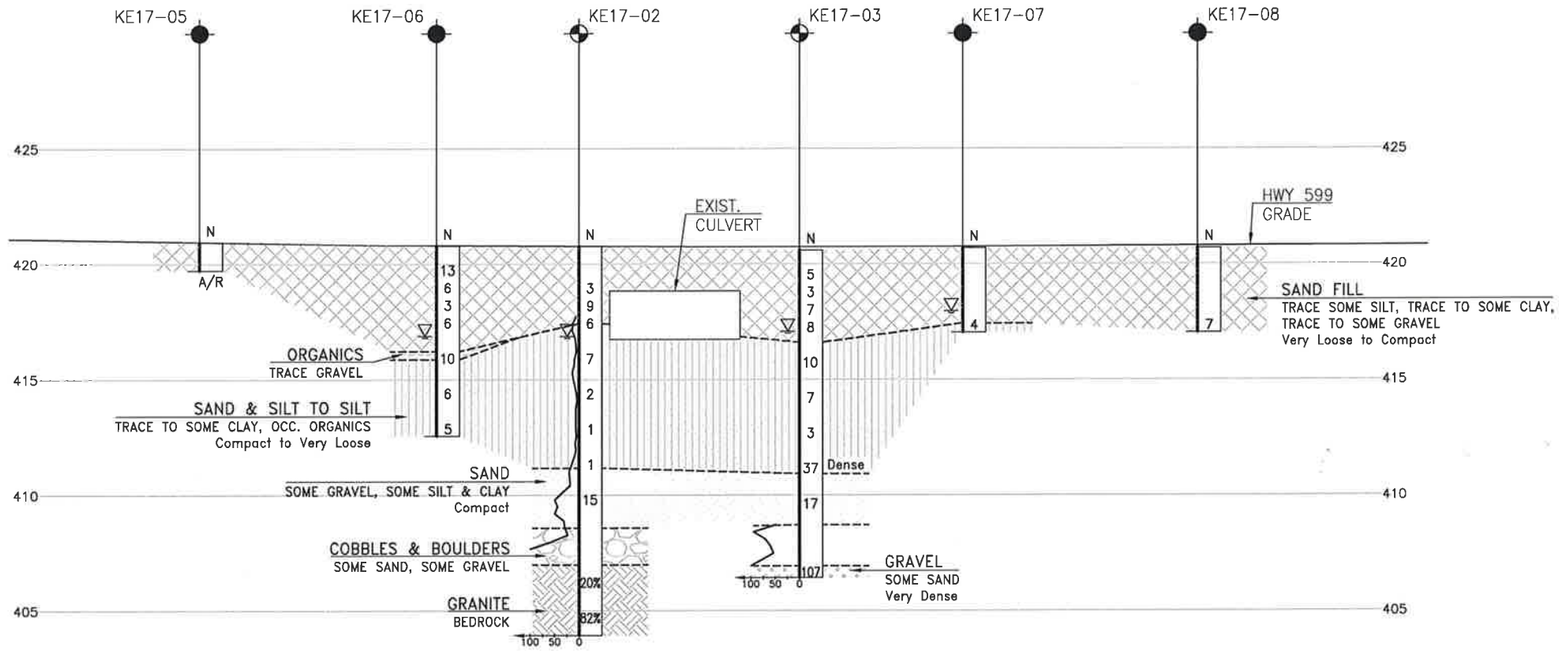
Borehole Locations and Soil Strata Drawing



PLAN

8 0 8 16m

SCALE 1:400



PROFILE ALONG ℄ HWY 599

5 0 5 10m

SCALE 1:250

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Feb 6/18
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
R. PALOMEQUE REYNA
100083209
Feb/8/18
PROVINCE OF ONTARIO

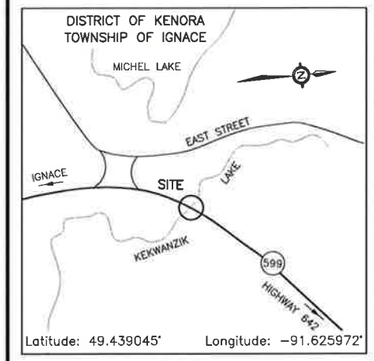
CONT No 2017-6036
WP No 6837-14-01

HIGHWAY 599
KEKWANZIK LAKE CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET 24

HATCH

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

✦	Borehole
✦	Borehole and 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
KE17-01A	417.5	5 478 833.0	404 445.2
KE17-01B	417.6	5 478 834.2	404 446.0
KE17-01C	418.2	5 478 820.2	404 435.8
KE17-02	420.8	5 478 815.9	404 445.7
KE17-03	420.6	5 478 821.5	404 454.6
KE17-04	418.5	5 478 802.5	404 453.6
KE17-05	420.9	5 478 801.9	404 437.0
KE17-06	420.8	5 478 810.3	404 442.8
KE17-07	420.7	5 478 827.4	404 458.6
KE17-08	420.7	5 478 835.7	404 464.5

-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 16.

GEOCRES No. 52G-17

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	RPR	CHK	JPL	CODE	LOAD	DATE	JAN 2018
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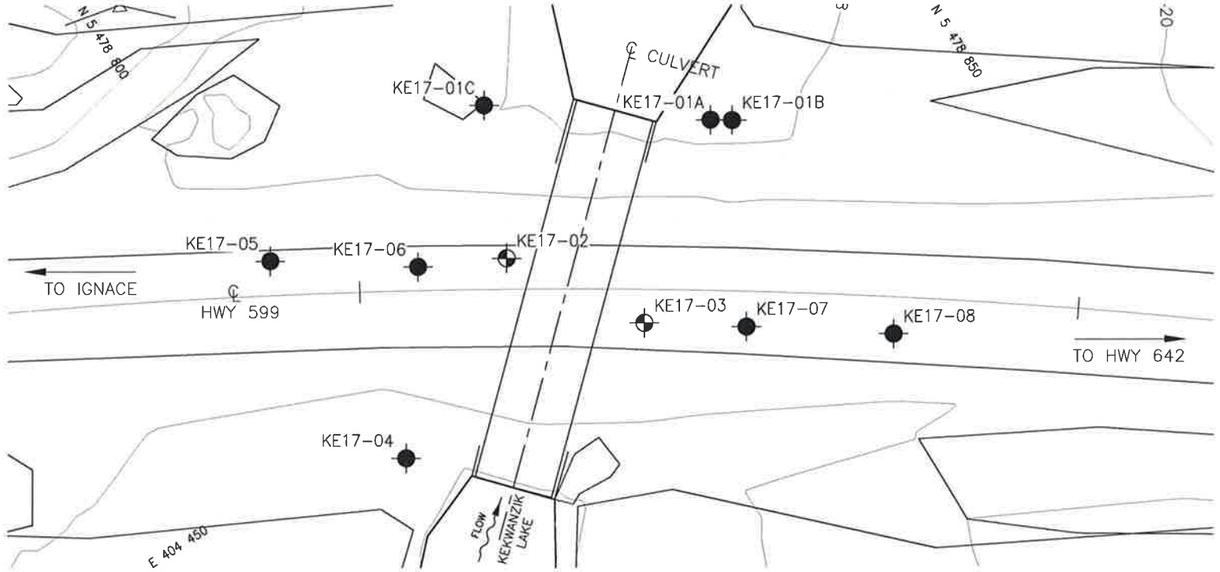
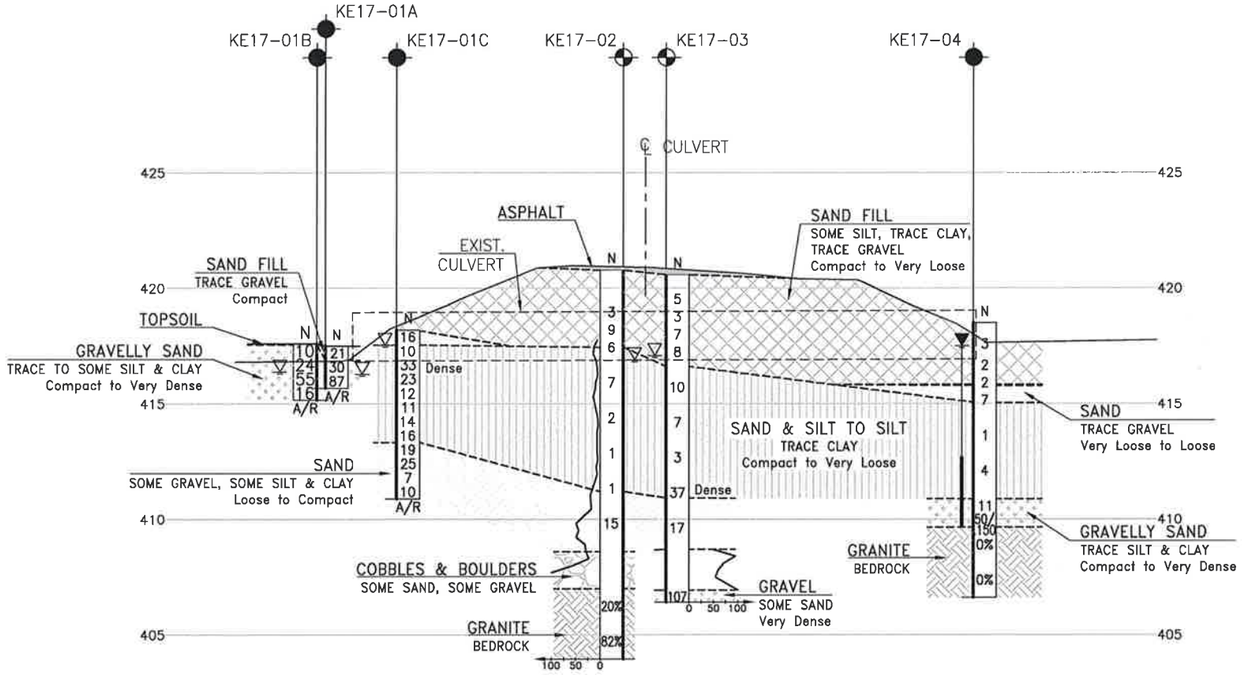


PLAN

8 0 8 16m

SCALE 1:400



PROFILE ALONG ℄ CULVERT

5 0 5 10m

SCALE 1:250

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

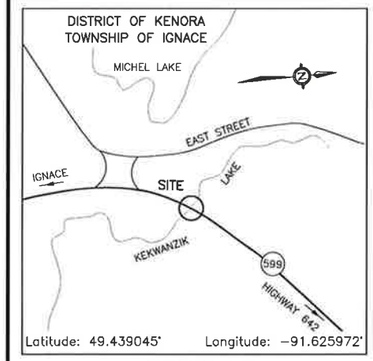
CONT No 2017-6036
WP No 6837-14-01

HIGHWAY 599
KEKWANZIK LAKE CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET 25

HATCH

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

	Borehole
	Borehole and 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
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KE17-01C	418.2	5 478 820.2	404 435.8
KE17-02	420.8	5 478 815.9	404 445.7
KE17-03	420.6	5 478 821.5	404 454.6
KE17-04	418.5	5 478 802.5	404 453.6
KE17-05	420.9	5 478 801.9	404 437.0
KE17-06	420.8	5 478 810.3	404 442.8
KE17-07	420.7	5 478 827.4	404 458.6
KE17-08	420.7	5 478 835.7	404 464.5

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2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
3) Coordinate system is MTM NAD 83 Zone 16.

GEOCRES No. 52G-17

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	RPR	CHK	JPL	CODE	LOAD
DRAWN	AN	CHK	RPR	SITE 48W-243C	STRUCT

DATE JAN 2018
DWG 3

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