



**THURBER** ENGINEERING LTD.

**DETAILED FOUNDATION INVESTIGATION REPORT  
LOUISE LAKE CULVERT REPLACEMENT  
HIGHWAY 641, TOWNSHIP OF PELLAT  
DISTRICT OF KENORA, ONTARIO  
LATITUDE: 49.774013°, LONGITUDE: -94.646125°**

**G.W.P. No. 6846-14-00, W.P. No. 6846-14-01, SITE No. 41S-097/C**

**GEOCRES Number: 52E-69**

**Report**

**to**

**WSP Canada Inc.**

Date: December 14, 2018  
File: 22155



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## **1. INTRODUCTION**

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for detailed design of the proposed Louise Lake Culvert replacement. The Louise Lake culvert is located on Highway 641, west of Kenora, in the Township of Pellat, District of Kenora, Ontario. Thurber previously conducted a preliminary foundation investigation at the culvert site in 2017.

The purpose of this investigation was to explore the subsurface conditions at the culvert location 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 WSP Canada Inc. (WSP) to carry out this detailed foundation investigation under the Ministry of Transportation Ontario (MTO) Agreement Number 6015-E-0035-016.

The preliminary investigation previously conducted by Thurber is described in the following report:

*“Preliminary Foundation Investigation Report, Louise Lake Culvert Replacement, Highway 641, Township of Pellat, District of Kenora, Ontario”, Geocres Number: 52E-65, Date: October 2, 2017, File: 15593”.*

The record of borehole sheets and laboratory test results from the preliminary investigation are included in this report.



## **2. SITE DESCRIPTION**

The site is located on Highway 641, approximately 4.2 km north of Highway 17, in the Township of Pellat, Ontario. The existing culvert allows Louise Lake to flow in a south to north direction under Highway 641. At each end of the culvert is open water of Louise Lake. Highway 641 generally runs in an east-west direction at the culvert site.

The Ontario Structure Inspection Manual (Inspection Form) prepared by MTO on December 15, 2015 indicates that the existing structure is a single span corrugated steel elliptical culvert, approximately 18 m long and 3.8 wide. The inspection report indicated that the structure was built in 1975. The estimated culvert invert is at approximate Elevation 317.6 m at the inlet (south) and 317.5 m at the outlet (north). The existing road grade at the culvert location is at approximate Elev. 321.1 m, which indicates approximately 0.8 m of fill above the culvert.

The lands surrounding the culvert site predominantly consist of rural forested areas. Louise Lake is located immediately to the north and south of the culvert. Several residential properties are located along Hwy 641 both to the east and west of the culvert. Local topography is generally of low relief with hummocky or knobby bedrock outcrops.

Photographs of the culvert and surrounding areas are presented in Appendix C.

Based on published geological information, the culvert lies within glaciolacustrine plains of clay and silt deposits with glaciofluvial deltas of sand and gravel located within the vicinity of the culvert. Bedrock at the site is identified as gneissic tonalite to granodiorite.

## **3. INVESTIGATION PROCEDURES**

The current site investigation and field testing program for this project was carried out in two phases; between March 14 and 19, 2018, and between May 26 and June 4, 2018. The field program consisting of drilling and sampling ten (10) boreholes (18-15 to 18-24) to depths of between approximately 5.5 m and 10.2 m below the existing ground or lake surface. Boreholes 18-15 to 18-23 were drilled near the locations of the proposed replacement culvert inlet and outlet, cofferdams, and roadway protection system. Borehole 18-24 was drilled through the paved portion of Highway 641 for the proposed roadway protection system.

The previous preliminary site investigation and field testing program for this project was carried out between March 15 and 18, 2017, and consisted of drilling and sampling seven (7) boreholes (17-01 to 17-07) to depths of between approximately 3.7 m and 10.0 m below existing ground



surface. Boreholes 17-01 to 17-03, and 17-05 to 17-07 were drilled through the paved portion of Highway 641. Borehole 17-04 was drilled near the inlet of the existing culvert and Borehole 17-01 was drilled as close as possible to the outlet of the culvert from atop the road embankment. Boreholes 17-05 to 17-07 were drilled to assess the existence and extent of any frost taper near the culvert.

The Record of Borehole sheets for the boreholes from the current and previous investigations are included in Appendix A. The approximate locations of the boreholes from both investigations are shown on the Borehole Locations and Soil Strata Drawings included in Appendix D.

Utility clearances were obtained prior to the start of drilling. The ground surface elevations for the boreholes were estimated from the cross sections and topographic drawings provided to Thurber by WSP. The lake water surface and ice level elevations were based on the most recently available surveyed water levels provided on the topographic drawings. The coordinate system MTM NAD 83, Zone 17 was used for these boreholes.

A truck-mounted drill rig was used to advance the Borehole 18-24 using hollow stem augers. A portable Hilti drill and tripod equipment and a raft were used to advance Boreholes 18-15 to 18-23 using wash boring techniques, which included drilling on ice or water at Boreholes 18-15 to 18-22. Soil samples were obtained in the boreholes at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). All of the boreholes from the current investigation were advanced into bedrock using an NQ core barrel. A Dynamic Cone Penetration Test (DCPT) was driven to cone refusal adjacent to Borehole 18-24.

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 and rock samples for transport to Thurber's laboratory for further examination and testing.

Groundwater conditions were observed throughout the drilling operations and in the open boreholes upon completion of drilling. The boreholes were backfilled upon completion in general accordance with Ontario Regulation 903.

Completion details of the boreholes are summarized in Table 3.1.

**Table 3.1 – Borehole Completion Details**

<b>Borehole Number</b>	<b>Borehole Depth / Base Elevation (m)</b>	<b>Completion Details</b>
18-15	6.2 / 311.8	Borehole backfilled with bentonite holeplug and auger cuttings to surface.
18-16	8.6 / 309.2	Borehole backfilled with bentonite holeplug and auger cuttings to surface.
18-17	7.8 / 310.0	Borehole backfilled with bentonite holeplug and auger cuttings to surface.
18-18	6.9 / 310.9	Borehole backfilled with bentonite holeplug and auger cuttings to surface.
18-19	6.0 / 311.8	Borehole backfilled with bentonite holeplug and auger cuttings to surface.
18-20	7.9 / 310.1	Borehole backfilled with bentonite holeplug and auger cuttings to surface.
18-21	7.1 / 310.9	Borehole backfilled with bentonite holeplug and auger cuttings to surface.
18-22	5.5 / 312.5	Borehole backfilled with bentonite holeplug and auger cuttings to surface.
18-23	5.5 / 312.4	Borehole backfilled with bentonite holeplug and auger cuttings to 0.3 m, then sand to surface.
18-24	10.2 / 310.9	Borehole backfilled with bentonite holeplug to 6.7 m, auger cuttings to 0.6 m, concrete to 0.3 m, then asphalt to surface.
17-01	7.7 / 313.4	Borehole backfilled with bentonite holeplug and auger cuttings to 0.4 m, then concrete to surface.
17-02	9.7 / 311.4	Borehole backfilled with bentonite holeplug, auger cuttings, then concrete to surface.
17-03	10.0 / 311.1	Borehole backfilled with bentonite holeplug, auger cuttings, then concrete to surface.
17-04	0.0 / 318.2	Auger refusal at surface using tripod equipment.



Borehole Number	Borehole Depth / Base Elevation (m)	Completion Details
17-05	3.7 / 317.3	Borehole backfilled with bentonite holeplug, auger cuttings, then concrete to surface.
17-06	3.7 / 317.4	Borehole backfilled with bentonite holeplug, auger cuttings, then concrete to surface.
17-07	3.7 / 317.5	Borehole backfilled with bentonite holeplug, auger cuttings, then concrete 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) and point load testing on bedrock, 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.

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 native soil, and a sample of the surface water from the lake upstream of the existing culvert were collected during the previous investigation and submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing of corrosivity parameters. The results of the analytical testing are summarized in this report and also presented in Appendix B.

#### 5. DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix A. Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets and on the Borehole Locations and Soil Strata drawings included in Appendix D. 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 must be used for interpretation of the 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 below the existing embankment fill consisted



of mainly sand to silty sand, with discontinuous deposits of gravelly sand and silty clay overlying granodiorite bedrock. Descriptions of the individual strata are presented below.

## **5.1 Asphalt**

Boreholes 17-01 to 17-03, 17-05 to 17-07, and 18-24 were drilled through the paved portion of Highway 641. The asphalt was approximately 50 mm thick in all boreholes drilled in the paved portion, except at Borehole 18-24, where it was 300 mm thick. The asphalt extended to Elevations from 320.8 to 321.1 m.

## **5.2 Embankment Fill**

Embankment fill beneath the asphalt was encountered in Boreholes 17-01 to 17-03, 17-05 to 17-07, and 18-24. Where fully penetrated, the fill extended to depths ranging from 4.1 to 5.3 m (Elev. 315.8 to 317.0 m). The fill consisted of predominantly sand to gravelly sand, containing trace to some silt, and was brown in colour. Underlying the granular fill, silty clay fill was also encountered in Boreholes 17-03, 17-05 to 17-07, and 18-24, and generally contained some sand, trace gravel, occasional organic material, and was grey in colour. A layer of cobble and boulder fill (possibly rock fill) was also encountered in Boreholes 17-01 to 17-03 and 18-24.

### **5.2.1 Sand to Gravelly Sand Fill**

Gravelly sand to sand fill was encountered in Boreholes 17-01 to 17-03, 17-05 to 17-07, and 18-24 beneath the asphalt. The gravelly sand to sand fill typically extended to depths of approximately 1.5 m to 4.1 m below existing road surface (Elev. 317.0 to 319.7).

The SPT 'N' values of the sand to gravelly sand fill ranged from 9 to 30 blows for 0.3 m penetration, indicating a loose to dense relative density. Higher 'N' values were observed which ranged from 68 blows for 300 mm penetration to 100 blows for 50 mm penetration, and were likely a result of upper frozen material and larger gravel or cobble material. A DCPT conducted in Borehole 18-24 reached refusal of 100 blows per 0.3 m penetration at a depth of 3.2 m (Elev. 317.9 m) on possible cobbles within the fill. The measured moisture content ranged from 2% to 9% in the sand to gravelly sand fill.

The results of grain size analyses conducted on samples of the sandy to gravelly sand fill are provided on the Record of Borehole sheets in Appendix A, and illustrated in Figure B1 of Appendix B. The results are summarized as follows:





Gravel %	11 to 27
Sand %	63 to 77
Silt and Clay %	7 to 14

### 5.2.2 Silty Clay Fill

Silty clay fill was encountered below the sand to gravelly sand fill in Boreholes 17-03, 17-05 to 17-07, and 18-24 at depths of approximately 1.5 m to 3.4 m (Elev. 317.7 to Elev. 319.7). The silty clay fill ranged in thickness from 1.2 m up to 2.2 m and extended to depths of approximately 3.7 to 4.6 m where fully penetrated or to the maximum drilled depth of 3.7 m in Boreholes 17-05 to 17-07. Sand pockets or seams were encountered in the silty clay fill in Boreholes 17-06 and 17-07. Occasional organic material was encountered within the silty clay fill.

The SPT 'N' values in the silty clay fill were 5 to 6 blows for 0.3 m penetration, indicating a firm consistency. Measured moisture contents in the silty clay fill ranged from 20% to 31%.

The results of grain size analyses conducted on samples of the silty clay fill are provided on the Record of Borehole sheets in Appendix A, and illustrated in Figure B2 of Appendix B. The results are summarized as follows:

Gravel %	0 to 5
Sand %	10 to 46
Silt %	23 to 40
Clay %	26 to 57

The results of Atterberg Limits tests conducted on samples of the silty clay fill are provided on the Record of Borehole sheets in Appendix A and illustrated in Figure B6 of Appendix B. The results are summarized as follows:

Liquid Limit	38 to 40
Plastic Limit	16
Plasticity Index	22 to 23

The results of the Atterberg Limits testing indicate that the silty clay has an intermediate plasticity with group symbol CI.



### **5.2.3 Cobbles and Boulders Fill (Possibly Rock Fill)**

A layer of cobbles and boulders (possibly rock fill) was encountered at the base of the embankment fill in Borehole 18-24. High DCPT values adjacent to Boreholes 17-02 and 17-03 as well as grinding observed during drilling in Boreholes 17-01 to 17-03 are also indicators of the presence of cobbles and boulders or rock fill. The deposit was countered at depths of between 3.7 m and 4.6 m below the existing road surface. The thickness of this layer ranged from 0.4 to 0.7 m, with the base of the layer extending to depths of 4.1 to 5.3 m (Elev. 315.8 to 317.0 m). Cobbles and boulders were also observed at the surface of the inlet and outlet of the existing culvert and prevented auger advancement in Borehole 17-04.

### **5.3 Organic Material / Lakebed Deposits**

Boreholes 18-15, 18-17 to 18-19, and 18-22 encountered a layer of organic lakebed material below the lake water. The organic material ranged in thickness from 0.7 to 0.8 m and extended to depths from 1.4 to 2.1 m (Elev. 315.7 to 316.4 m). Where measured, the organic material was loose, based on an SPT 'N' value of 4 blows per 0.3 m penetration in Borehole 18-15. Samples of the organic lakebed material were not successfully recovered during the drilling process, due to the loose, underwater nature of the material.

A layer of peat was also encountered at a depth of 1.4 m in Borehole 18-23, which was buried by possible fill or recent alluvial lakebed deposits. The peat was 1.5 m thick and underlain by bedrock at a depth of 2.9 m (Elev. 315.1 m). The peat was very soft, based on SPT 'N' values of 2 blows per 0.3 m penetration. Measured moisture contents in the peat ranged from 110 to 171%.

### **5.4 Silty Clay**

A layer of sandy, silty clay with trace gravel was encountered below the water and a thin veneer of sand in Boreholes 18-20 and 18-21. The silty clay was 0.9 to 1.5 m thick and extended to depths from 2.6 to 2.9 m (Elev. 315.1 to 315.4 m).

The silty clay was very soft to stiff, based on SPT 'N' values from 1 to 9 blows per 0.3 m penetration. Measured moisture contents in the silty clay ranged from 34 to 60%.

The results of grain size analyses conducted on samples of the silty clay are provided on the Record of Borehole sheets in Appendix A, and illustrated in Figure B3 of Appendix B. The results are summarized as follows:



Gravel %	2 to 5
Sand %	22 to 32
Silt %	29 to 39
Clay %	27 to 44

## 5.5 Sand to Silty Sand

A deposit of sand to silty sand containing some silt to silty, trace clay to clayey, and trace gravel to gravelly was encountered beneath the embankment fill in Boreholes 17-01 to 17-03 and 18-24, beneath the surficial and lakebed deposits in Boreholes 18-15 to 18-19, 18-22 and 18-23. Occasional boulders and sand and gravel layers were encountered within this deposit. The thickness of this deposit ranged from 0.6 m to 4.6 m and extended to depths from 1.4 m to 7.7 m (Elev. 312.2 to Elev. 316.6 m).

SPT 'N' values recorded in the sand to silty sand ranged between 1 to 42 blows for 0.3 m penetration, indicating a loose to dense relative density (typically compact to dense). Higher SPT 'N' values of greater than 100 blows per 0.3 m penetration were also encountered due to the presence of boulders and near the interface with the underlying bedrock. Measured moisture contents in the sand to silty sand ranged from 6% to 89%.

The results of grain size analyses conducted on samples of the sand to silty sand 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:

Gravel %	0 to 21
Sand %	54 to 81
Silt %	15 to 24
Clay %	3 to 18
Silt and Clay %	12 to 21

## 5.6 Gravelly Sand

A 0.8 m thick layer of gravelly sand with some cobbles was encountered at the ground surface in Borehole 18-23, extending to Elev. 317.2 m. The layer may have been fill or recent alluvial material.

A 1.0 to 1.6 m thick layer of gravelly sand with trace to some silt was also encountered above the bedrock in Boreholes 18-15, 18-20 and 18-21, which extended to depths from 3.5 m to 4.5 (Elev. 313.5 to 314.5 to m). The gravelly sand was loose to very dense based on SPT 'N' values of 9 to



61 blows per 0.3 m penetration. Measured moisture contents in the gravelly sand ranged from 8% to 19%.

The results of grain size analyses conducted on samples of the gravelly sand are provided on the Record of Borehole sheets in Appendix A, and illustrated in Figure B5 of Appendix B. The results are summarized as follows:

Gravel %	13 to 24
Sand %	61 to 75
Silt and Clay %	12 to 15

## 5.7 Bedrock

Granodiorite bedrock was encountered below the overburden deposits in Boreholes 17-02, 17-03 and 18-15 to 18-24. Auger refusal on probable bedrock also occurred in Borehole 17-01.

The depth to bedrock is summarized in Table 5.1 below:

**Table 5.1 – Summary of Bedrock Surface Depths / Elevations**

Location	Borehole	Bedrock Surface	
		Depth (m)	Elevation (m)
Below Highway Embankment	17-01*	7.7	313.4
	17-02	6.7	314.4
	17-03	7.0	314.1
	18-24	7.4	313.7
Culvert Inlet	18-15	3.5	314.5
	18-20	4.5	313.5
	18-21	3.6	314.4
	18-22	3.4	314.6
	18-23	2.9	312.4
Culvert Outlet	18-16	5.6	312.2
	18-17	5.5	312.3
	18-18	5.6	312.2
	18-19	4.5	313.3

\* Bedrock depth estimated from drill refusal in Borehole 17-01

The bedrock was proven in Boreholes 17-02, 17-03 and 18-15 to 18-24 by coring approximately 3 m in the majority of the boreholes.

The bedrock is generally described as moderately to slightly weathered and grey. Total Core Recovery (TCR) in the bedrock ranged from 77% to 100% with Solid Core Recovery (SCR)



ranging from 63% to 100%. The Rock Quality Designation (RQD) determined from the recovered cores generally ranged from 26% to 100%, indicating a highly variable poor to excellent rock quality. RQD values under 25% (very poor quality) were also recorded at highly broken / rubble zones in the bedrock. Average unconfined compressive strengths (UCS) of the rock ranged between 32 MPa to 424 MPa based on correlations with the point load tests (PLT) on solid rock cores indicating the rock varies from medium strong to extremely strong. Photographs of the bedrock core samples are included in Appendix B.

## 5.8 Groundwater Conditions

Groundwater conditions were observed during drilling operations and groundwater levels were measured in the open boreholes upon completion of drilling. The groundwater level should be assumed to reflect the local lake water level. Water level measurements in the lake were reported on the MTO Site Plan Drawing, E-505-641-1, which reported measurements of Elev. 317.99 at the inlet and 317.84 at the outlet in May 2016. These lake level elevations were also used to reflect the lake level at the boreholes drilled on water or ice near the culvert inlet (Boreholes 18-15, 18-20 to 18-22), and outlet (Boreholes 18-16 to 18-19).

The groundwater levels measured in the open boreholes drilled on land are summarized in Table 5.2 below.

**Table 5.2 – Groundwater Measurements**

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
18-23	March 19, 2018	0.0	318.0	Open borehole
18-24	March 14, 2018	Not recorded due to addition of coring water		
17-01	March 16, 2017	4.7	316.4	Open borehole
17-02	March 18, 2017	Not recorded due to addition of coring water		
17-03	March 15, 2017	4.8	316.3	Open borehole (prior to rock coring water added)
17-04	March 18, 2017	Dry	-	Open borehole
17-05	March 16, 2017	Dry	-	Open borehole
17-06	March 15, 2017	Dry	-	Open borehole
17-07	March 15, 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.



## 6. CORROSIVITY AND SULPHATE TEST RESULTS

A sample of the gravelly sand fill and silty clay fill from Boreholes 17-01 and 17-03, respectively, and a sample of the surface water from the Lake 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.

**Table 6.1 – Analytical Test Results**

Parameter	Units (Soil)	Units (Water)	Test Results		
			17-01 SS#3 2.4 m	17-03 SS#3 2.4 m	Louise Lake
			(Gravelly Sand Fill)	(Silty Clay Fill)	(Lake Water)
Sulphide	%	mg/L	<0.02	<0.02	0.007
Chloride	µg/g	mg/L	18	75	3.1
Sulphate	µg/g	mg/L	3.3	27	1.6
pH	-	-	9.41	8.56	7.46
Conductivity	µS/cm	µS/cm	96	235	56
Resistivity	Ohms.cm	Ohms.cm	10400	4260	17700
Redox Potential	mV	mV	249	237	239

## 7. MISCELLANEOUS

Thurber obtained subsurface utility clearances prior to drilling. The northing and easting coordinates and ground surface elevations were estimated based on field measurements relative to the topographic plans provided by WSP.

OGS Inc. of Almonte, Ontario supplied and operated the drilling, sampling and in-situ testing equipment for the current field investigation. The field investigation was supervised on a full time basis by Mr. Jilesh Patel of Thurber. Overall supervision of the field program was provided by Mr. Mark Farrant, P.Eng. of Thurber.

Geotechnical laboratory testing was carried out in 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. Mark Farrant,



P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.



Mark Farrant, P.Eng.  
Geotechnical Engineer



P.K. Chatterji, P.Eng.  
Review Principal, Designated MTO Contact



## **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 <sup>(1)</sup> '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

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


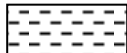



 Water Level  
 Shear Strength Determination by Pocket Penetrometer

- (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.

# 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			

## EXPLANATION OF ROCK LOGGING TERMS

<u>ROCK WEATHERING CLASSIFICATION</u>		<u>SYMBOLS</u>			
<b>Fresh (FR)</b>	No visible signs of weathering.				
<b>Fresh Jointed (FJ)</b>	Weathering limited to the surface of major discontinuities.		CLAYSTONE		
<b>Slightly Weathered (SW)</b>	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.		SILTSTONE		
<b>Moderately Weathered (MW)</b>	Weathering extends throughout the rock mass, but the rock material is not friable.		SANDSTONE		
<b>Highly Weathered (HW)</b>	Weathering extends throughout the rock mass and the rock is partly friable.		COAL		
<b>Completely Weathered (CW)</b>	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.		Bedrock (general)		
<u>DISCONTINUITY SPACING</u>		<u>STRENGTH CLASSIFICATION</u>			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength (MPa) (psi)	Field Estimation of Hardness*	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m		Very Strong	100-250	15,000 to 36,000
Thinly bedded	60mm to 0.2m				
Very thinly bedded	20 to 60mm	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Laminated	6 to 20mm				
Thinly Laminated	Less than 6mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
<u>TERMS</u>		Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.	Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.	Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage 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.				

# RECORD OF BOREHOLE No 18-15

1 OF 1

METRIC

W.P. 6846-14-01 LOCATION Louise Lake Culvert, MTM NAD 83-17 N 5 516 026.5 E 402 318.9 ORIGINATED BY JP  
DIST Thunder Bay HWY 11 BOREHOLE TYPE Wash Boring/NQ Coring COMPILED BY MP  
DATUM Geodetic DATE 2018.03.18 - 2018.03.18 LATITUDE 49.77389616 LONGITUDE -94.64600622 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100						
								20 40 60 80 100						
318.0	GROUND SURFACE													
0.0	ICE													
317.5														
0.5	WATER													
317.1														
0.9	ORGANICS: LAKEBED DEPOSITS Loose Wet		1	SS	4		317							
316.4	(No recovery)													
1.6	Silty SAND, some clay to clayey, trace gravel Loose Grey Wet		2	SS	5		316							4 54 24 18
315.6														
2.4	Gravelly SAND, trace silt Compact to Very Dense Grey Wet		3	SS	22		315							
314.5			4	SS	50/ 0.050								FI	
3.5	GRANODIORITE moderately to slightly weathered, grey, extremely strong sub horizontal fracture (75mm) at 3.5m, (100mm) at 3.7m and 3.8m  horizontal break at 4.0m, 4.1m, 4.2m, 4.3m, 4.5m, 4.6m, 4.8m and 5.0m  vertical break (75mm) at 5.0m  horizontal break at 5.0m, 5.5m, 5.6m, 5.7m, 5.8m, 5.9m, 6.0m and 6.1m		1	RUN			314						5	RUN #1 TCR=100% SCR=100% RQD=0% UCS=268MPa
			2	RUN									2	RUN #2 TCR=100% SCR=100% RQD=69% UCS=424MPa
			3	RUN			313						2	RUN #3 TCR=100% SCR=100% RQD=50% UCS=403MPa
311.8	sub horizontal break (150mm) at 6.1m						312						0	
6.2	END OF BOREHOLE AT 6.2m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.												2	

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# RECORD OF BOREHOLE No 18-16

1 OF 1

METRIC

W.P. 6846-14-01 LOCATION Louise Lake Culvert, MTM NAD 83-17 N 5 516 050.6 E 402 323.7 ORIGINATED BY JP  
DIST Thunder Bay HWY 11 BOREHOLE TYPE Wash Boring/NQ Coring COMPILED BY MP  
DATUM Geodetic DATE 2018.05.31 - 2018.05.31 LATITUDE 49.77411238 LONGITUDE -94.64593246 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								○ UNCONFINED    + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE					
								WATER CONTENT (%) 20 40 60 80 100      20 40 60					
317.8	GROUND SURFACE												
0.0	<b>WATER</b>												
317.1													
0.7	<b>SAND</b> , some silt, some gravel, trace clay Very Loose to Dense Grey Wet		1	SS	1								
			2	SS	35								
315.9													
1.9	<b>SAND</b> and <b>GRAVEL</b> Compact Grey Wet		3	SS	29								
315.3													
2.5	Silty <b>SAND</b> , trace gravel, trace clay Loose to Compact Grey Wet		4	SS	8								
			5	SS	10								
			6	SS	24								
312.5													
5.3	Sandy <b>GRAVEL</b> , trace silt, some cobbles		7	SS	100/								
312.2	Very Dense Grey Wet		1	RUN	0.025								
5.6	<b>GRANODIORITE</b> moderately to slightly weathered, grey, very strong horizontal fractures at 5.7m, 5.9m and 6.0m horizontal fractures at 6.1m, 6.3m, 6.4m, 6.5m and 6.6m sub horizontal fracture (50mm) at 6.3m, (25mm) at 6.4m and (50mm) at 6.6m horizontal fractures at 7.1m, 7.2m, 7.5m, 7.7m and 7.8m sub horizontal fracture (150mm) at 7.5m and (25mm) at 7.8m horizontal fractures at 7.9m, 8.1m, 8.2m, 8.3m and 8.4m sub horizontal fracture (25mm) at 8.3m		2	RUN									
			3	RUN									
			4	RUN									
			5	RUN									
309.2													
8.6	END OF BOREHOLE AT 8.6m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.												

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

# RECORD OF BOREHOLE No 18-17

1 OF 1

METRIC

W.P. 6846-14-01 LOCATION Louise Lake Culvert, MTM NAD 83-17 N 5 516 055.5 E 402 324.7 ORIGINATED BY JP  
DIST Thunder Bay HWY 11 BOREHOLE TYPE Wash Boring/NQ Coring COMPILED BY MP  
DATUM Geodetic DATE 2018.06.02 - 2018.06.02 LATITUDE 49.77415625 LONGITUDE -94.64591731 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
317.8	GROUND SURFACE							<div>20406080100</div> <div>○ UNCONFINED + FIELD VANE</div> <div>● QUICK TRIAXIAL × LAB VANE</div>						
0.0	<b>WATER</b>							<div>20406080100</div> <div>WATER CONTENT (%)</div> <div>W<sub>P</sub> W W<sub>L</sub></div>						
317.0							317							
0.8	<b>ORGANICS:</b> LAKEBED DEPOSITS Wet													
316.2	(No recovery)													
1.6	<b>SAND</b> , some silt to silty, some gravel, trace clay Compact to Dense Grey Wet		1	SS	18		316					○		
			2	SS	14		315					○		
			3	SS	12		314					○		
			4	SS	36		313					○		
			5	SS	100/		312							
312.3														
5.5	<b>GRANODIORITE</b> moderately weathered, grey, very strong to strong vertical fracture (50mm) at 5.5m horizontal fractures from 5.6m to 6.0m sub horizontal fracture (125mm) at 5.7m horizontal fractures from 6.0m to 6.7m rubble zone (50mm) at 6.2m and (75mm) at 6.6m vertical fracture (50mm) at 6.5m sand seam (25mm) at 6.9m horizontal fractures from 7.1 and 7.4m  rubble zone (100mm) at 7.3m vertical fracture at (50mm) at 7.4m		1	RUN	0.075		312							FI
			2	RUN			311							>10
			3	RUN										>10
			4	RUN										>10
310.0							310							>10
7.8	END OF BOREHOLE AT 7.8m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.												5	SCR=88% RQD=0% UCS=99MPa (Average)

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

# RECORD OF BOREHOLE No 18-18

1 OF 1

METRIC

W.P. 6846-14-01 LOCATION Louise Lake Culvert, MTM NAD 83-17 N 5 516 053.8 E 402 328.4 ORIGINATED BY JP  
DIST Thunder Bay HWY 11 BOREHOLE TYPE Wash Boring/NQ Coring COMPILED BY MP  
DATUM Geodetic DATE 2018.06.04 - 2018.06.04 LATITUDE 49.77414015 LONGITUDE -94.64586656 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
317.8	GROUND SURFACE												
0.0	<b>WATER</b>												
317.1													
0.7	<b>ORGANICS:</b> LAKEBED DEPOSITS Wet						317						
316.4	(No recovery)												
1.4	Silty <b>SAND</b> , some gravel to gravelly, trace clay, occasional cobbles Compact to Dense Grey Wet		1	SS	25		316						
			2	SS	19		315						
			3	SS	11		314						
			4	SS	42								
313.5													
4.3	<b>BOULDER</b>						313						
312.6													
5.2			5	SS	100/								
312.2					0.075								
5.6	<b>GRANODIORITE</b> moderately weathered, grey, medium to very strong horizontal fractures from 5.8m to 6.2m and 6.4m vertical fracture (25mm) at 6.0m sub horizontal fracture (25mm) at 6.3m sand seam (25mm) at 6.3m horizontal fractures at 6.4m, 6.6m and 6.7m		1	RUN			312						
			2	RUN									
			3	RUN									
310.9			4	RUN			311						
6.9	sub horizontal fracture (125mm) at 6.8m  END OF BOREHOLE AT 6.9m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.												

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+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 18-19

1 OF 1

METRIC

W.P. 6846-14-01 LOCATION Louise Lake Culvert, MTM NAD 83-17 N 5 516 055.5 E 402 319.5 ORIGINATED BY JP  
DIST Thunder Bay HWY 11 BOREHOLE TYPE Wash Boring/NQ Coring COMPILED BY MP  
DATUM Geodetic DATE 2018.06.01 - 2018.06.01 LATITUDE 49.77415694 LONGITUDE -94.64598981 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)					
317.8	GROUND SURFACE							20	40	60	80	100		W <sub>P</sub>	W	W <sub>L</sub>	kN/m <sup>3</sup>	GR   SA   SI   CL
0.0	<b>WATER</b>																	
316.5	<b>ORGANICS: LAKEBED DEPOSITS</b> Wet																	
315.7	(No recovery)																	
2.1	Silty <b>SAND</b> , some gravel to gravelly, trace clay, occasional cobbles Dense Grey Wet		1	SS	36									○				
	Loose		2	SS	4									○				
	Compact		3	SS	20									○				
313.3			4	SS	100/ 0.075													
4.5	<b>GRANODIORITE</b> moderately to slightly weathered, grey, very strong horizontal fracture at 4.5m, 4.6m, 4.8m, 4.9m and 5.1m		1	RUN														
	horizontal fracture at 5.2m, 5.7m and 5.8m sub horizontal fracture (100mm) at 5.7m and (125mm) at 5.9m rubble zone (75mm) at 5.8m		2	RUN														
311.8																		
6.0	END OF BOREHOLE AT 6.0m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.																	

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



# RECORD OF BOREHOLE No 18-20

1 OF 1

METRIC

W.P. 6846-14-01 LOCATION Louise Lake Culvert, MTM NAD 83-17 N 5 516 020.7 E 402 322.8 ORIGINATED BY JP  
DIST Thunder Bay HWY 11 BOREHOLE TYPE Wash Boring/NQ Coring COMPILED BY MP  
DATUM Geodetic DATE 2018.03.17 - 2018.03.17 LATITUDE 49.77384398 LONGITUDE -94.645953 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
318.0	GROUND SURFACE							20 40 60 80 100					
0.0	ICE												
317.2							317						
0.8	WATER												
316.6													
1.4	Silty <b>CLAY</b> , sandy, trace gravel Soft to Stiff Grey Moist		1	SS	2		316						2 32 39 27
			2	SS	9								
315.1													
2.9	Gravelly <b>SAND</b> , trace silt Very Dense Grey Wet boulder at 3.2m		3	SS	61		315						13 75 12 (SI+CL)
	Compact		4	SS	13		314						
313.5			5	SS	100/								
4.5	<b>GRANODIORITE</b> moderately to slightly weathered, grey, very to extremely strong vertical fracture (75mm) at 4.5m		1	RUN	0.050		313						RUN #1 TCR=100% SCR=100% RQD=0%
	horizontal break at 4.6m, 4.7m, 4.8m, 4.9m, 5.1m, 5.2m and 5.3m		2	RUN									RUN #2 TCR=100% SCR=100% RQD=29% UCS=225MPa (Average)
	vertical break (25mm) at 4.6m, (125mm) at 4.9m and 5.6m		3	RUN			312						RUN #3 TCR=88% SCR=79% RQD=43% UCS=298MPa (Average)
	horizontal break at 5.7m, 5.8m, 6.0m and 6.5m												
	sub horizontal fracture (50mm) at 7.2m		4	RUN			311						RUN #4 TCR=100% SCR=100% RQD=88%
	horizontal break at 7.4m and 7.5m												
310.1													
7.9	END OF BOREHOLE AT 7.9m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.												

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+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 18-21

1 OF 1

METRIC

W.P. 6846-14-01 LOCATION Louise Lake Culvert, MTM NAD 83-17 N 5 516 020.6 E 402 317.7 ORIGINATED BY JP  
DIST Thunder Bay HWY 11 BOREHOLE TYPE Wash Boring/NQ Coring COMPILED BY MP  
DATUM Geodetic DATE 2018.05.26 - 2018.05.26 LATITUDE 49.77384349 LONGITUDE -94.64602423 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
318.0	GROUND SURFACE							20	40	60	80	100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 18-22

1 OF 1

METRIC

W.P. 6846-14-01 LOCATION Louise Lake Culvert, MTM NAD 83-17 N 5 516 022.6 E 402 313.0 ORIGINATED BY JP  
DIST Thunder Bay HWY 11 BOREHOLE TYPE Wash Boring/NQ Coring COMPILED BY MP  
DATUM Geodetic DATE 2018.03.16 - 2018.03.16 LATITUDE 49.77386197 LONGITUDE -94.6460888 CHECKED BY MEF

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 <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)							
318.0	GROUND SURFACE							20	40	60	80	100	W <sub>P</sub>	W	W <sub>L</sub>	GR	SA	SI	CL
0.0	<b>WATER</b>																		
316.6																			
1.4	<b>ORGANICS:</b> LAKEBED DEPOSITS Wet																		
315.9	(No recovery)																		
2.1	Silty <b>SAND</b> , some gravel Compact Grey Wet		1	SS	21									○					
			2	SS	100/ 0.075									○					
314.6																			
3.4	<b>GRANODORITE</b> moderately to slightly weathered, grey, very strong  horizontal fractures at 2.5m, 2.7m and 2.8m  sub horizontal fracture (125mm) at 2.5m, (50mm) at 2.7m    horizontal breaks at 3.8m, 4.0m and 4.1m sub horizontal break (275mm) at 3.8m		1	RUN										○					
			2	RUN															
			3	RUN															
312.5																			
5.5	END OF BOREHOLE AT 5.5m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.																		
														</					

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 18-23

1 OF 1

METRIC

W.P. 6846-14-01 LOCATION Louise Lake Culvert, MTM NAD 83-17 N 5 516 028.4 E 402 314.2 ORIGINATED BY JP  
DIST Thunder Bay HWY 11 BOREHOLE TYPE Wash Boring/NQ Coring COMPILED BY MP  
DATUM Geodetic DATE 2018.03.19 - 2018.03.19 LATITUDE 49.77391464 LONGITUDE -94.64607079 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE						WATER CONTENT (%) w P                      w                      w L				
318.0	GROUND SURFACE							20	40	60	80	100						
0.0	Gravelly <b>SAND</b> , some cobbles Grey Wet (Possible FILL)																	
317.2																		
0.8	Silty <b>SAND</b> , some gravel Compact Grey Wet (Possible FILL)		1	SS	13		317											
316.6																		
1.4	<b>PEAT</b> , trace sand Very Soft Brown Wet		2	SS	2		316										110	
			3	SS	2												170	
315.1																		
2.9	<b>GRANODIORITE</b> slightly weathered, grey, extremely weathered horizontal breaks at 3.1m, 3.5m, 3.8m, 3.9m and 4.1m		1	RUN			315											RUN #1 TCR=100% SCR=100% RQD=100% UCS=32MPa (Average)
			2	RUN			314											RUN #2 TCR=100% SCR=100% RQD=83% UCS=268MPa (Average)
			3	RUN														RUN #3 TCR=100% SCR=100% RQD=100% UCS=326MPa (Average)
			4	RUN			313											RUN #4 TCR=100% SCR=100% RQD=83% UCS=384MPa (Average)
312.4	horizontal breaks at 5.2m, 5.3m, 5.4m and 5.7m																	
5.6	END OF BOREHOLE AT 5.6m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG, CUTTINGS TO 0.3m THEN SAND TO SURFACE.																	

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 18-24

1 OF 2

METRIC

W.P. 6846-14-01 LOCATION Louise Lake Culvert, MTM NAD 83-17 N 5 516 037.4 E 402 316.0 ORIGINATED BY JP  
DIST Thunder Bay HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY MP  
DATUM Geodetic DATE 2018.03.14 - 2018.03.14 LATITUDE 49.77399481 LONGITUDE -94.64604336 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				
321.1	GROUND SURFACE							20 40 60 80 100				
0.0	ASPHALT						321	20 40 60 80 100				
320.8								20 40 60 80 100				
0.3	Gravelly <b>SAND</b> , trace silt Dense to Compact Brown Moist (FILL)		1	SS	38		320	20 40 60 80 100				20 73 7 (SI+CL)
	some cobbles		2	SS	38		319	20 40 60 80 100				
			3	SS	26		318	20 40 60 80 100				
317.7			4	SS	50/ 0.050		317	20 40 60 80 100				
3.4	Silty <b>CLAY</b> Grey Wet (FILL)							20 40 60 80 100				
316.5								20 40 60 80 100				
4.6	<b>COBBLES</b> and <b>BOULDERS</b> some sand and gravel Very Dense Grey Wet (FILL)		5	SS	50/ 0.125		316	20 40 60 80 100				
315.8								20 40 60 80 100				
5.3	Silty <b>SAND</b> , trace gravel, trace clay Compact Grey Wet		6	SS	16		315	20 40 60 80 100				
							314	20 40 60 80 100				
313.7								20 40 60 80 100				
7.4	<b>GRANODIORITE</b> moderately weathered, grey, extremely to very strong horizontal fractures at 7.5m, 7.9m, 8.2m, 8.3m, 8.4m and 8.6m sub horizontal fractures (25mm) at 7.6m, (75mm) at 7.6m, at 7.7m, (50mm) at 7.8m and (25mm) at 8.0m  sub horizontal fractures at (175mm) at 8.6m, (75mm) at 9.4m, (50mm) at 9.0m, (25mm) at 9.1m, 9.2m  rubble zone (50mm) at 9.3m  horizontal fractures at 9.0m, 9.4m,		1	RUN			313	20 40 60 80 100			FI 5 7 3 5 4 5 4 4	RUN #1 TCR=100% SCR=100% RQD=43% UCS=318MPa (Average)  RUN #2 TCR=100% SCR=84% RQD=82% UCS=136MPa (Average)  RUN #3
			2	RUN			312	20 40 60 80 100			<10	
								20 40 60 80 100				

Continued Next Page

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

# RECORD OF BOREHOLE No 18-24

2 OF 2

METRIC

W.P. 6846-14-01 LOCATION Louise Lake Culvert, MTM NAD 83-17 N 5 516 037.4 E 402 316.0 ORIGINATED BY JP  
 DIST Thunder Bay HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY MP  
 DATUM Geodetic DATE 2018.03.14 - 2018.03.14 LATITUDE 49.77399481 LONGITUDE -94.64604336 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
310.9	Continued From Previous Page		3	RUN													
10.2	9.5m, 9.6m and 9.8m horizontal fractures at 9.9m, 10.0m and 10.1m  END OF BOREHOLE AT 10.2m. BOREHOLE OPEN TO 10.2m AND BACKFILLED WITH BENTONITE HOLEPLUG TO 6.7m, CUTTINGS TO 0.6m, CONCRETE TO 0.3m THEN ASPHALT TO SURFACE.															TCR=100% SCR=100% RQD=0%	

# RECORD OF BOREHOLE No 17-01

1 OF 1

METRIC

W.P. 6846-14-01 LOCATION Louise Lake Culvert, MTM NAD 83 Zone 17 N 5 516 041.8 E 402 317.3 ORIGINATED BY AHF  
 HWY 641 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.03.16 - 2017.03.16 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	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 <sub>p</sub> w w <sub>L</sub>				
321.1	GROUND SURFACE							20 40 60 80 100								
0.0	ASPHALT: (50mm)							20 40 60 80 100								
	Gravelly SAND, trace silt Very Dense to Compact Brown Moist (FILL)		1	GS												
			1	SS	100/ 0.050											
			2	SS	68											
			3	SS	11											
			4	SS	10											
317.0																
4.1	COBBLES and BOULDERS (FILL)															
316.5																
4.6	SAND, some silt, trace to some gravel, trace to some clay Compact to Very Dense Grey Wet		5	SS	14											
			6	SS	5											
313.4			7	SS	100/ 0.125											
7.7	END OF BOREHOLE AT 7.7m UPON AUGER REFUSAL ON PROBABLE BEDROCK. WATER LEVEL AT 4.7m IN OPEN BOREHOLE UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO 0.4m, THEN CONCRETE TO SURFACE.															

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

# RECORD OF BOREHOLE No 17-02

1 OF 2

METRIC

W.P. 6846-14-01 LOCATION Louise Lake Culvert, MTM NAD 83 Zone 17 N 5 516 042.0 E 402 309.2 ORIGINATED BY AHF  
 HWY 641 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
 DATUM Geodetic DATE 2017.03.16 - 2017.03.18 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
321.1	GROUND SURFACE							20 40 60 80 100	PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>		
0.0	ASPHALT: (50mm)							20 40 60 80 100	WATER CONTENT (%)				
	SAND, gravelly to some gravel, trace silt Compact to Very Dense Brown Moist (FILL)		1	GS				○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					27 63 10 (SI+CL)
			2	GS									
			1	SS	27								17 76 7 (SI+CL)
			2	SS	30								
			3	SS	100/ 0.125								
317.2	COBBLES and BOULDERS (FILL)												
316.5	SAND, some silt, some gravel, roots and rootlets Loose to Very Dense Grey Wet		4	SS	6								
			5	SS	100/ 0.125								
314.4	GRANODIORITE moderately weathered, grey											FI	
6.7	125mm highly fracture zone at 6.7m  Sub-horizontal fracture at 7.0m and at 7.3m  Vertical fracture (50mm) at 6.9m  Horizontal fracture at 6.9m, 7.0m, 7.2m, 7.4m, 7.7m, 7.8m, 7.9m, 8.3m, 8.5m, 9.2m, 9.3m and 9.6m  Sub-horizontal fracture at 8.6m and 8.7m  Sub-vertical fracture from 9.1m to 9.7m		1	RUN								>10	RUN #1 TCR=83% SCR=63% RQD=57%
			2	RUN								3	RUN #2 TCR=100% SCR=77% RQD=79%
311.4	END OF BOREHOLE AT 9.7m. BOREHOLE BACKFILLED WITH												
9.7													

Continued Next Page

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



RECORD OF BOREHOLE No 17-02

2 OF 2

METRIC

W.P. 6846-14-01 LOCATION Louise Lake Culvert, MTM NAD 83 Zone 17 N 5 516 042.0 E 402 309.2 ORIGINATED BY AHF  
HWY 641 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
DATUM Geodetic DATE 2017.03.16 - 2017.03.18 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page  BENTONITE HOLEPLUG, CUTTINGS AND CONCRETE TO SURFACE.  GROUND WATER LEVEL IN OPEN BOREHOLE NOT RECORDED DUE TO WATER ADDED FOR ROCK CORING. DYNAMIC CONE PENETRATION TEST CONDUCTED ADJACENT TO BOREHOLE.																

# RECORD OF BOREHOLE No 17-03

1 OF 2

METRIC

W.P. 6846-14-01 LOCATION Louise Lake Culvert, MTM NAD 83 Zone 17 N 5 516 035.9 E 402 322.3 ORIGINATED BY AHF  
 HWY 641 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
 DATUM Geodetic DATE 2017.03.15 - 2017.03.15 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				
321.1	GROUND SURFACE							20 40 60 80 100				
0.0	ASPHALT: (50mm)						321	20 40 60 80 100				
	SAND, trace to some silt and gravel Very Dense to Loose Brown Moist (FILL)		1	GS								11 75 14 (SI+CL)
			1	SS	100/							
					0.100							
			2	SS	9		320					13 77 10 (SI+CL)
318.8							319					
2.3	Silty CLAY, some sand, trace gravel, organics Firm Grey Moist (FILL)		3	SS	6		318					0 10 33 57
			4	SS	6							
317.4												
3.7	COBBLES and BOULDERS (FILL)						317					
317.0												
4.1	Silty SAND, some clay, some gravel Compact Grey Wet		5	SS	15		316					
315.5							315					
5.6	SAND, some silt and gravel Compact Brown Wet		6	SS	20							
314.1							314				FI	RUN #1 TCR=100% SCR=95% RQD=82%
7.0	GRANODIORITE moderately weathered, grey Sub-horizontal fracture at 7.5m		1	RUN							0	
	Highly broken zone (200mm) at 7.9m										1	
	Horizontal fracture at 8.5m, 8.6m, 9.0m and 9.1m		2	RUN			313				0	RUN #2 TCR=100% SCR=83% RQD=83%
	Sub-vertical fracture at 9.0m										2	
	Sub-horizontal fracture at 9.4m, 9.7m, 9.8m and 9.9m		3	RUN			312				0	RUN #3 TCR=100% SCR=81% RQD=62%
311.1											2	
											4	

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 17-03

2 OF 2

METRIC

W.P. 6846-14-01 LOCATION Louise Lake Culvert, MTM NAD 83 Zone 17 N 5 516 035.9 E 402 322.3 ORIGINATED BY AHF  
 HWY 641 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
 DATUM Geodetic DATE 2017.03.15 - 2017.03.15 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)						
	Continued From Previous Page					20	40	60	80	100	20	40	60				
10.0	END OF BOREHOLE AT 10.0m. WATER LEVEL AT 4.8m IN OPEN BOREHOLE PRIOR TO ROCK CORING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG, AUGER CUTTINGS, AND CONCRETE TO SURFACE.  DYNAMIC CONE PENETRATION TEST CONDUCTED ADJACENT TO BOREHOLE.																

# RECORD OF BOREHOLE No 17-04

1 OF 1

METRIC

W.P. 6846-14-01 LOCATION Louise Lake Culvert, MTM NAD 83 Zone 17 N 5 516 032.1 E 402 316.0 ORIGINATED BY AHF  
 HWY 641 BOREHOLE TYPE Tripod COMPILED BY AN  
 DATUM Geodetic DATE 2017.03.18 - 2017.03.18 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
							20	40	60	80	100						
318.2	GROUND SURFACE																
0.0	TRIPOD REFUSAL DUE TO COBBLES AND BOULDERS AT SURFACE.																

ONTMT4S MTO-15593.GPJ 2017TEMPLATE(MTO).GDT 10/2/17

# RECORD OF BOREHOLE No 17-05

1 OF 1

METRIC

W.P. 6846-14-01 LOCATION Louise Lake Culvert, MTM NAD 83 Zone 17 N 5 516 044.2 E 402 299.5 ORIGINATED BY AHF  
 HWY 641 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.03.16 - 2017.03.16 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT							UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
321.0	GROUND SURFACE							20 40 60 80 100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
0.0	ASPHALT: (50mm)							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								WATER CONTENT (%) W P W W L																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
	SAND, trace silt, some gravel, trace clay Brown Moist (FILL)		1	GS			320																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															</

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

# RECORD OF BOREHOLE No 17-06

1 OF 1

METRIC

W.P. 6846-14-01 LOCATION Louise Lake Culvert, MTM NAD 83 Zone 17 N 5 516 033.7 E 402 334.1 ORIGINATED BY AHF  
 HWY 641 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.03.15 - 2017.03.15 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				
321.1	GROUND SURFACE							20 40 60 80 100				
0.0	ASPHALT: (50mm)						321					
	SAND, some silt, trace gravel Brown Moist (FILL)		1	GS			320					
319.3												
1.8	Silty CLAY, trace gravel, with sand and gravel seams Grey Moist to Wet (FILL)		2	GS			319					
	Firm		1	SS	6		318					
317.4												
3.7	END OF BOREHOLE AT 3.7m. BOREHOLE DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH CUTTINGS AND DRY CONCRETE TO SURFACE.											

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

# RECORD OF BOREHOLE No 17-07

1 OF 1

METRIC

W.P. 6846-14-01 LOCATION Louise Lake Culvert, MTM NAD 83 Zone 17 N 551 603.7 E 402 343.9 ORIGINATED BY AHF  
 HWY 641 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.03.15 - 2017.03.15 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE								
321.2	GROUND SURFACE						20	40	60	80	100					
0.0	ASPHALT: (50mm)						20	40	60	80	100					
	SAND, some silt, trace gravel Brown Moist (FILL)		1	GS										○		
319.7																
1.5	Silty CLAY, some sand, trace gravel, with sand seams Brown Moist (FILL)		2	GS										○		
	Firm		1	SS	5									○		0 61 22 17
317.5																
3.7	END OF BOREHOLE AT 3.7m. BOREHOLE DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH CUTTINGS AND DRY CONCRETE TO SURFACE.															

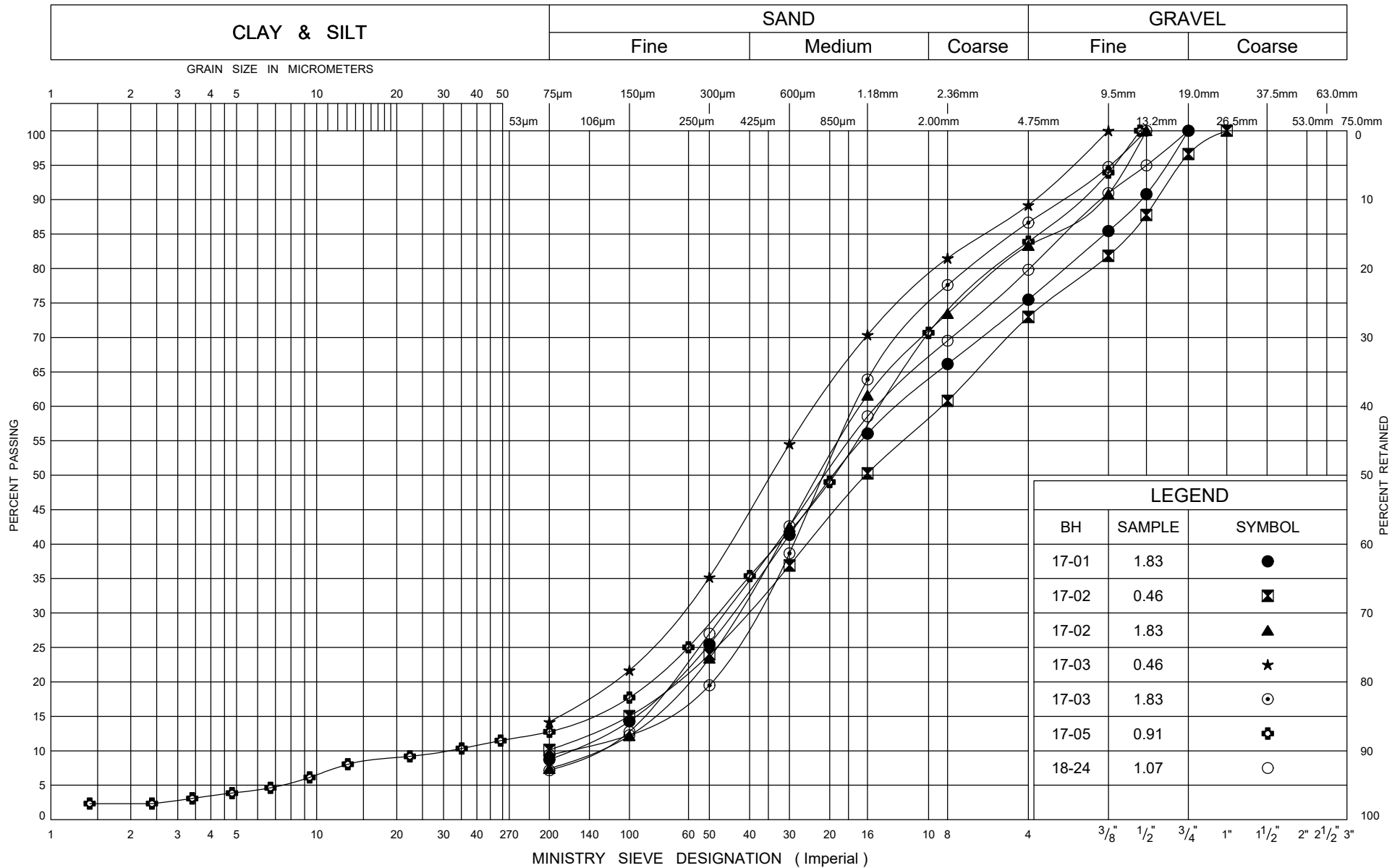
+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE



## **Appendix B**

### **Geotechnical and Analytical Laboratory Test Results**





Ministry of  
Transportation

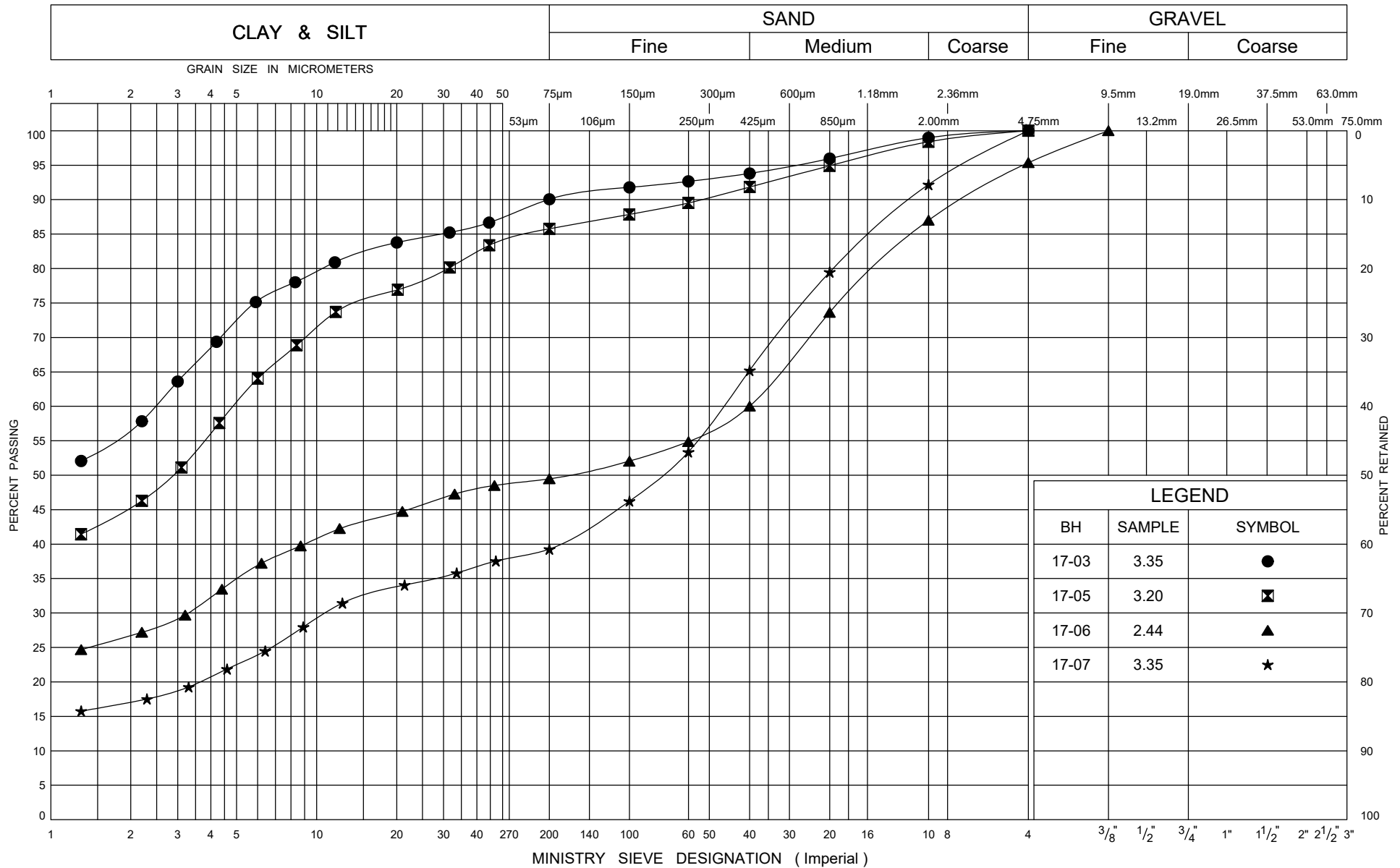
## GRAIN SIZE DISTRIBUTION

### SAND to Gravelly SAND FILL

FIG No B1

W P 6846-14-01

Louise Lake Culvert Replacement



Ministry of  
Transportation

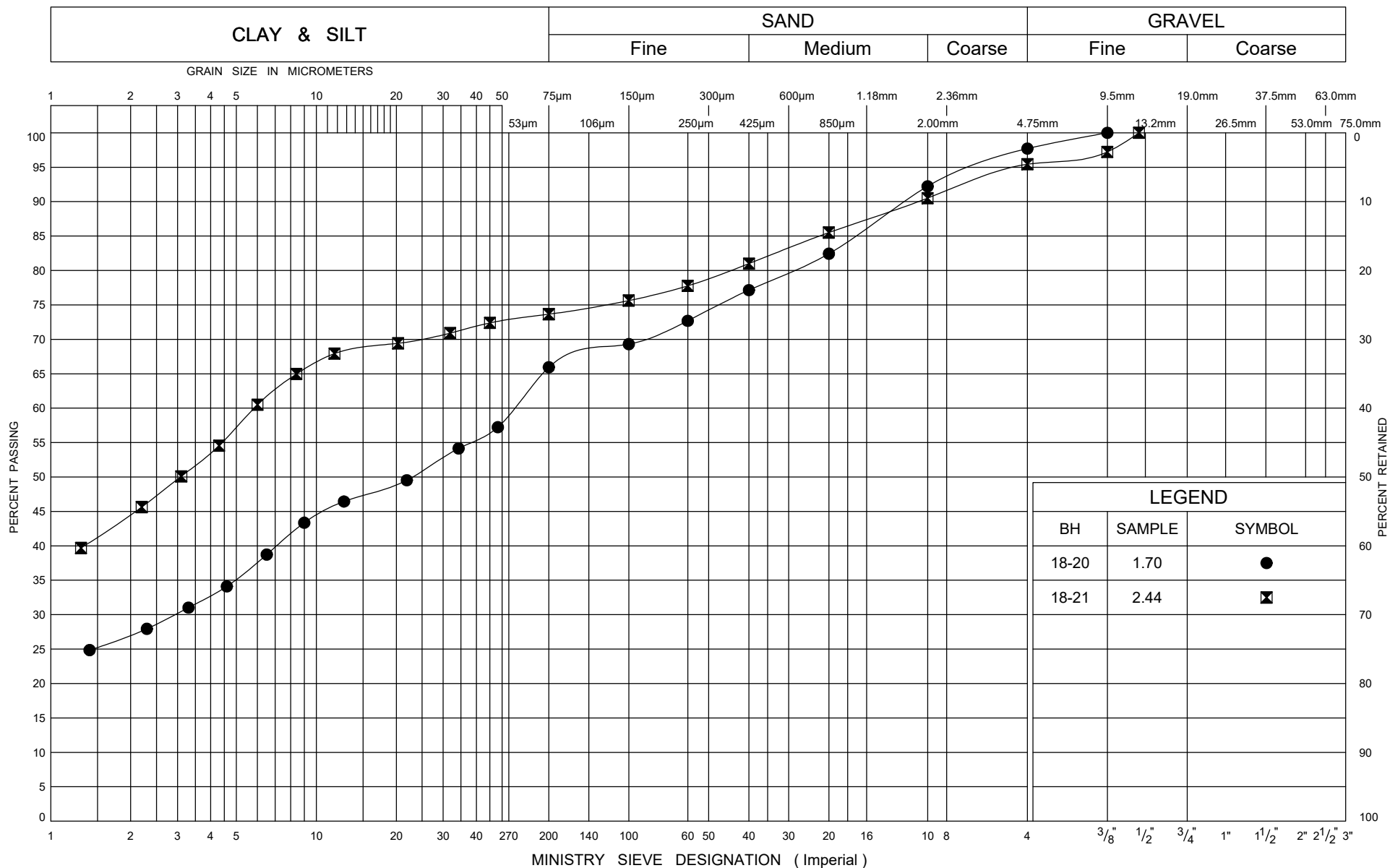
## GRAIN SIZE DISTRIBUTION

Silty CLAY FILL

FIG No B2

W P 6846-14-01

Louise Lake Culvert Replacement



Ministry of  
Transportation

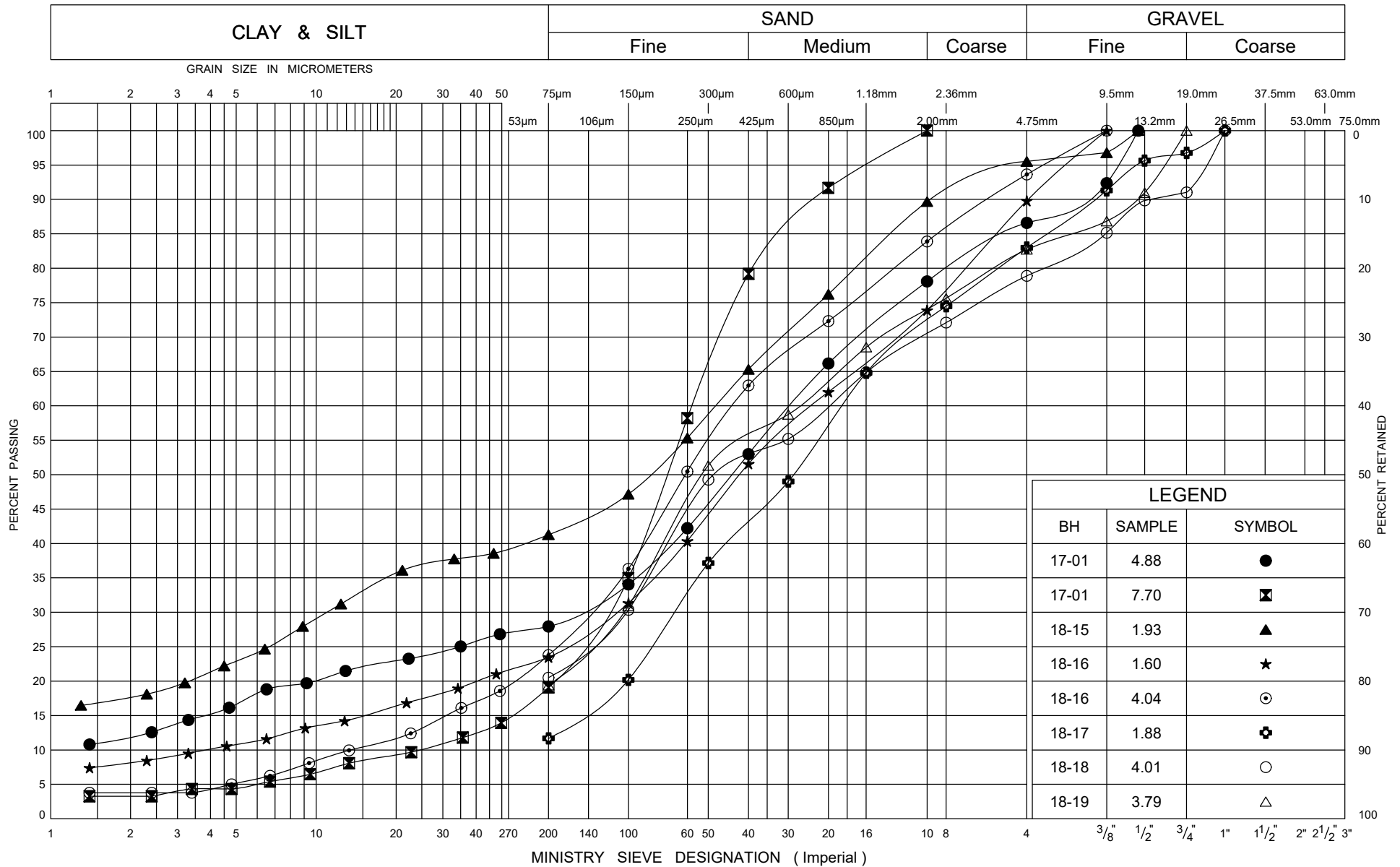
## GRAIN SIZE DISTRIBUTION

Silty CLAY

FIG No B3

W P 6846-14-01

Louise Lake Culvert Replacement



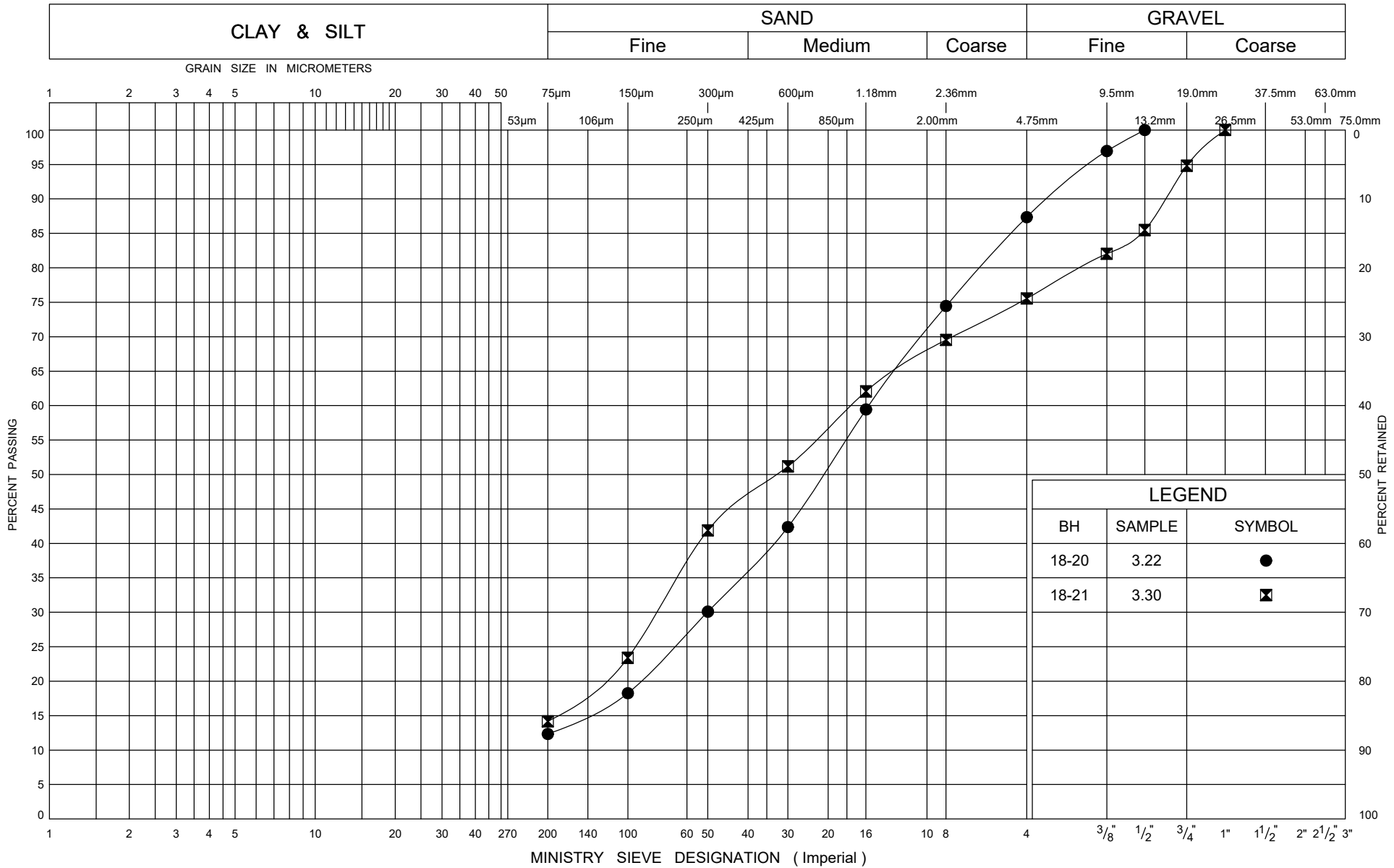
Ministry of  
Transportation

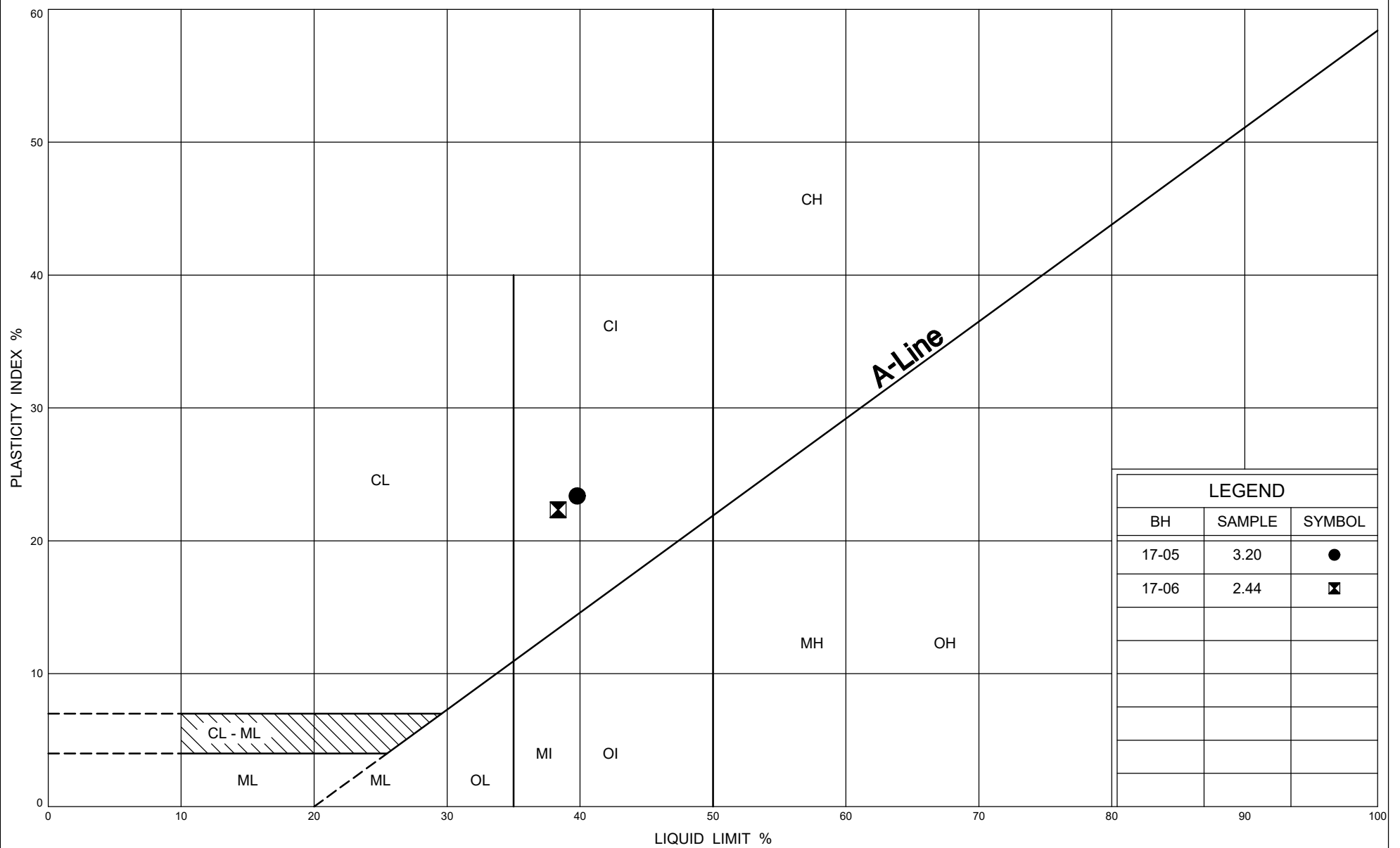
## GRAIN SIZE DISTRIBUTION SAND to Silty SAND

FIG No B4

W P 6846-14-01

Louise Lake Culvert Replacement





Ministry of  
Transportation

## PLASTICITY CHART

### Silty CLAY FILL

FIG No B6

W P 6846-14-01

Louise Lake Culvert Replacement



**THURBER** ENGINEERING LTD.

## POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 22155  
Client: WSP  
Project Name: Louise Lake Culvert  
Core Size: NQ BH No : 18-15

Date Drilled: 18-Mar-18  
Date Tested: 26-Mar-18  
Tester: KF  
Reviewed by: MEF

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	2.7	D	27.4	47.7	154.6	11.2	268.2	Granodiorite	Extremely Strong
2	2	3.6	D	45.0	48.9	140.7	17.6	423.5	Granodiorite	Extremely Strong
3	3	4.6	D	43.1	49.1	170.2	16.8	403.1	Granodiorite	Extremely Strong
4										
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7										
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\* It is ideal to perform axial test on core specimens with D/L ratio of  $1.1 \pm 0.1$

Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

\* Diametral Test should have  $0.7 \times D$  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: 22155  
 Client: WSP  
 Project Name: Louise Lake Culvert  
 Core Size: NQ BH No : 18-16

Date Drilled: 31-May-18  
 Date Tested: 07-Jun-18  
 Tester: BS  
 Reviewed by: MEF

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	5.5	D	23.7	50.5	50.5	8.9	212.6	Granodiorite	Very Strong
2	1	5.8	D	25.7	50.8	51.4	9.5	227.9	Granodiorite	Very Strong
3	1	6.1	D	15.0	50.3	50.5	5.6	135.4	Granodiorite	Very Strong
4	1	6.6	D	4.4	50.0	48.9	1.7	40.2	Granodiorite	Medium Strong
5	1	7.1	D	17.6	50.2	50.2	6.6	159.0	Granodiorite	Very Strong
6	1	7.3	D	19.3	49.8	94.0	7.3	176.4	Granodiorite	Very Strong
7										
8										
9										
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12										
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14										
15										
16							RUN#1 AVG=	158.6		Very Strong
17										
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 Long pieces of core can be tested diametrically to produce suitable lengths for axial testing
- \* Diametral Test should have  $0.7 \times D$  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: 22155  
 Client: WSP  
 Project Name: Louise Lake Culvert  
 Core Size: NQ BH No : 18-17

Date Drilled: 02-Jun-18  
 Date Tested: 08-Jun-18  
 Tester: BS  
 Reviewed by: MEF

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	2	5.3	D	21.8	49.3	50.0	8.4	202.6	Granodiorite	Very Strong
2	2	5.7	D	20.2	49.6	50.2	7.8	186.5	Granodiorite	Very Strong
3	2	6.0	D	15.7	49.8	49.1	6.0	144.1	Granodiorite	Very Strong
4	3	6.2	D	18.3	49.7	52.9	7.0	168.3	Granodiorite	Very Strong
5	4	6.4	D	0.9	36.5	36.8	0.5	12.7	Granodiorite	Weak
6	4	6.9	D	12.7	36.9	36.9	7.7	185.7	Granodiorite	Very Strong
7										
8										
9										
10						RUN#2 AVG=		177.7		Very Strong
11						RUN#3 AVG=		168.3		Very Strong
12						RUN#4 AVG=		99.2		Strong
13										
14										
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\* It is ideal to perform axial test on core specimens with D/L ratio of  $1.1 \pm 0.1$

Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

\* Diametral Test should have  $0.7 \times D$  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: 22155  
Client: WSP  
Project Name: Louise Lake Culvert  
Core Size: NQ BH No : 18-18

Date Drilled: 04-Jun-18  
Date Tested: 11-Jun-18  
Tester: BS  
Reviewed by: MEF

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	5.0	D	11.4	50.0	53.7	4.3	104.1	Granodiorite	Very Strong
2	2	5.2	D	10.0	49.8	54.4	3.8	91.4	Granodiorite	Strong
3	2	5.6	D	6.6	49.9	47.3	2.5	60.3	Granodiorite	Strong
4	3	5.8	D	5.0	49.8	50.8	1.9	46.2	Granodiorite	Medium Strong
5	3	6.1	D	3.4	50.5	45.5	1.3	30.5	Granodiorite	Medium Strong
6	4	6.2	D	14.6	37.0	37.3	8.8	211.6	Granodiorite	Very Strong
7										
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14										
15										
16							RUN#1 AVG=	104.1		Very Strong
17							RUN#2 AVG=	75.8		Strong
18							RUN#3 AVG=	38.3		Medium Strong
19							RUN#4 AVG=	211.6		Very Strong
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- \* Diametral Test should have  $0.7 \times D$  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: 22155  
Client: WSP  
Project Name: Louise Lake Culvert  
Core Size: NQ BH No : 18-19

Date Drilled: 01-Jun-18  
Date Tested: 08-Jun-18  
Tester: BS  
Reviewed by: MEF

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	3.8	D	20.0	50.0	51.7	7.6	181.8	Granodiorite	Very Strong
2	2	4.0	D	11.3	49.7	50.8	4.3	104.0	Granodiorite	Very Strong
3										
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Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

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\* Correlation factor to obtain UCS values is 24.



THURBER ENGINEERING LTD.

## POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 22155  
Client: WSP  
Project Name: Louise Lake Culvert  
Core Size: NQ BH No : 18-20

Date Drilled: 17-Mar-18  
Date Tested: 26-Mar-18  
Tester: KF  
Reviewed by: MEF

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	2	3.3	D	23.6	48.5	117.2	9.4	225.2	Granodiorite	Very Strong
2	3	4.5	D	26.9	48.8	154.6	10.6	253.8	Granodiorite	Extremely Strong
3	3	4.8	D	36.4	49.0	106.2	14.2	341.4	Granodiorite	Extremely Strong
4										
5										
6										
7							RUN#2 AVG=	225.2		Very Strong
8							RUN#3 AVG=	297.6		Extremely Strong
9										
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Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

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THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 22155  
Client: WSP  
Project Name: Louise Lake Culvert  
Core Size: NQ BH No : 18-21

Date Drilled: 26-May-18  
Date Tested: 08-Jun-18  
Tester: BS  
Reviewed by: MEF

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	2.4	D	20.8	48.2	48.0	8.4	200.6	Granodiorite	Very Strong
2	1	2.8	D	16.2	49.3	48.2	6.3	150.3	Granodiorite	Very Strong
3	2	3.3	D	13.0	50.2	46.4	4.9	117.4	Granodiorite	Very Strong
4	3	3.7	D	22.1	49.8	50.6	8.4	202.6	Granodiorite	Very Strong
5	4	4.0	D	26.1	50.3	55.2	9.8	235.3	Granodiorite	Very Strong
6	4	4.4	D	14.7	50.1	50.6	5.6	133.5	Granodiorite	Very Strong
7	4	4.9	D	8.5	50.2	53.1	3.2	76.7	Granodiorite	Strong
8	5	5.0	D	16.0	50.1	52.3	6.1	145.3	Granodiorite	Very Strong
9	5	5.5	D	20.5	50.2	51.7	7.7	185.6	Granodiorite	Very Strong
10										
11										
12										
13										
14										
15										
16							RUN#1 AVG=	175.4		Very Strong
17							RUN#2 AVG=	117.4		Very Strong
18							RUN#3 AVG=	202.6		Very Strong
19							RUN#4 AVG=	148.5		Very Strong
20							RUN#5 AVG=	165.4		Very Strong
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THURBER ENGINEERING LTD.

## POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 22155  
Client: WSP  
Project Name: Louise Lake Culvert  
Core Size: NQ BH No : 18-22

Date Drilled: 28-May-18  
Date Tested: 07-Jun-18  
Tester: BS  
Reviewed by: MEF

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	2.8	D	13.2	50.3	52.6	4.9	118.7	Granodiorite	Very Strong
2										
3										
4										
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7										
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\* Correlation factor to obtain UCS values is 24.



THURBER ENGINEERING LTD.

## POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 22155  
Client: WSP  
Project Name: Louise Lake Culvert  
Core Size: NQ BH No : 18-23

Date Drilled: 19-Mar-18  
Date Tested: 26-Mar-18  
Tester: KF  
Reviewed by: MEF

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	3.0	D	33.4	47.7	154.7	13.6	326.8	Granodiorite	Extremely Strong
2	2	3.7	D	27.4	47.7	310.0	11.2	267.9	Granodiorite	Extremely Strong
3	3	4.3	D	38.8	49.2	147.1	15.1	361.9	Granodiorite	Extremely Strong
4	4	5.3	D	41.6	49.5	115.7	16.0	384.4	Granodiorite	Extremely Strong
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THURBER ENGINEERING LTD.

## POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 22155  
Client: WSP  
Project Name: Louise Lake Culvert  
Core Size: NQ BH No : 18-24

Date Drilled: 14-Mar-18  
Date Tested: 26-Mar-18  
Tester: KF  
Reviewed by: MEF

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	7.4	D	33.4	46.8	153.7	14.0	336.6	Granodiorite	Extremely Strong
2	1	8.2	D	29.8	46.8	154.6	12.5	300.3	Granodiorite	Extremely Strong
3	2	9.0	D	13.6	47.2	154.6	5.7	135.7	Granodiorite	Very Strong
4										
5										
6						RUN#1 AVG=		318.4		Extremely Strong
7						RUN#2 AVG=		135.7		Very Strong
8										
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# ASTM D5731-08

<b>Date Drilled:</b>	18-Mar-17
<b>Date Tested:</b>	25-Apr-17
<b>Tester:</b>	RT
<b>Reviewed by:</b>	CZ

[illegible]



# ASTM D5731-08

Date Drilled:	15-Mar-17
Date Tested:	21-Apr-17
Tester:	WHW
Reviewed by:	CZ

[illegible]



Photo 1: Borehole 18-15 Bedrock Core Sample



Photo 2: Borehole 18-16 Bedrock Core Sample





Photo 3: Borehole 18-17 Bedrock Core Sample





Photo 4: Borehole 18-18 Bedrock Core Sample





Photo 5: Borehole 18-19 Bedrock Core Sample



Photo 6: Borehole 18-20 Bedrock Core Sample





Photo 7: Borehole 18-21 Bedrock Core Sample



Photo 8: Borehole 18-22 Bedrock Core Sample





Photo 9: Borehole 18-23 Bedrock Core Sample



Photo 10: Borehole 18-24 Bedrock Core Sample





Photo 11: Borehole 17-02 Bedrock Core Sample



Photo 12: Borehole 17-03 Bedrock Core Sample



**SGS Canada Inc.**

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

**Thurber Engineering Ltd**

Attn : Cory Zanatta

2010 Winston Park Dr  
Oakville, ON  
L6H 5R7,

Phone: 905-829-8666 x 240

Fax:

**Project :** 15593

08-May-2017

**Date Rec. :** 02 May 2017

**LR Report:** CA14060-MAY17

**Reference:** 15593 Cory Zanatta

**Copy:** #1

## CERTIFICATE OF ANALYSIS

### Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Approval Date	4: Analysis Approval Time	5: 17-01 SS3	6: 17-03 SS3
Sample Date & Time					26-Mar-17	26-Mar-17
Temperature Upon Receipt [°C]	---	---	---	---	6.0	6.0
Corrosivity Index [none]	08-May-17	14:35	08-May-17	14:35	4.0	4.0
Soil Redox Potential [mV]	03-May-17	16:33	04-May-17	14:12	249	237
Sulphide [%]	05-May-17	13:47	05-May-17	15:54	< 0.02	< 0.02
% Moisture (wet wt) [%]	04-May-17	13:57	04-May-17	14:37	1.4	16.7
pH [no unit]	03-May-17	15:41	05-May-17	09:17	9.41	8.56
Chloride [µg/g]	05-May-17	17:42	08-May-17	14:40	18	75
Sulphate [µg/g]	05-May-17	17:42	08-May-17	14:40	3.3	27
Conductivity [uS/cm]	03-May-17	15:41	05-May-17	09:17	96	235
Resistivity (calculated) [Ohms.cm]	03-May-17	15:41	08-May-17	14:21	10400	4260

Temperature of Sample upon Receipt: 12 degrees C

Cooling Agent Present: Yes

Custody Seal Present: No

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



**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.

Lakefield - Ontario - K0L 2H0

Phone: 705-652-2000 FAX: 705-652-6365

**Project :** 15593

**LR Report :** CA14060-MAY17

### Method Descriptions

Parameter	SGS Method Code
Anions by IC	ME-CA-[ENV]IC-LAK-AN-001
Carbon/Sulphur	ME-CA-[ENV]ARD-LAK-AN-020
Conductivity	ME-CA-[ENV]EWL-LAK-AN-006
Metals Prep	ME-CA-[ENV]ARD-LAK-AN-013
pH	ME-CA-[ENV]EWL-LAK-AN-001

*Deanna Edwards, B.Sc, C.Chem*

*Project Specialist*

*Environmental Services, Analytical*



**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.

Lakefield - Ontario - KOL 2H0

Phone: 705-652-2000 FAX: 705-652-6365

**Project :** 15593

**LR Report :** CA14060-MAY17

## Quality Control Report

Inorganic Analysis												
Parameter	Reporting Limit	Unit	Method Blank				LCS / Spike Blank			Matrix Spike / Reference Material		
					RPD	Acceptance Criteria	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
						%		Low	High		Low	High
Anions by IC - QCBatchID: DIO0108-MAY17												
Chloride	0.4	µg/g	<0.4		3	20	101	80	120	105	75	125
Sulphate	0.4	µg/g	<0.4		2	20	97	80	120	87	75	125
Carbon/Sulphur - QCBatchID: ECS0006-MAY17												
Sulphide	0.02	%	<0.02		ND	20	113	80	120			
Conductivity - QCBatchID: EWL0047-MAY17												
Conductivity	2	uS/cm	< 2		2	10	93	90	110	NA		
pH - QCBatchID: EWL0047-MAY17												
pH	0.05	no unit	NA		0		100			NA		

**SGS Canada Inc.**

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

**Thurber Engineering Ltd**

Attn : Cory Zanatta

2010 Winston Park Dr  
Oakville, ON  
L6H 5R7,

Phone: 905-829-8666 x 240  
Fax:

19-April-2017

**Date Rec. :** 11 April 2017  
**LR Report:** CA14206-APR17  
**Reference:** Cory Zanatta


**Copy:** #1

## CERTIFICATE OF ANALYSIS

### Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Approval Date	4: Analysis Approval Time	5: MDL	6: Louise Lake
Sample Date & Time						18-Mar-17
Temperature Upon Receipt [°C]	---	---	--	--	---	7.0
pH [no unit]	12-Apr-17	15:59	17-Apr-17	11:28	0.05	7.46
Conductivity [µS/cm]	12-Apr-17	15:59	17-Apr-17	11:28	2	56
Resistivity (calculated) [Ohms.cm]	17-Apr-17	16:10			---	17700
Redox Potential [mV]	12-Apr-17	13:31	13-Apr-17	11:42	---	239
Chloride [mg/L]	12-Apr-17	15:47	17-Apr-17	14:55	0.04	3.1
Sulphate [mg/L]	12-Apr-17	15:47	17-Apr-17	14:55	0.04	1.6
Sulphide [mg/L]	12-Apr-17	10:31	12-Apr-17	13:44	0.006	0.007

Temperature of Sample upon Receipt: 7 degrees C  
Cooling Agent Present: Yes  
Custody Seal Present: No

  
**Deanna Edwards, B.Sc, C.Chem**  
**Project Specialist**  
**Environmental Services, Analytical**

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.

Lakefield - Ontario - KOL 2H0

Phone: 705-652-2000 FAX: 705-652-6365

**LR Report : CA14206-APR17**

## Method Descriptions

Parameter	Units	SGS Method Code	Reference Method Code
Anions by IC	mg/L	ME-CA-[ENV]IC-LAK-AN-001	EPA300/MA300-Ions1.3
Conductivity	uS/cm	ME-CA-[ENV]EWL-LAK-AN-006	SM 2510
pH	no unit	ME-CA-[ENV]EWL-LAK-AN-006	SM 4500
Redox Potential	mV		SM 2580
Sulphide by SFA	mg/L	ME-CA-[ENV]SFA-LAK-AN-008	SM 4500

## Quality Control Report

Inorganic Analysis												
Parameter	Reporting Limit	Unit	Method Blank				LCS / Spike Blank			Matrix Spike / Reference Material		
					RPD	Acceptance Criteria	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
						%		Low	High		Low	High
Anions by IC - QCBatchID: DIO0135-APR17												
Chloride	0.04	mg/L	<0.04		3	20	99	80	120	103	75	125
Sulphate	0.04	mg/L	<0.04		1	20	96	80	120	101	75	125
Conductivity - QCBatchID: EWL0161-APR17												
Conductivity	2	µS/cm	< 2		0	10	100	90	110	NA		
pH - QCBatchID: EWL0161-APR17												
pH	0.05	no unit	NA		0		100			NA		
Redox Potential - QCBatchID: EWL0152-APR17												
Redox Potential	no	mV	NA		4	20	104	80	120	NA		
Sulphide by SFA - QCBatchID: SKA0090-APR17												
Sulphide	0.006	mg/L	<0.006		ND	20	87	80	120	NV	75	125



## **Appendix C**

### **Site Photographs**





**Photo 1: Highway 654 embankment over Louis Lake Culvert, looking west**



**Photo 2: Louis Lake Culvert, South Side**



**Photo 3: Louis Lake Culvert, north side**



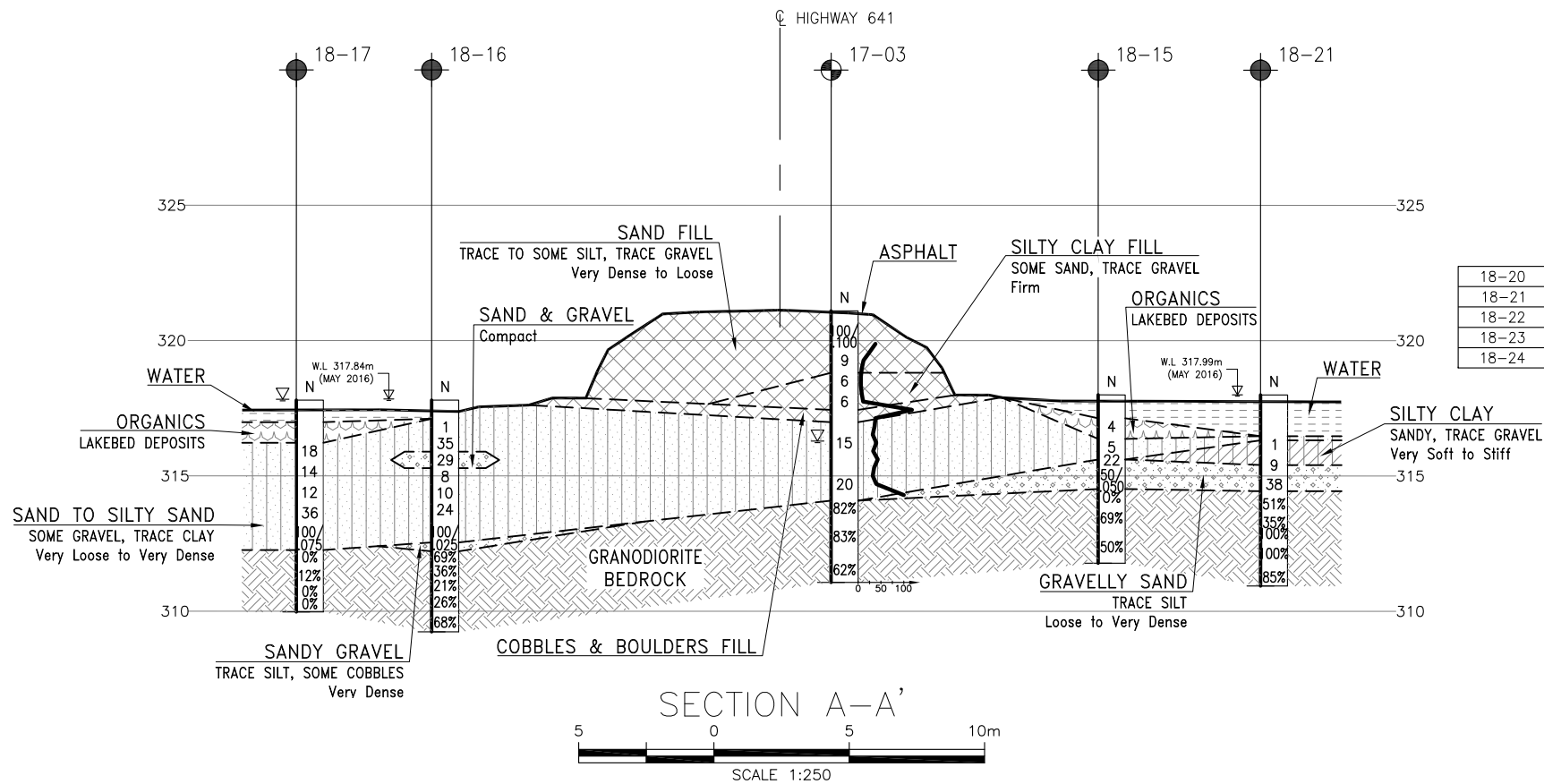
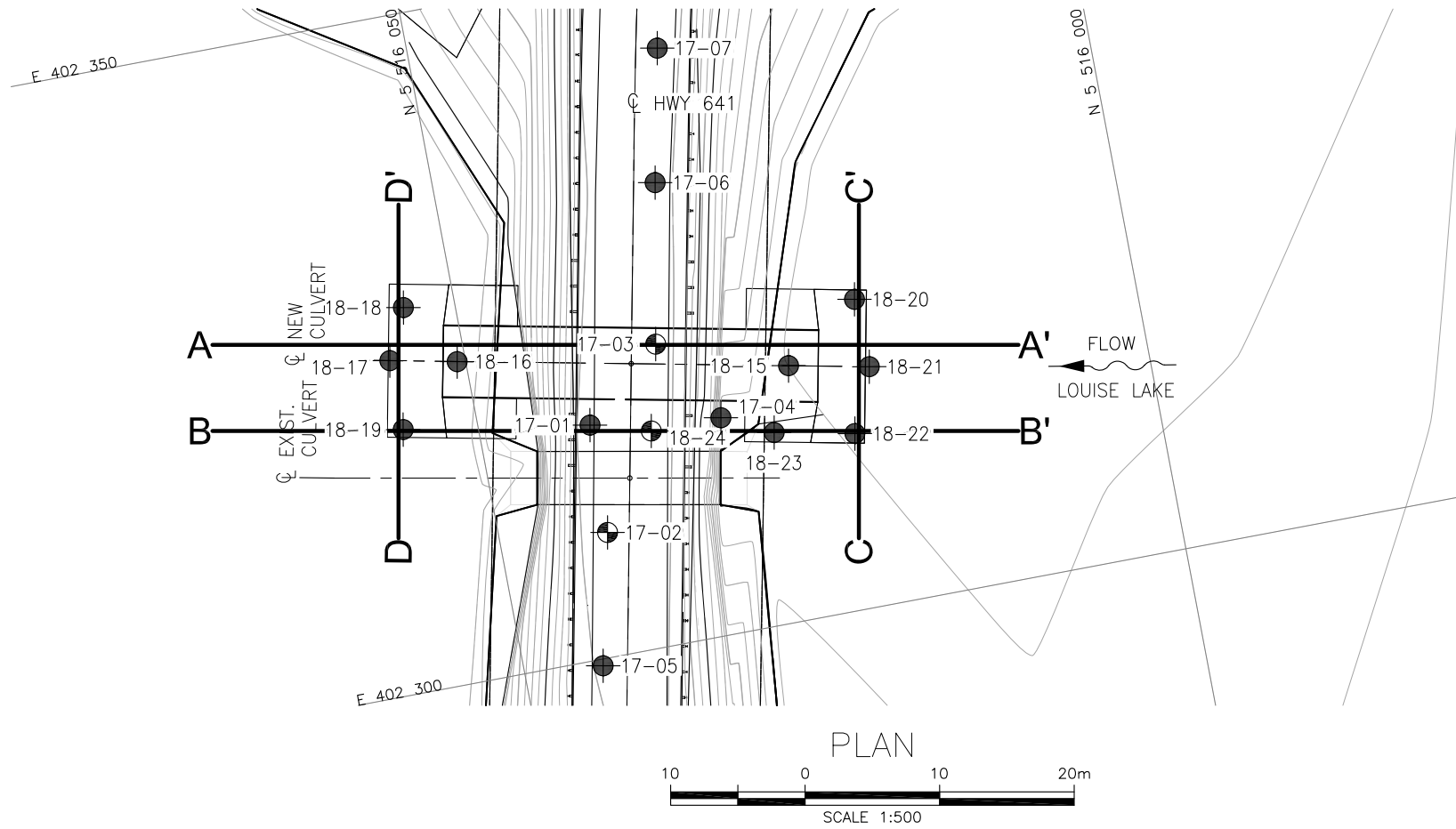


**Photo 4: Louis Lake culvert, south side, location of Borehole 17-04**



## **Appendix D**

### **Borehole Locations and Soil Strata Drawing**



18-20	318.0	5 516 020.7	402 322.8
18-21	318.0	5 516 020.6	402 317.7
18-22	318.0	5 516 022.6	402 313.0
18-23	318.0	5 516 028.4	402 314.2
18-24	321.1	5 516 037.4	402 316.0

CONT No  
WP No 6846-14-01

HIGHWAY 641  
LOUISE LAKE  
CULVERT REPLACEMENT  
BOREHOLE LOCATIONS AND SOIL STRATA



THURBER ENGINEERING LTD.



LATITUDE: 49.774013° LONGITUDE: -94.646125°

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
17-01	321.1	5 516 041.8	402 317.3
17-02	321.1	5 516 042.0	402 309.2
17-03	321.1	5 516 035.9	402 322.3
17-04	318.2	5 516 032.1	402 316.0
17-05	321.0	5 516 044.2	402 299.5
17-06	321.1	5 516 033.7	402 334.1
17-07	321.2	5 516 031.7	402 343.9
18-15	318.0	5 516 026.5	402 318.9
18-16	317.8	5 516 050.6	402 323.7
18-17	317.8	5 516 055.5	402 324.7
18-18	317.8	5 516 053.8	402 328.4
18-19	317.8	5 516 055.5	402 319.5

NOTES-

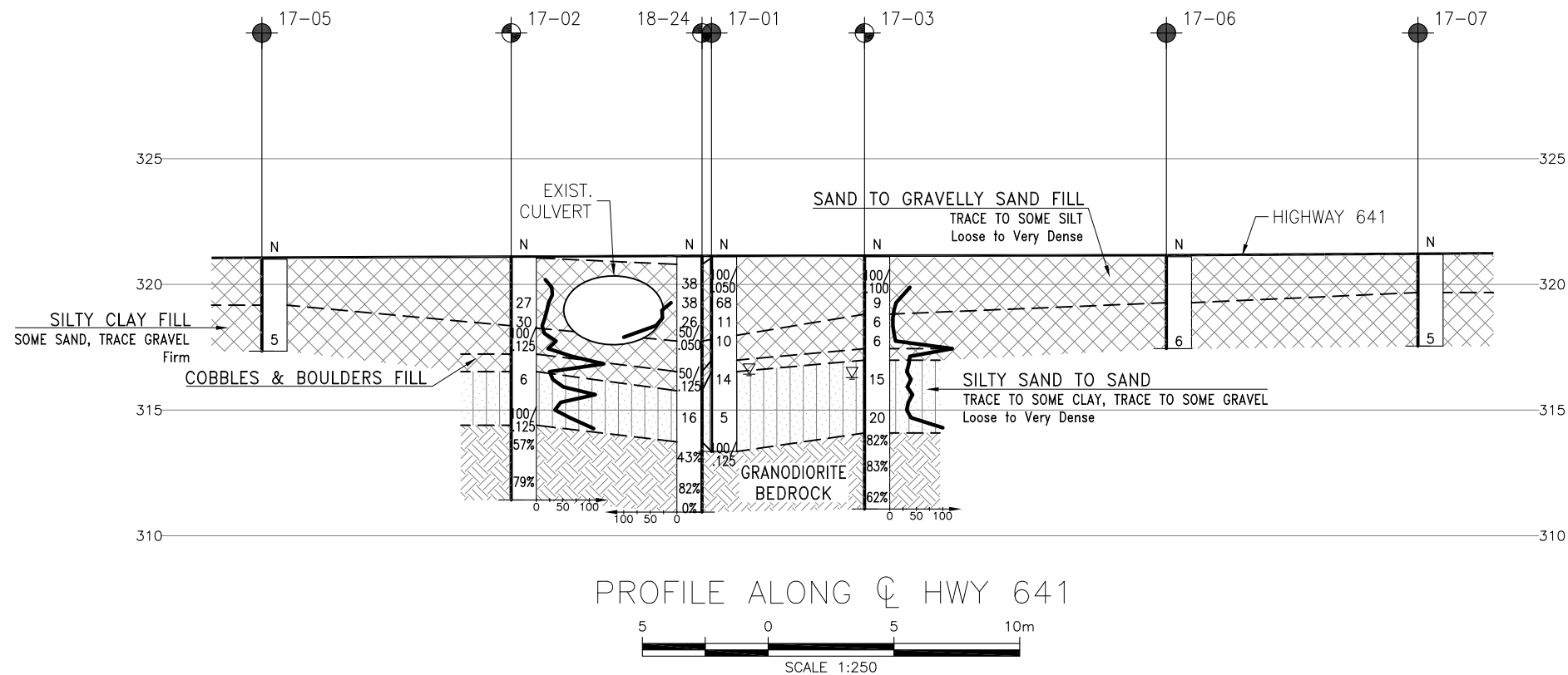
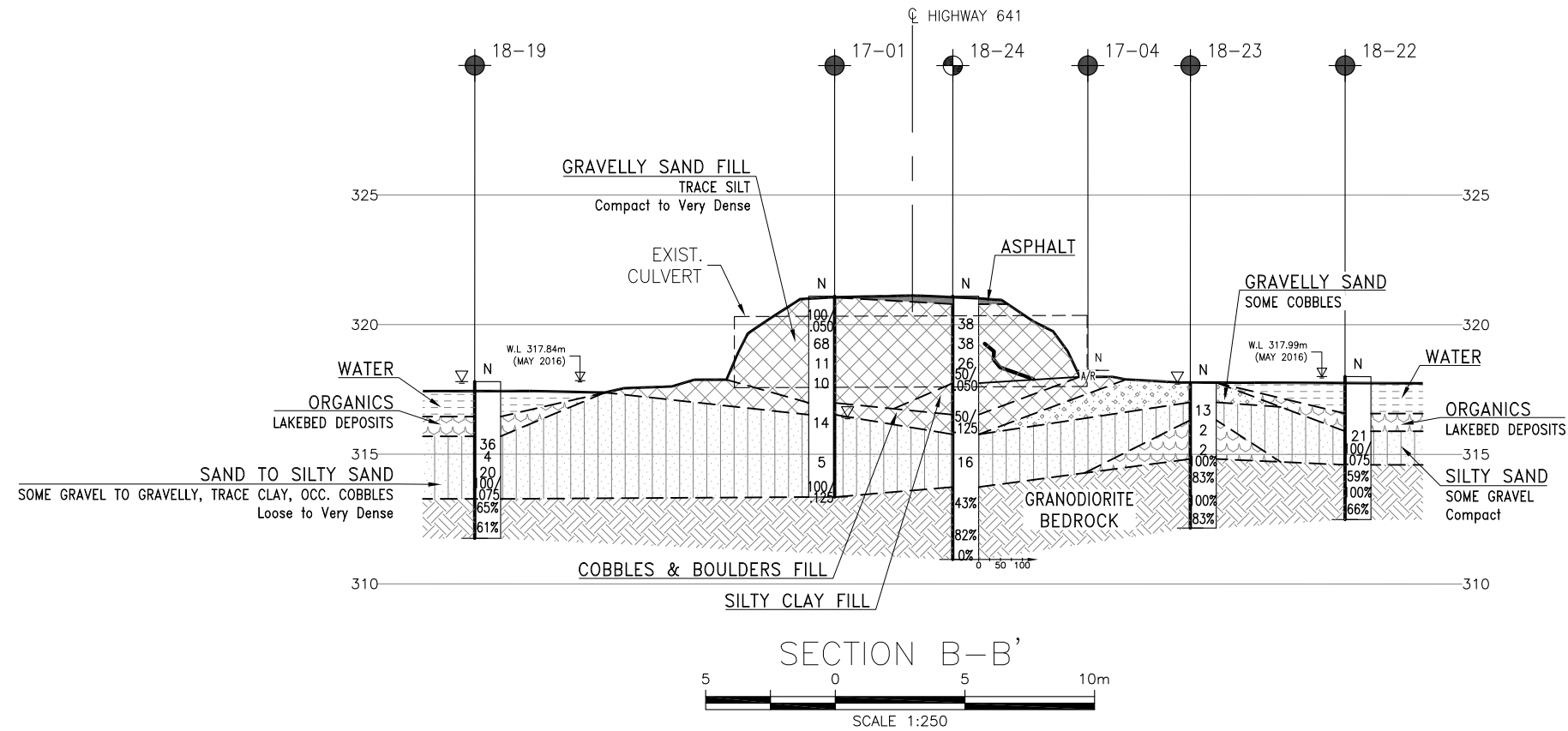
- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 17

GEOCRES No. 52E-69

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	MEF	CHK PKC	CODE
DRAWN	AN	CHK MEF	SITE
			LOAD
			DATE
			DEC 2018
			STRUCT
			DWG 1



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



18-20	318.0	5 516 020.7	402 322.8
18-21	318.0	5 516 020.6	402 317.7
18-22	318.0	5 516 022.6	402 313.0
18-23	318.0	5 516 028.4	402 314.2
18-24	321.1	5 516 037.4	402 316.0



CONT No  
WP No 6846-14-01

HIGHWAY 641  
LOUISE LAKE  
CULVERT REPLACEMENT  
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



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
17-01	321.1	5 516 041.8	402 317.3
17-02	321.1	5 516 042.0	402 309.2
17-03	321.1	5 516 035.9	402 322.3
17-04	318.2	5 516 032.1	402 316.0
17-05	321.0	5 516 044.2	402 299.5
17-06	321.1	5 516 033.7	402 334.1
17-07	321.2	5 516 031.7	402 343.9
18-15	318.0	5 516 026.5	402 318.9
18-16	317.8	5 516 050.6	402 323.7
18-17	317.8	5 516 055.5	402 324.7
18-18	317.8	5 516 053.8	402 328.4
18-19	317.8	5 516 055.5	402 319.5

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 17

GEOCRES No. 52E-69

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

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



CONT No  
WP No 6846-14-01

HIGHWAY 641  
LOUISE LAKE  
CULVERT REPLACEMENT  
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

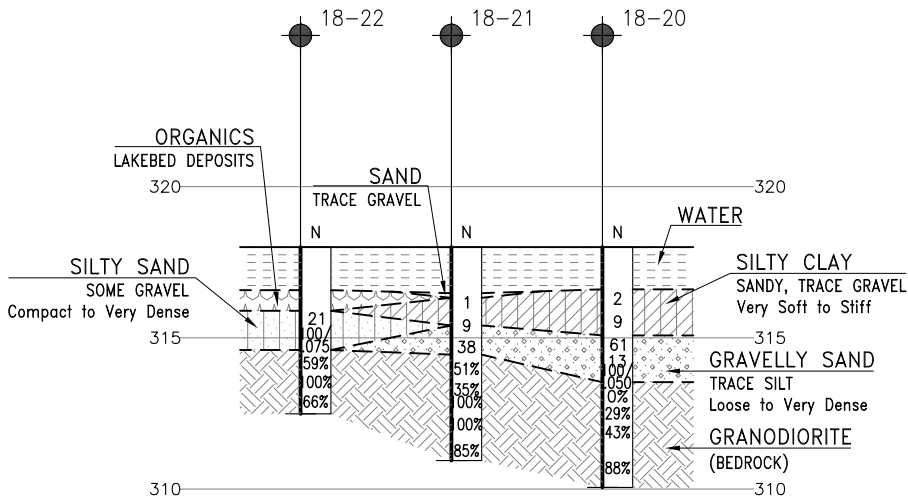
	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60" Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
17-01	321.1	5 516 041.8	402 317.3
17-02	321.1	5 516 042.0	402 309.2
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17-04	318.2	5 516 032.1	402 316.0
17-05	321.0	5 516 044.2	402 299.5
17-06	321.1	5 516 033.7	402 334.1
17-07	321.2	5 516 031.7	402 343.9
18-15	318.0	5 516 026.5	402 318.9
18-16	317.8	5 516 050.6	402 323.7
18-17	317.8	5 516 055.5	402 324.7
18-18	317.8	5 516 053.8	402 328.4
18-19	317.8	5 516 055.5	402 319.5

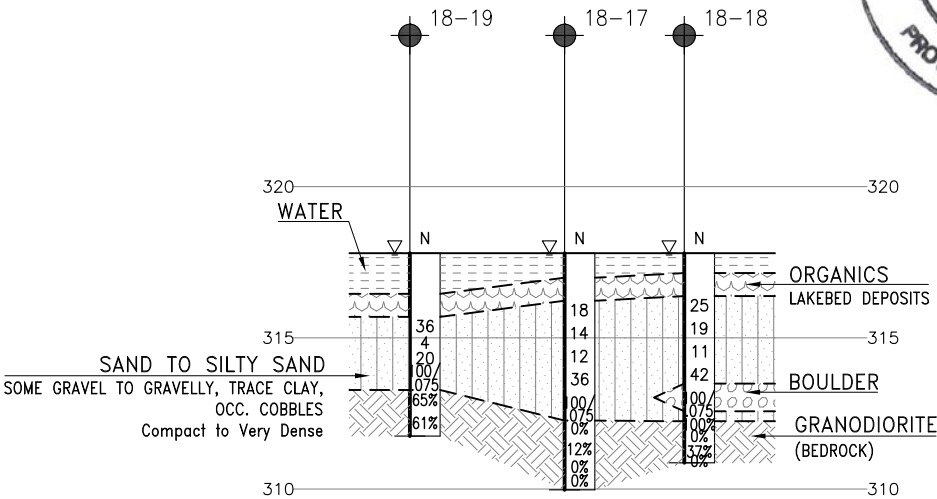
-NOTES-

- 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 17

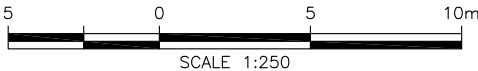
GEOCRES No. 52E-69



SECTION C-C'



SECTION D-D'



18-20	318.0	5 516 020.7	402 322.8
18-21	318.0	5 516 020.6	402 317.7
18-22	318.0	5 516 022.6	402 313.0
18-23	318.0	5 516 028.4	402 314.2
18-24	321.1	5 516 037.4	402 316.0

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	MEF	CHK PKC	CODE
DRAWN	AN	CHK MEF	SITE
LOAD	DATE	DEC 2018	
STRUCT	DWG	3	