



**THURBER** ENGINEERING LTD.

**DETAILED FOUNDATION INVESTIGATION AND DESIGN REPORT  
BLACKWATER RIVER TRIBUTARY CULVERT REPLACEMENT  
HIGHWAY 11, DISTRICT OF THUNDER BAY, ONTARIO  
AGREEMENT 6019-E-0009, WORK ORDER 15  
G.W.P. 6313-14-00, SITE NO. 48C-0180/C0  
LATITUDE: 49.539347°, LONGITUDE: -88.003512°**

**GEOCRES No.: 52H-50**

**Report**

to

**HATCH**

Date: October 15, 2021  
File: 30543





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**PART 1: FACTUAL INFORMATION**

**1. INTRODUCTION**

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for design of the proposed Blackwater River Tributary Culvert replacement. The Blackwater River Tributary Culvert is located on Highway 11, south of Beardmore, in Unsurveyed Territory, District of Thunder Bay, Ontario.

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 carried out the investigation as a sub-consultant to Hatch, under the Ministry of Transportation Ontario (MTO) Retainer Agreement Number 6019-E-0009, Work Order 15.

Reference has been made to information on subsurface conditions contained in a previous foundation report prepared for this site. The title of the report is:

- Foundation Investigation and Design Report, Highway 11 Culvert Rehabilitations, Postagoni River and Blackwater River Tributary Culverts, Sites 48C-2/C and 48C-180/C, Ministry of Transportation, Ontario, GWP 6166-04-00, WP 6314-14-01 and WP 6313-14-01. Geocres No. 52H-41, prepared by Golder Associates, dated October 7, 2016. (Reference 1).

The records of borehole sheets from the previous investigation are included in Appendix E for reference.

**2. SITE DESCRIPTION**

The site is located on Highway 11, approximately 8 km south of Beardmore, in Unsurveyed territory, District of Thunder Bay, Ontario. The existing culvert allows the Blackwater River





Tributary to flow in an east to west direction under Highway 11. Highway 11 generally runs in an north-south direction at the culvert site.

The available base plan drawing provided by Hatch (Plan E-493880-11-1) indicates that the existing structure is a concrete, cast-in-place box culvert. Field observations conducted by Hatch suggest that the structure may be a closed-bottom box culvert, but this could not be visually confirmed. The base plan indicates that the span of the structure is 3.05 m, the height is 1.52 m and the length is 17.95 m. The estimated culvert invert is at approximate Elev. 372.6 m at the inlet (east) and 372.5 m at the outlet (west). The existing road grade at the culvert location is at approximate Elev. 375.8 m, which indicates approximately 1.4 m of fill above the 0.3 m thick top slab of the culvert. The local river water level was reportedly measured at Elev. 373.7 m in September 2014, and was subsequently measured at Elev. 373.3 m in February 2016 by Golder and Elev. 373.3 m in March 2021 by Thurber. The site topography within the culvert area is generally flat surrounding Blackwater River Tributary on both sides of Highway 11. The existing highway embankment side slopes beyond the culvert are inclined at approximately 2H:1V or flatter and appear to be performing satisfactorily. Some surficial erosion gullies were however noted at the top of the granular slopes.

The lands surrounding the site predominantly consist of heavily forested areas with lakes and other tributaries, with localized marshy conditions along the highway near the culvert. Photographs in Appendix C show the general nature of the site and the existing culvert.

Based on published geological information, the culvert lies within an area consisting of primarily Precambrian bedrock covered by a discontinuous thin layer of drift. Based on the OGS Map MRD126-REV1 titled "Bedrock Geology of Ontario", dated 2011, the bedrock at site is identified as metasedimentary rock.

### **3. INVESTIGATION PROCEDURES**

The current site investigation and field testing program for this project was carried out between March 22 and March 27, 2021, and consisted of drilling and sampling four (4) boreholes (21-01 to 21-04) to depths of 8.8 to 11.9 m below ground surface (Elev. 366.9 m to 363.7 m). Boreholes 21-01 and 21-04 were drilled through the paved portion of Highway 11. Boreholes 21-02 and 21-03 were drilled through the Highway 11 shoulders near the existing culvert. The approximate borehole locations are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix D.

The previous site investigation by Golder (Reference 1), consisted of drilling and sampling four (4) boreholes (BW-1 to BW-4) to depths of 4.2 to 9.8 m below the existing ground surface





(Elevation 370.0 to 364.5 m). Two of the boreholes were advanced near the inlet (east end) and two of the boreholes were advanced near the outlet (west end) of the culvert.

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

Utility clearances were obtained prior to the start of drilling. The ground surface elevations for the boreholes were estimated from field measurements relative to existing site features and the topographic drawings provided to Thurber by Hatch. The coordinate system MTM NAD 83, Zone 14 was used for the boreholes.

All boreholes were advanced using a rubber-tired CME 750 drill rig, using hollow stem augers and NW casing / Tricone with wash boring techniques. Soil samples were obtained in all boreholes at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). Bedrock coring using an NQ size core barrel was used to advance all four boreholes into bedrock.

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.

The rock cores were logged, and the Total Core Recovery (TCR), Solid Core Recovery (SCR), Rock Quality Designation (RQD) and the Fracture Indices (FI) were determined.

Monitoring wells were installed in Boreholes 21-02 and 21-04. Both wells consisted of 50 mm Schedule 40 PVC pipe with a 3.0 m long slotted screen, enclosed in a column of filter sand to permit groundwater level monitoring. Well installation details, groundwater level observations and water level readings are shown on the Record of Borehole sheets. A sample of the groundwater was obtained during the field investigation and submitted to a specialist analytical laboratory under chain of custody procedures for testing for a suite of water quality parameters. Single well response tests ("slug") tests were carried out in the 50 mm diameter wells installed in both Boreholes 21-02 and 21-04. Upon collection of the final water level readings on March 27, 2021, the wells were decommissioned in accordance with MOECP O.Reg. 903.

Details of the drilling program, including drilling depths, piezometer installation and completion details are summarized in Table 3.1 below.



**Table 3.1: Borehole Completion Details**

Borehole Number	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
21-01	10.4 / 365.3	None installed	Borehole backfilled with bentonite holeplug from 10.4 m to 0.5 m, sand from 0.5 m to 0.2 m and cold patch asphalt from 0.2 m to surface.
21-02	8.8 / 366.8	5.3 / 370.4	Borehole was backfilled with bentonite holeplug from 8.8 m to 5.3 m, filter sand from 5.3 m to 1.7 m, bentonite holeplug from 1.7 m to 0.2 m, shoulder gravel from 0.2 m to ground surface.
21-03	11.9 / 363.7	None installed	Borehole backfilled with bentonite holeplug from 11.9 m to 0.2 m and shoulder gravel from 0.2 m to surface.
21-04	8.8 / 366.9	5.8 / 369.9	Borehole was backfilled with bentonite holeplug from 8.8 m to 5.8 m, filter sand from 5.8 m to 2.1 m, bentonite holeplug from 2.1 m to 0.3 m, sand from 0.3 m to 0.2 m and cold patch asphalt from 0.2 m to surface.

#### 4. LABORATORY TESTING

All recovered soil samples were subjected to visual identification and natural moisture content determination. Selected samples were subjected to grain size distribution analyses (sieve and hydrometer) for 25% of the collected samples. Point load tests were also conducted on the bedrock cores. The results of this testing program are summarized on the Record of Borehole sheets in Appendix A and are shown 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, two (2) samples of the native soil were collected during the investigation and submitted to SGS, a CALA accredited analytical laboratory in Mississauga, Ontario, for analytical testing of soil corrosivity parameters. In order to assess the quality of the groundwater for disposal purposes, a water sample was collected from the well





installed in Borehole 21-02. The results of the analytical testing are summarized in this report and presented in Appendix B.

## **5. DESCRIPTION OF SUBSURFACE CONDITIONS**

Reference is made to the Record of Borehole sheets for the current and previous investigations included in Appendix A and Appendix E, respectively. Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets and on the Borehole Locations and Soil Strata drawings 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 in the Record of Borehole sheets governs any interpretation of the site conditions. It must be recognized that soil conditions may vary between and beyond the borehole locations. Description of the soil stratigraphy encountered in the previous boreholes is included in Reference 1.

In general, the subsurface stratigraphy below the asphalt typically consists of sand and gravel to gravelly sand fill underlain by peat, sand, and sandy silt to silt and sand glacial till. The overburden soils are underlain by bedrock. More detailed descriptions of individual strata are presented below.

### **5.1 Asphalt**

Boreholes 21-01 and 21-04 were drilled through the paved portion of Highway 11. The asphalt ranged in thickness from 100 to 150 mm at these locations.

### **5.2 Embankment Fill**

Embankment fill ranging in composition from sand and gravel to gravelly sand was encountered at the ground surface in Boreholes 21-02 and 21-03 and below the asphalt Boreholes 21-01 and 21-04. The fill was brown to grey in colour and contained trace to some silt and occasional cobbles.

The embankment fill ranged in thickness from 2.8 m to 3.1 m, with an underside depth ranging from 2.8 m to 3.2 m below ground surface (Elev. 372.8 m to 372.5 m).

SPT 'N' values in the fill generally ranged from 25 to more than 50 blows per 0.3 m of penetration, indicating a compact to very dense relative density.

The measured moisture contents generally ranged from 2 to 20%.





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

Soil Particle	Percentage (%)
Gravel	23 to 38
Sand	48 to 65
Silt and Clay	12 to 14

### 5.3 Peat

A black fibrous peat layer with roots and wood fragments was encountered below the embankment fill in all four boreholes, with an underside depth of 4.1 m (Elev. 371.6 to 371.5 m). The peat layer ranged in thickness from 0.9 to 1.3 m.

Peat was also encountered at the ground surface in the off-road previous boreholes BW-1 to BW-4 from Reference 1, where the underside of the peat extended to depths from 1.4 to 2.6 m (Elev. 372.5 to 371.4 m).

SPT 'N' Values ranging from 1 to 6 blows per 0.3 m penetration were recorded in the fibrous peat deposit, indicating a very soft to firm consistency.

Recorded moisture contents of the peat ranged from 116.9 percent to 524.8 percent.

### 5.4 Sand

A deposit of sand with trace gravel and trace silt was encountered below the peat in Boreholes 21-01 and 21-03. The sand deposit extended to a depth of 5.6 m below ground surface (Elev. 370.1 m to 370.0 m).

SPT 'N' Values of 22 blows per 0.3 m penetration were recorded in the sand deposit, indicating a compact relative density. No sample was recovered in the SPT for Borehole 21-01.

The measured moisture content was 18 percent. The results of a grain size analysis conducted on a sample of the sand deposit is provided on the Record of Borehole sheets in Appendix A and plotted on Figure B2 of Appendix B. The results are summarized as follows:



Soil Particle	Percentage (%)
Gravel	2
Sand	97
Silt and Clay	1

### 5.5 Sandy Silt to Silt and Sand Till

A sandy silt to silt and sand till deposit was encountered below the peat layer in Boreholes 21-02 and 21-04 and below the sand layer in Boreholes 21-01 and 21-03. The sandy silt to silt and sand till was grey in colour and contained some clay and trace gravel and possible cobbles and rock fragments.

The till layer extended to bedrock in all four boreholes at depths ranging from 5.4 m to 8.6 m below ground surface (Elev. 370.2 m to 367.0 m).

SPT 'N' Values in the till ranged from 10 to over 50 blows per 0.3 m penetration, indicating a compact to very dense relative density.

Recorded moisture contents on five samples tested ranged from 1 percent and 10 percent. The results of grain size analyses conducted on two samples of the sandy silt to silt and sand till deposit are provided on the Record of Borehole sheets in Appendix A and plotted in Figure B3 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	5 to 8
Sand	31 to 37
Silt	43 to 53
Clay	11 to 12

### 5.6 Bedrock

The overburden soils described above are underlain by bedrock. The bedrock is described as metabasalt, is grey in colour and is slightly weathered. Bedrock was proved by coring 2.8 to 3.4 m in all four boreholes. Bedrock was also encountered in Boreholes BW-3 and BW-4 from Reference 1. Boreholes BW-1 and BW-2 from Reference 1 were terminated on or above possible bedrock.



Table 5.1 summarizes the depths and elevations to the top of the bedrock at the borehole locations. Photographs of the rock cores are included in Appendix B.

**Table 5.1 - Depths and Elevations of Top of Bedrock**

Location	Borehole	Top of Bedrock	
		Depth Below Existing Grade Level (m)	Elevation (m)
West Culvert End (Outlet)	BW-4	2.0	371.9
West Culvert End (Outlet)	BW-3	3.4	370.6
West Shoulder near Culvert	21-02	5.4	370.3
West Lane	21-04	5.8	369.9
East Lane	21-01	7.6	368.1
East Shoulder near Culvert	21-03	8.6	367.0
East Culvert End (Inlet)	BW-2	4.2*	370.0*
East Culvert End (Inlet)	BW-1	9.8*	364.5*

\* Bedrock surface not confirmed

Based on the variation in the bedrock depth between the boreholes, it is likely that the bedrock surface is generally sloping downward from west to east.

Total Core Recovery (TCR) in the bedrock ranged from 95 to 100%, and Solid Core Recovery (SCR) ranged between 43% and 100%. The Rock Quality Designation (RQD) determined from the recovered cores ranged between 0 and 100% (typically 48 to 94%), which indicates poor to excellent rock quality. The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, ranged from 0 to 6, with occasional broken zones with FI of greater than 10.

Average unconfined compressive strengths (UCS) of the rock ranged between 35 and 111 MPa, indicating the rock is ranges from medium strong to very strong. These estimated rock strength values are interpreted from thirty-six point load tests that were conducted on rock cores recovered from the boreholes. A summary of the point load tests results are presented in Appendix B.

## 5.7 Groundwater Conditions

Groundwater conditions were observed during drilling operations and groundwater levels were measured in the open boreholes upon completion of drilling, and in the monitoring wells installed in Boreholes 21-02 and 21-04. The measured groundwater levels are summarized in Table 5. below, including measurements recorded from Boreholes BW-1 to BW-4 from Reference 1. The



monitoring wells were decommissioned on March 27, 2021 following final water level readings and slug testing.

**Table 5.2: Groundwater Measurements**

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
21-01	March 27, 2021	-	-	No measurement (water added for rock coring)
21-02	March 27, 2021	1.7	373.9	In monitoring well
21-03	March 22, 2021	-	-	No measurement (water added for rock coring)
21-04	March 27, 2021	1.7	374.0	In monitoring well
BW-1	February 18, 2016	0.9	373.4	Open Borehole
BW-2	February 10, 2016	1.1	373.1	Open Borehole
BW-3	February 16, 2016	0.0	374.0	Open Borehole
BW-4	February 17, 2016	0.0	373.9	Open Borehole

The groundwater level is likely to reflect the local river water level. The surface water level of the Blackwater River Tributary was reportedly measured at Elev. 373.7 m in September 2014, Elev. 373.3 m in February 2016 and Elev. 373.3 m in March 2021.

It should also be noted that groundwater levels are short term observations and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant and/or prolonged precipitation and spring snow melts.

## 6. CORROSIVITY AND SULPHATE TEST RESULTS

Samples of the native sandy silt to silt and sand till from Boreholes 20-03 and 20-04 were submitted for analytical testing of corrosivity parameters and sulphate. A sample of surface water taken from the Blackwater River Tributary from Reference 1 was tested for pH, sulphate, chloride, resistivity and conductivity. The laboratory certificates of analysis for the current investigation are presented in Appendix B and the analysis results from the previous investigation (surface water



sample) are included in Reference 1. The results of the analytical tests are summarized below in Table 6.1.

**Table 6.1: Analytical Test Results**

Parameter	Units (Soil)	Units (Water)	Test Results		
			20-03, SS6 (15'-17') (4.6 – 5.2 m)	20-04, SS6 (15' – 17') (4.6 – 5.2 m)	Blackwater River Tributary*
			(Native Silt and Sand Till)	(Native Sandy Silt Till)	(Surface Water)
Redox Potential	mV	N/A	217	131	N/A
Sulphide	%	N/A	0.06	0.05	N/A
pH	-	-	8.78	8.62	7.38
Chloride	µg/g	mg/L	41	38	296
Sulphate	µg/g	mg/L	12	11	7.11
Conductivity	uS/cm	µS/cm	146	215	1170
Resistivity	ohm-cm	ohm-cm	6850	4650	856

\* Refer to Reference 1

## 7. WATER QUALITY

For assessment of the general groundwater quality in the project area, a sample of the groundwater from the monitoring well at Borehole 21-02 was collected on March 27, 2021. The water sample was analyzed for selected inorganic parameters included in the Ontario Provincial Water Quality Objectives (PWQO), as well as Total Suspended Solids. A filtered sub-sample was also tested for dissolved metal parameters for comparison purposes. The analytical test results are presented in Appendix B.

The analytical results of the water testing were compared to limits for the PWQO for surface water discharge. The concentrations of all parameters tested that did not meet the criteria established in the PWQO are listed below in Table 7.1. The Total Suspended Solids concentration was 1580 mg/L (no assigned PWQO criteria).



**Table 7.1 – Water Parameters Exceeding PWQO Criteria**

Sample ID	Parameter	Criteria	Parameter Limit (µg/L)	Result (µg/L)
21-02	Total Aluminum	PWQO	15	6400
	Total Arsenic	PWQO	5	14.8
	Total Cobalt	PWQO	0.9	18.4
	Total Cadmium	PWQO	0.1	1.03
	Total Copper	PWQO	1	101
	Total Iron	PWQO	300	11800
	Total Nickel	PWQO	25	37
	Total Phosphorus	PWQO	10	1000
	Total Lead	PWQO	1	3.56
	Total Silver	PWQO	0.1	3.61
	Total Vanadium	PWQO	6	24.5
	Total Zinc	PWQO	20	41
	Total Phenols	PWQO	1	<2*
21-02 (filtered sub-sample)	Dissolved Aluminum	PWQO	15	24
	Dissolved Cobalt	PWQO	0.9	3.0
	Dissolved Cadmium	PWQO	0.1	0.49
	Dissolved Copper	PWQO	1	21.8
	Dissolved Phosphorus	PWQO	10	15
	Dissolved Silver	PWQO	0.1	0.94

\*Note: The laboratory detection limit is higher than the PWQO criteria for this parameter and therefore this test result may not be indicative of an actual parameter exceeding the criteria.

## 8. SINGLE WELL RESPONSE TEST RESULTS

### 8.1 Test Procedure

Single well response tests (SWRTs), or “slug” tests, were carried out in the 50-mm diameter wells installed in Boreholes 21-02 and 21-04. The wells were screened across sand and gravel fill, peat, and silt and sand to silty sand till. The tests were completed using the following method:

- The static water level was measured and recorded, and a datalogger was inserted into the well below the water level. The datalogger was set to record water levels every 0.5 seconds, based on the anticipated rate of recovery of each well.
- A slug of groundwater was removed from the well with a dedicated bailer for each well to induce a change in hydraulic head (rising head test).



- Manual and electronic measurements were recorded until the water level in the well recovered sufficiently.
- Manual measurements were compared to electronic measurements for quality control of the data.

## 8.2 Hydraulic Conductivity

The two slug tests were completed and analyzed using the Hvorslev method. Plots of the slug test results are included in Appendix B. The hydraulic conductivity values calculated from the in-situ slug tests are summarized in Table 8.1 below.

**Table 8.1: Single Well Response Test Results**

Monitoring Well	Hydraulic Conductivity (m/s)	Screened Formation
21-02	$1.7 \times 10^{-6}$	Sand and gravel fill, peat, silt and sand till
21-04	$4.7 \times 10^{-7}$	Sand and gravel fill, peat, sandy silt till

From the grain size distribution curve of the sand and gravel fill, sand, and sandy silt to silt and sand at Boreholes 21-01, 21-02, 21-03, and 21-04, the  $D_{10}$  values range from approximately 0.0013 mm to 0.3 mm. Using the Kozeny-Carman and Hazen correlations of grain size to hydraulic conductivity, the estimated hydraulic conductivity values range from  $5.1 \times 10^{-9}$  m/s to  $9.0 \times 10^{-4}$  m/s, which is a much larger range than found from the slug test analysis. Generally, the accuracy of hydraulic conductivity values derived from grain size correlations are low in comparison to slug tests.

The calculated hydraulic conductivities of the soil samples using the Kozeny-Carmen and Hazen correlations are present in the below table:

**Table 8.2: Hydraulic Conductivity (K) Estimates Using Grain Size Correlations**

Borehole	Depth of Sample (m)	Soil Type of Sample	Approx. $d_{10}$ (mm)	Hydraulic Conductivity from Kozeny-Carman (m/s)	Hydraulic Conductivity from Hazen (m/s)
21-01	2.59	Sand and gravel to gravelly sand fill	0.063	$1.2 \times 10^{-5}$	$4.0 \times 10^{-5}$



Borehole	Depth of Sample (m)	Soil Type of Sample	Approx. $d_{10}$ (mm)	Hydraulic Conductivity from Kozeny-Carman (m/s)	Hydraulic Conductivity from Hazen (m/s)
21-02	0.30	Sand and gravel to gravelly sand fill	0.058	$1.0 \times 10^{-5}$	$3.4 \times 10^{-5}$
21-02	1.75	Sand and gravel fill	0.053	$8.4 \times 10^{-6}$	$2.8 \times 10^{-5}$
21-03	4.88	Sand	0.3	$2.7 \times 10^{-4}$	$9.0 \times 10^{-4}$
21-03	6.40	Sandy Silt to Silt and Sand	0.0013	$5.1 \times 10^{-9}$	$1.7 \times 10^{-8}$
21-04	4.88	Sandy Silt to Silt and Sand	0.0013	$5.1 \times 10^{-9}$	$1.7 \times 10^{-8}$

## 9. MISCELLANEOUS

Thurber obtained utility clearances for the borehole locations prior to drilling. Borehole locations were selected and established in the field by Thurber Engineering Ltd.

RPM Drilling of Thunder Bay, Ontario supplied a rubber-tired CME 750 drill rig and conducted the drilling, sampling and in-situ testing operations for the boreholes. Traffic control services were provided by Men at Worx Ltd. of Thunder Bay, Ontario.

Geotechnical laboratory testing was carried out in Thurber's geotechnical laboratory. Analytical testing was carried out by SGS.

The field investigation was supervised on a full-time basis by Ms. Madisan Chiarotto, EIT of Thurber. The overall supervision of the field program was conducted by Mr. Joshua Alexander, EIT and Mr. Mark Farrant, P.Eng. of Thurber.

Interpretation of the field data and preparation of this report was carried out by Mr. Joshua Alexander, EIT and Mr. Mark Farrant, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.





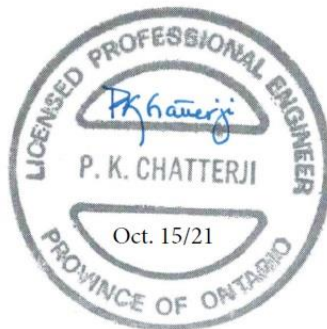
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Dr. P.K. Chatterji, P.Eng.  
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**PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS**

**10. GENERAL**

This report provides an interpretation of the factual data from Part 1 of the report and presents foundation design recommendations for the proposed replacement of the Blackwater River Tributary Culvert on Highway 11, south of Beardmore, in Unsurveyed Territory, District of Thunder Bay, Ontario.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation, and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. The contractors must make their own interpretation based on the factual data in Part 1 of the report. Where comments are made on construction, they are provided only in order to highlight those aspects which could affect the design of the project. Contractors must make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

The available base plan drawing provided by Hatch (Plan E-493880-11-1) indicates that the existing structure is a cast-in-place concrete box culvert. Field observations conducted by Hatch suggest that the structure may be a closed-bottom box culvert, but this could not be visually confirmed. The base plan indicates that the span of the structure is 3.05 m, the height is 1.52 m and the length of is 17.95 m. The estimated culvert invert is at approximate Elev. 372.6 m at the inlet (east) and 372.5 m at the outlet (west). The existing road grade at the culvert location is at approximate Elev. 375.8 m, which indicates approximately 1.7 m of fill above the culvert. The local river water level was reportedly measured at Elev. 373.7 m in September 2014, and was subsequently measures at Elev. 373.3 m in February 2016 by Golder and Elev. 373.3 m in March 2021 by Thurber. The site topography within the culvert area is generally flat surrounding Blackwater River Tributary on both sides of Highway 11. The existing highway embankment side





slopes are inclined at approximately 1.1 to 1.5H:1V above the culvert and approximately 2H:1V or flatter beyond the culvert and appear to be performing satisfactorily. Some surficial erosion gullies were however noted at the top of the granular slopes.

Based on preliminary General Arrangement (GA) drawings and discussions with Hatch, the replacement culvert options being considered at this site consist of a corrugated steel pipe or multiple pipes, or a precast concrete box culvert. An open footing concrete culvert was considered but is not recommended as described below. The replacement culvert is anticipated to be approximately 25 m long, installed along the same alignment as the existing culvert, with a similar streambed level and slightly lower (0.3 to 0.5 m) invert level. No grade raise is anticipated, however some widening of the embankment slopes is planned to accommodate a longer culvert. No wingwalls / headwalls are present at the existing culvert or planned as part of the replacement culvert. Staged construction utilizing a temporary roadway protection system is anticipated.

This report refers to the following applicable codes:

- Canadian Highway Bridge Design Code (CHBDC), 2019
- National Building Code of Canada (NBCC), 2015

## **11. CULVERT DESIGN**

### **11.1 Culvert Alternatives**

This section presents discussions on various types of replacement culverts and foundation alternatives and provides recommendations on preferred culvert types and foundation options.

Several common culvert types that may be considered for the culvert replacement at this site are listed below:

- Corrugated steel pipe (CSP) or twin CSPs
- Concrete box (closed) culvert composed of pre-cast segments
- Concrete box, open footing culvert

A comparison of the culvert types and foundation alternatives based on their respective advantages and disadvantages is included in Appendix F. From a foundations and constructability perspective, use of the CSP or pre-cast concrete closed box culverts are preferred over the open footing culvert option, based on the following considerations:

- Pre-cast closed box or pipe culverts would require shallower depth of excavation compared with the open footing culvert;





- Pre-cast concrete box or pipe segments can often be installed more expeditiously than cast in place open footing culverts, resulting in shorter durations for dewatering and construction;
- A segmental box or pipe structure can accommodate some potential differential settlement along the culvert axis.

The open footing culvert is not recommended at this site since it would involve deeper excavation in cohesionless soils and more dewatering effort to provide adequate frost protection.

Recommendations for the design and installation of pipe and concrete box culverts are presented below.

## **11.2 Summary of Subsurface Conditions**

In general, the subsurface conditions encountered in the boreholes consisted of sand and gravel to gravelly sand embankment fill, underlain by a 0.9 to 1.3 m thick layer of peat, which is further underlain by deposits of compact sand, and compact to very dense sandy silt to silt and sand glacial till. The peat is thicker beyond the embankment toes, ranging from 1.4 to 2.6 m. The overburden soils are underlain by metabasalt bedrock, with a sloping surface that decreases from west to east from approximate Elev. 372 to 364.5 m.

The groundwater level in the open boreholes and monitoring wells was typically measured at an approximate Elevation of 374 m. The tributary surface water level has been measured at Elevations between 373.3 to 373.7 m since 2014.

## **11.3 Foundation Design for Culverts**

The invert level of the existing culvert is at approximate Elevation 372.5 m.

Foundation design aspects for the replacement culvert include subgrade conditions and preparation, geotechnical capacities, settlement of foundation soils, lateral earth pressures, roadway protection system design, groundwater control, staged construction, and restoration of the roadway embankment.

In particular, construction of the replacement culvert will require the removal of the buried peat layer prior to placing the new culvert.





### **11.3.1 Corrugated Steel Pipe (CSP) or Multiple CSP Culverts**

Replacement of the culvert with a single or multiple CSPs along the same alignment may be considered for this site. It is anticipated that the subgrade soils within the culvert footprint will not be subjected to any significant additional loading due to the culvert replacement, except where the culvert is to be lengthened beyond the existing culvert.

If this alternative is selected, the CSPs should be placed on a minimum 300 mm thick layer of bedding material conforming to OPSS.PROV 1010 Granular A or Granular B Type II requirements as per OPSD 802.010. All the peat encountered at and below the culvert subgrade must be removed and replaced by compacted granular fill or rock fill up to the underside of the bedding material, as described in Section 11.3.4. The bedding material should be placed on the prepared subgrade as soon as practical, following its inspection and approval. The subgrade preparation should be carried out in the dry. However, as it may not be feasible to fully dewater the cohesionless soils below the peat, consideration may be given to conducting the subexcavation of the peat and preparation of the subgrade in the wet, as described in Section 11.3.5. The granular fill or rock fill below the culvert must be placed on the native compact sand or compact to very dense till deposits below the peat. Adequate preparation of the subgrade will be essential for performance of the culvert. Construction equipment should not be allowed to travel on the bedding or the prepared subgrade, which should be protected from disturbance during construction. A separation layer consisting of a non-woven geotextile should be placed between the subgrade soils and the bedding material. The geotextile should meet the specifications for the OPSS Class II (OPSS 1860), and have a fabric opening size (FOS) not greater than 212 µm.

The underside of the bedding layer should be placed at or below Elevation 371.5 m, on the prepared subgrade following peat removal, or the underlying compact sand or compact to very dense till deposits. Any other buried topsoil, excessively soft soil, large cobbles and boulders, and any soft, very loose organic or other deleterious material encountered during subgrade preparation should be sub-excavated and replaced with compacted granular material to provide a uniformly competent subgrade condition.

### **11.3.2 Concrete Box Culvert**

Replacement of the culvert with a concrete box culvert on the same alignment is also considered a viable alternative for this site. It is anticipated that the subgrade soils within the culvert footprint will not be subjected to any significant additional loading due to the culvert replacement, except where the culvert is to be lengthened beyond the existing culvert.





In order to provide a uniform foundation subgrade, a minimum 300 mm thick layer of bedding material conforming to OPSS.PROV 1010 Granular A or Granular B Type II requirements should be provided under the base of the box culvert, similar to as shown on OPSD 803.010. All the peat encountered at and below the culvert subgrade, including where the culvert will be lengthened, must be removed and replaced by compacted granular fill or rock fill up to the underside of the bedding material, as described in Section 11.3.4. The bedding material should be placed on the prepared subgrade as soon as practicable following its inspection and approval. The subgrade preparation and placement and compaction of the bedding material should be carried out in the dry. However, as it may not be feasible to fully dewater the cohesionless soils below the peat, consideration may be given to conducting the subexcavation of the peat and preparation of the subgrade in the wet, as described in Section 11.3.5. The granular fill or rock fill below the culvert must be placed on the native compact sand or compact to very dense till deposits below the peat. Adequate preparation of the subgrade will be essential for performance of the culvert. A separation layer consisting of a non-woven geotextile should be placed between the subgrade soils and the bedding material. The geotextile should meet the specifications for the OPSS Class II, and have a fabric opening size (FOS) not greater than 212  $\mu\text{m}$ . The subgrade surface prepared to support the box units should have a 75 mm minimum thick top levelling course consisting of uncompacted Granular A as per OPSS 422. Construction equipment should not be allowed to travel on the bedding or the prepared subgrade, which should be protected from disturbance during construction.

The underside of the bedding layer should be placed at or below Elevation 371.5 m, on the prepared subgrade following peat removal, or the underlying compact sand or compact to very dense till deposits. Any other buried topsoil, excessively soft soil, large cobbles and boulders, and any soft, very loose organic or other deleterious material encountered during subgrade preparation should be sub-excavated and replaced with compacted granular material to provide a uniformly competent subgrade condition.

The following geotechnical resistances are recommended for the preliminary design of a box culvert with a 4 to 5 m bearing width founded at or below Elevation 371.5 m on the compact sand or compact to very dense till, or prepared subgrade following removal of all peat:

<b>Geotechnical Resistance</b>	<b>4 to 5 m wide Culvert</b>
Factored Geotechnical Resistance at ULS	200 kPa
Geotechnical Resistance at SLS (for up to 25 mm settlement)	125 kPa





A consequence factor of 1.0 was utilized in this design adopting the typical consequence level. The geotechnical resistance factor of 0.5 for bearing and 0.8 for settlement, both adopted for typical degree of understanding, were used to obtain the above values, as per Canadian Highway Bridge Design Code (CHBDC) 2019, Section 6.9.

The factored ultimate resistance and settlement are dependent on the culvert size, configuration and applied loads; the geotechnical resistances should, therefore, be reviewed if the culvert width or founding/invert elevation differs significantly from that given above.

The above geotechnical resistances are for vertical, concentric loads. Where eccentric or inclined loads are applied, the resistance values used in design must be reduced in accordance with CHBDC 2014, Clause 6.10.5.3.

Resistance to sliding between the concrete and the underlying Granular A or B Type II bedding material should be calculated assuming an ultimate coefficient of friction of 0.45.

The culvert should be designed to resist external loadings including frost forces, lateral earth pressures, hydrostatic pressure, weight of embankment fill, traffic loadings and surcharge due to construction equipment.

### **11.3.3 Frost Cover**

The depth of frost penetration at this site is approximately 2.5 m based on OPSD 3090.100. The base of any concrete footings if employed should be provided with a minimum of 2.5 m of earth cover as protection against frost action. The frost cover requirement does not apply to the pipe and box culvert options.

### **11.3.4 Peat Replacement and Subgrade Preparation**

Performance of the replacement culvert will depend on the preparation of the subgrade. The borehole information indicates a variable thickness of peat below the existing embankment fill and near the culvert footprint area. Approximately 0.9 to 1.3 m of peat was encountered below the embankment fill, with thicker peat (1.4 to 2.6 m in thickness) beyond the existing inlet and outlet. The base elevation of the peat deposit ranges from 372.5 to 371.4 m.

The peat must be sub-excavated to expose the native sand or till subgrade. The removal of the peat should extend a minimum of 1.5 m beyond the width of the replacement culvert for the entire length of the culvert and extend for 1.5 m beyond the toe of slope of the final embankment. The excavation should be carried out in accordance with OPSS.PROV 209 (Embankments over





Swamps and Compressible Soils). Care must be exercised not to destabilize the existing highway embankment while excavating the peat near the toe of the embankment.

The sub-excavated area should then be backfilled with granular material meeting OPSS.PROV 1010 Granular A or Granular B Type II requirements and be compacted as per OPSS.PROV 501, provided that the peat sub-excavation and compaction and placement of the replacement granular fill is carried out in the dry as per OPSS 902 and SP 109S12. If full dewatering is not possible, the peat sub-excavation should be backfilled with rock fill as described in Section 11.3.5.

Construction equipment should not be allowed to travel on the prepared subgrade, which must be protected from disturbance during construction.

### **11.3.5 Construction in Wet Conditions**

Given that removal and replacement of peat below the water table is required, and that seepage of groundwater through the foundation sand and of surface water through the embankment fill is expected, backfilling in the wet conditions (below water level) could be considered. This approach will still require diversion of the stream flow and surface water so that the excavations can be done within stagnant water. When backfilling is conducted in the wet, select rock fill should be used below the water table after removal of the peat. The recommended gradation of the rock fill is as follows:

<b>Sieve Size</b>	<b>Percent Passing (%)</b>
150 mm	100
106 mm	50 – 100
75 mm	15 – 80
26.5 mm	0 – 15
0.075 mm	0 – 2

Care must be exercised not to destabilize the existing highway embankment while excavating the peat near the toe of the embankment.

Following peat removal, a separation layer consisting of a non-woven geotextile should be placed between the native sand and rock fill. The geotextile should meet the specifications for OPSS 1860 Class II, and have a fabric opening size (FOS) not greater than 212 micro millimetres. The rock fill should be completely wrapped with the geotextile to minimize migration of fines into the rock fill.





Rock fill used to backfill sub-excavated areas below the water table may be placed by end dumping. Granular fill must not be used to backfill excavations below the water table. The rock fill placement below the water level should follow OPSS.PROV 209 (Embankments over Swamps and Compressible Soils).

Rock fill placed above the water level should be placed in a controlled manner (not end dumped) including blading, dozing and chinking of the rock to minimize voids and bridging. Rock fill above the water level must be compacted as per OPSS.PROV 206. Where granular fill or bedding material is to be placed over rock fill, the rock fill subgrade must be blinded with spall material and rock fill chinking shall be in accordance with OPSS.PROV 206. All granular fill must be compacted as per OPSS 501.

Other options would be to use a coarse 53 mm clear stone, fully wrapped in geotextile, for backfilling in the wet below the culvert. Once the clear stone backfill is above the water level, granular bedding for the culvert may be placed in the dry. The granular bedding may consist of OPSS.PROV 1010 Granular A, Granular B Type II or 19 mm clear stone. The bedding should be placed in the dry so that it can be compacted.

For this backfilling option under water, if the peat is not completely removed or the rock fill traps peat, there is a risk of additional settlement of the culvert.

Please note that this option will still require dewatering in order to lower the groundwater level to a sufficient depth to allow for placement of the culvert bedding in the dry.

### **11.3.6 Settlement**

The replacement culvert will be constructed approximately on the same alignment and with a similar or larger opening size as the existing culvert with no grade raise on the overlying embankment. As the replacement culvert will be longer than the existing culvert, some placement of additional fill will be required to widen the embankment slopes. The anticipated additional fill height ranges from an average of 0.7 m to a maximum of 1.2 m. Due to the presence of native peat in the widened areas, foundation settlement under this fill in the order of 60 to 80 mm near the highway shoulders and 300 to 400 mm near the toes of the slopes are anticipated if the peat remains in place. However, provided that all peat is removed from below the existing culvert and the widened embankment areas, the foundation settlement would be reduced to less than 25 mm, which would be completed by the end of construction.





### **11.3.7 Recommended Approach for Culvert Replacement**

From a foundation engineering perspective, both the circular pipe and concrete box culvert are considered feasible culvert replacement options. However, the concrete box culvert option is recommended from a geotechnical perspective as it may be constructed in the wet without the requirement for significant dewatering.

## **12. EXCAVATION AND GROUNDWATER CONTROL**

All excavations should be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the embankment fill, native sand and native sandy silt to silt and sand till deposits at this site are classified as a Type 3 soil above the water table. Below the water table (i.e., if the groundwater flow is not controlled), the soils would be classified as Type 4 soils. The native peat and other surficial alluvial deposits that are anticipated in the inlet and outlet areas should be classified as Type 4 soils.

Excavation and backfilling for culvert construction should be carried out in accordance with OPSS 902 and SP 109S12. Excavations for culvert replacement will be carried out through the existing embankment fill and to the base of the native peat.

It is anticipated that excavation for culvert replacement will be carried out below the tributary water level, and diversion of the tributary flow will be required. Furthermore, groundwater and surface runoff will tend to seep into and accumulate in the excavations. Due to the presence of the water-bearing peat and sand layers, full dewatering to the base of the temporary excavations is likely to be difficult at this site. It is anticipated that watertight sheet pile cofferdam enclosures driven into the underlying very dense till will not be effective to cut-off groundwater flow, since it may be difficult to drive the sheet piles to a sufficient depth into the very dense till. Therefore, it may be necessary to construct the culvert in the wet, as described in Section 11.3.5. Further discussion on dewatering is provided in Section 14. Please note that this option of constructing in the wet will still require some dewatering in order to lower the groundwater level to a sufficient depth to allow for placement of the culvert bedding in the dry.

The design of any dewatering systems is the responsibility of the Contractor. The Contract Documents must alert the Contractor to this responsibility and to design the system in accordance with SP FOUN0003 which amends OPSS 902 and SP 109S12.

In accordance with SP FOUN0003, the dewatering system is to be designed in accordance with OPSS.PROV 517 and SP 517F01. A preconstruction survey is not required at this site, thus





Designer Fill-In \*\* in SP FOUN0003 should be “N/A”. An NSSP in this regard is included in Appendix H.

The groundwater level will fluctuate and the minimum groundwater elevation at the time of the proposed work should be taken as the tributary water level of the design storm return period defined by the contract documents for the temporary dewatering system.

### **13. STREAM DIVERSION PIPE**

A temporary stream diversion pipe may be required to accommodate tributary water flow during culvert replacement. It is anticipated that the invert level of the diversion pipe will be at or below Elevation 372.5 m, which corresponds to the base of the sand and gravel fill, or within the buried peat deposit. If peat is encountered at the invert level of the stream diversion pipe trench, it may be left in place, provided some settlement of the stream diversion pipe is acceptable. If the settlement is not acceptable, the underlying peat should be removed and replaced with well compacted granular material.

The temporary diversion pipe should be placed on a minimum 300 mm thick layer of bedding material conforming to OPSS.PROV 1010 Granular A or Granular B Type II requirements as per OPSD 802.010. The bedding material should be placed on the prepared subgrade as soon as practical, following its inspection and approval. The subgrade preparation should be carried out in the dry unless measures are taken to work in the wet as described in Section 11.3.5. The prepared subgrade should be protected from disturbance during construction.

The stream diversion pipe could be installed within the temporary open cut excavations, or within a shored excavation using a trench box.

### **14. DEWATERING ASSESSMENT**

Groundwater taking for construction dewatering is governed by the Ontario Water Resources Act (OWRA), Environmental Protection Act (EPA) and the Water Taking and Transfer Regulation 387/04, a regulation under the OWRA.

If the water taking rate will be greater than 50,000 L/day and less than 400,000 L/day then registration on the Environmental Activity and Sector Registry (EASR) will be required. If the water taking rate will be greater than 400,000 L/day, then a Category 3 Permit To Take Water (PTTW) will be required. A preliminary assessment of the need for water taking permitting is provided herein; however, additional analysis will be required to confirm this.



Based on the preliminary GA drawings, the dimensions and conditions that were assumed for the preliminary dewatering assessment are provided in Table 14.1 below. For a full dewatering plan to the base of the temporary excavations, the geologic units that will need to be dewatered include the sand and gravel to gravelly sand fill, the native peat, sand, and silt and sand to sandy silt till foundation soils. It is assumed that one half of the culvert will be constructed at a time in order to maintain a live traffic lane.

**Table 14.1: Assumed Excavation Dimensions and Ground Conditions**

Structure	Assumed Excavation Footprint (m)	Lowest Assumed Elevation of Excavation (m)	Assumed Groundwater Elevation (m)	Geologic Units to Dewater
Blackwater Tributary East 1/2 Culvert Excavation	22 x 16	371	374	Sand and gravel fill, peat, sand, silt and sand to sandy silt till.
Blackwater Tributary West 1/2 Culvert Excavation	22 x 16	371	374	Sand and gravel fill, peat, silt and sand to sandy silt till, and possible sand.

For the purpose of estimating water taking flow rates it was assumed that surface water flow would be directed around the excavations such that surface water will not enter the excavations at a significant rate.

The following approach was used to estimate the budgeted peak water taking rate for a full dewatering plan to the base of the temporary excavations:

- A base groundwater extraction flow rate was estimated, and a factor of safety of three was applied to this flow rate to provide an allowance for removal of water from soil storage, variation in hydraulic conductivity, actual excavation dimensions and geometry, and ground water levels due to seasonality or other factors;
- An allowance for removal of rainfall directly into the excavation was included, assuming 24 hours are used to remove 50 mm of rainfall; and
- Lowering of groundwater to 0.5 m below the base of the excavation to facilitate a dry, stable work area was assumed.

The water taking will be temporary in nature for the purpose of construction dewatering for installation of the infrastructure. Dewatering rates were estimated using the Dupuit analytical solution. The radius of influence was calculated using the Sichardt equation.





For excavation of the eastern half of the culvert, it is assumed that the predominant unit controlling flow to the excavation will be the sand layer observed in Boreholes 21-01, 21-03 and BW-1. The hydraulic conductivity of the sand is assumed to be represented by the Kozeny-Carman grain size, with a calculated value of  $2.7 \times 10^{-4}$  m/s (as described in Section 8). Constructing this half of the culvert with full dewatering is expected to result in high groundwater flow rates that exceed 2,500,000 litres per day, including the safety factor and rainfall allowance. The preliminary radius of influence was estimated to be approximately 200 m from the edge of the excavation. Controlling this volume of groundwater flow would require significant dewatering effort and a Category 3 PTTW. To reduce this flow to less than those that require a PTTW, a dewatering scheme including sheet pile watertight shoring driven into the till would be required to cut-off flow from the sand layer. However, it is anticipated that sheet piles would not be able to penetrate deep enough into the very dense till to form an effective cut-off for dewatering. Therefore, dewatering within a watertight enclosure is not expected to be a feasible option.

For the western half, it is assumed that watertight shoring may not be required in order to control flows considering the sand layer was not observed in the boreholes on the western side. It is assumed the predominant units controlling flow to the excavation will be the till, peat, and fill units. The geometric mean was taken of the highest slug test result and the Kozeny-Carmen grain size result from the sand layer as a conservative estimate of hydraulic conductivity for the western half, as the possibility of encountering a thin layer of the sand exists. The resultant hydraulic conductivity value used for the western half is  $2.1 \times 10^{-5}$  m/s. The top elevation of the bedrock for the western half was assumed to be 369.9 m, which is the deepest bedrock elevation found in boreholes on the western half. The preliminary peak water taking rate for the western half was estimated to be less than 200,000 litres per day including the safety factor and rainfall allowance and assuming non-watertight shoring. The preliminary radius of influence was estimated to be approximately 60 m from the edge of the excavation.

Considering the total estimated flow rates for both halves of the excavation are expected to be greater than 2,700,000 litres per day, a Category 3 PTTW would be required for full dewatering at this site. A Hydrogeological Study would be required to provide the necessary data and analysis for application to the Ministry of the Environment, Conservation and Parks (MECP). The Hydrogeological Study will need to include an impact assessment as well as mitigation measures, a monitoring plan, and a contingency plan. An assessment of the potential need for additional field work will need to be assessed. The duration required to receive the permit from MECP once it has been received in good order is typically 3 to 5 months, assuming no further field work or significant revisions are required.





Considering the above factors, it is recommended that consideration be given to constructing the replacement culvert in the wet, as described in Section 11.3.5.

## **15. WATER QUALITY**

For assessment of the general groundwater quality in the project area for potential discharge purposes, a sample of the groundwater from the monitoring well at Borehole 21-02 was collected. As noted in Section 7, the water sample was tested and the results were compared to the Provincial Water Quality Objectives (PWQO) criteria. A filtered sub-sample was also tested for dissolved metal parameters for comparison purposes. The water sample test results are summarized in Table 7.1.

The test results indicate that twelve of the metals parameters tested exceeded the PWQO criteria for total concentrations. However, testing of a filtered sample to remove the high Total Suspended Solids, indicated considerably reduced metals concentrations, with only five parameters exceeding the PWQO criteria. If dewatering is used at this site, it is likely that treatment of the discharge water through the use of filtering, settling tanks or other methods may be required to reduce the amount of suspended solids and the metals concentrations prior to discharge into local surface water bodies such as creeks. It is recommended that additional water samples be collected and tested during construction to confirm the groundwater quality and monitor the quality of discharge water, if necessary to meet PTTW requirements.

## **16. CULVERT BACKFILL AND LATERAL EARTH PRESSURES**

Backfill to the culvert should consist of free-draining, non-frost susceptible granular materials such as Granular A or B Type II conforming to the requirements of OPSS PROV 1010. Reference should be made to the backfill arrangements stipulated in OPSD 802.010 or 803.010, as appropriate. Backfilling for the culvert should be in accordance with OPSS PROV 401 for a CSP and OPSS 902 and SP 109S12 for a box culvert. All fills should be placed in regular lifts and be compacted in accordance with OPSS PROV 501. The backfill should be placed and compacted in simultaneous lifts on both sides of the culvert, and the top of backfill elevation should not differ more than 500 mm on both sides of the culvert at all times. Heavy compaction equipment should not be used adjacent to the walls and on the roof of the culvert. Compaction equipment to be used adjacent to the culvert should be restricted in accordance with OPSS PROV 501.





Lateral earth pressures acting on the culvert walls may be assumed to be a triangular distribution. For a fully drained backfill, the pressures should be computed in accordance with the CHBDC 2014, but are generally given by the expression:

$$p_h = K (\gamma h + q)$$

where	$p_h$	=	horizontal pressure on the wall at depth $h$ (kPa)
	$K$	=	earth pressure coefficient (see table below)
	$\gamma$	=	bulk unit weight of retained soil (see table below)
	$h$	=	depth below top of fill where pressure is computed (m)
	$q$	=	value of any surcharge (kPa)

Earth pressure coefficients for backfill to the culvert walls are dependent on the material used as backfill. Recommended unfactored values are shown in Table 16.1 below.

**Table 16.1 – Lateral Earth Pressure Coefficients (K)**

Loading Condition	OPSS Granular A or Granular B Type II $\phi = 35^\circ; \gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I (modified) or Type III $\phi = 32^\circ; \gamma = 21.2 \text{ kN/m}^3$	
	Horizontal Backfill	Sloping Backfill (2H:1V)	Horizontal Backfill	Sloping Backfill (2H:1V)
Active (Unrestrained Wall)	0.27	0.40	0.31	0.48
At-rest (Restrained Wall)	0.43	0.62	0.47	0.70
Passive	3.7	-	3.2	-

Note: Submerged unit weight should be used below the groundwater level/high tributary level.

For rigid structures such as concrete box culverts, at-rest horizontal earth pressures should be used for design. Active earth pressures should be used for any unrestrained wall.

The use of a material with a high friction angle and low active pressure coefficient (e.g. Granular A, Granular B Type II) is preferred as it results in lower earth pressures acting on the culvert.

In accordance with Clause 6.12.3 of the CHBDC 2019, a compaction surcharge should be added. The magnitude of the surcharge should be 12 kPa at the top of fill and decrease to 0 kPa at a depth of 1.7 m for Granular B Type I, or at a depth of 2.0 m for Granular A or B Type II.



## 17. SEISMIC CONSIDERATIONS

In accordance with the CHBDC 2019, the selection of the seismic site classification is based on the soil conditions encountered in the upper 30 m of the stratigraphy. Based on the presence of compact to very dense embankment fill, sand and till, as well as the presence of a buried peat layer, the site is classified as Seismic Site Class D in accordance with Table 4.1, Clause 4.4.3.2 of the CHBDC. The peak ground acceleration, PGA, for a 2% in 50-year probability of exceedance at this site is 0.034 g as per the National Building Code of Canada (NBCC). The Seismic Hazard Calculation sheet from Natural Resources Canada is included in Appendix I.

In accordance with Section 6.14.7 of the CHBDC 2019, the culvert walls should be designed using active ( $K_{AE}$ ) and passive ( $K_{PE}$ ) earth pressure coefficients that incorporate the effects of earthquake loading. The coefficients of horizontal earth pressure for seismic loading presented in Table 17.1 may be used:

**Table 17.1 – Earth Pressure Coefficients for Earthquake Loading**

Condition	Earth Pressure Coefficient (K)		
	OPSS Granular A or Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$	OPSS Granular B Type I (modified) or Type III $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$	Existing Sand and Gravel to Gravelly Sand Fill $\phi = 32^\circ, \gamma = 21 \text{ kN/m}^3$
Active ( $K_{AE}$ ) <sup>1</sup>	0.29	0.32	0.32
Passive ( $K_{PE}$ ) <sup>2</sup>	3.6	3.2	3.2
At Rest ( $K_{OE}$ ) <sup>3</sup>	0.49	0.53	0.53

Note 1: Mononobe and Okabe, 1929, World Engineering Congress 9: 179-187

Note 2: Passive case assumes a horizontal surface in front of the wall.

Note 3: Wood, J. H. 1973, earthquake induced soil pressures on structures, PhD Thesis, California Institute of Technology, Pasadena, CA.

In view of the low potential for seismic activity in the area, liquefaction is not considered to be a concern at this site.

## 18. COFFERDAMS

Construction of cofferdams will be required for stream diversion and constructing the culvert replacement in the dry. Options for cofferdams include interlocking sheet piles or sandbags. However due to the presence of very dense till and shallow and sloping bedrock, it will be difficult to drive sheet piles, which therefore may not achieve sufficient embedment at all locations along the culvert. Therefore, the use of sandbag cofferdam enclosures is anticipated.



## 19. TEMPORARY PROTECTION SYSTEM

A temporary roadway protection system, if utilized, should be implemented in accordance with OPSS PROV 539 and designed for Performance Level 2.

Options for roadway protection are a soldier pile and lagging system or interlocking sheet piles. However due to the presence of shallow and sloping bedrock and possible obstructions in the fill and very dense till, interlocking sheet piles may not achieve sufficient embedment. Suggested wording for an NSSP on Obstructions is provided in Appendix H. For the soldier pile and lagging system, if sufficient embedment cannot be achieved by driving, the soldier piles may need to be drilled in and socketed into very dense till or bedrock. Tiebacks may be required in light of the shallow bedrock.

The soil parameters in Table 19.1 may apply for the design of the temporary roadway protection system with horizontal backfill.

**Table 19.1 – Soil Parameters for Temporary Protection System Design**

Soil Parameter	Existing Sand and Gravel to Gravelly Sand Fill	Native Peat	Native Sand	Native Sandy Silt to Silt and Sand Till
$\Phi$ (angle of internal friction)	32°	25°	32°	34°
$\gamma$ (total unit weight)	21 kN/m <sup>3</sup>	14 kN/m <sup>3</sup>	21 kN/m <sup>3</sup>	22 kN/m <sup>3</sup>
$\gamma_w$ (submerged unit weight)	10 kN/m <sup>3</sup>	4 kN/m <sup>3</sup>	10 kN/m <sup>3</sup>	12 kN/m <sup>3</sup>
$K_a$	0.31	0.41	0.31	0.28
$K_p$	3.3	2.4	3.3	3.5

Full hydrostatic pressure should be considered assuming a water level at least equal to the design tributary water level.

The temporary protection system may be removed or partially removed upon completion of the work. Care must be taken when removing the soldier piles as to not incur damage to the subgrade of the newly installed culvert. If the soldier piles are drilled into bedrock, it will not be possible to remove them, and the piles should be left in place with the top portion removed as per the guidelines in OPSS PROV 539.





The design of the temporary protection system is the responsibility of the Contractor. The actual pressure distribution acting on the protection/shoring system is a function of the construction sequence and the relative flexibility of the wall, and these factors have to be considered when designing the shoring system. All protection systems should be designed by a Professional Engineer experienced in such designs, who will determine an appropriate support system.

## **20. SLOPE STABILITY**

The existing highway embankment side slopes beyond the culvert are inclined at approximately 2H:1V or flatter and appear to be performing satisfactorily. As the replacement culvert will be longer than the existing culvert, some placement of additional fill (ranging from 0.7 to 1.2 m in height) will be required to widen and flatten the embankment slopes.

Slope stability analyses were conducted for the widened embankment side slopes of Highway 11 to assess the stability if the buried peat is left in place or removed and replaced with granular material. The stability assessments assume the embankment fill will consist of Granular B Type II, constructed at a 2H:1V slope. Figures 1 and 2 in Appendix G indicate that the safety factor of the embankment slopes will not be acceptable for a long-term condition if the peat is left in place along the culvert alignment (Factor of Safety of 1.2 for the west and east slopes). If the peat is removed to a minimum of 1.5 m beyond the toe of slope of the final embankment and replaced with well-compacted granular fill, rock fill or clear stone, then the widened slopes will be stable, with a Factor of Safety of 1.6 for the west and east slopes (Figures 3 and 4).

## **21. EMBANKMENT RESTORATION**

Embankment restoration after completion of the culvert replacement should be carried out in accordance with OPSS PROV 206 and OPSS PROV 209. The embankment reconstruction material should consist of imported Granular A, Granular B Type II, or Granular B Type III material. The restored embankment beyond the culvert should be reinstated at the existing slope inclination, but no steeper than 2H:1V. Soils generated from the culvert excavation should not be used for reinstatement of the embankment.

In general, surface vegetation, peat, topsoil, organic deposits, disturbed material or otherwise loose/soft soils should be stripped from the areas around the culvert inlets and outlets, and within the embankment footprints. Inspection and approval of the foundation surfaces by qualified geotechnical personnel should be conducted.



## **22. SCOUR AND EROSION PROTECTION**

Erosion protection should be provided at the culvert inlet and outlet. Design of the erosion protection measures should consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field in accordance with OPSD 810.010, OPSS 511 and OPSS PROV 1004.

Typically, rock protection should be provided over all surfaces with which tributary water is likely to be in contact. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS PROV 804.

Surficial erosion gullies in the granular shoulder material were observed near the culvert during the field investigation. The eroded portion will likely be removed during excavation of the existing embankment to replace the culvert; however it is recommended that additional erosion protection should be added to the embankment slopes to prevent future loss of material. To channelize surface water flow to the erosion protection measures, an asphalt barrier curb in general accordance with OPSD 601.010 with a rock-lined ditch or other measures may be considered.

A concrete cut-off wall and a clay seal (only at the inlet) should be used to minimize the potential for erosion or piping around the culvert. The clay seal should extend to approximately 0.3 m above the high water level and laterally for the width of the granular material, and have a minimum thickness of 0.5 m. The material requirements should be in accordance with OPSS PROV 1205. A geosynthetic clay liner may be used in place of a compacted clay seal.

Selection of streambed material should be in accordance with OPSS 1005.

Liaison between the Foundations Consultant, Structural Engineer and Hydraulic / Drainage Engineer will be required in design to ensure that scour protection is adequately addressed.

## **23. CORROSION AND SULPHATE ATTACK POTENTIAL**

The results of the corrosivity and sulphate content analytical tests conducted on the soil and tributary water samples indicate the following conditions at the locations tested:

- The potential for corrosion or sulphate attack on concrete foundations from the surrounding soil and surface water is considered to be negligible due to the low concentration of sulphate and chloride in the samples tested. The effect of road deicing salt should be considering while selecting the class of concrete.





- The potential for soil corrosion on metal is considered to be mild to moderate, with higher corrosion potential due to the surrounding surface water.
- Appropriate protection measures are recommended for metal or concrete structural elements. The effect of road deicing salt should be considered while selecting the corrosion protection measures.

#### 24. **CONSTRUCTION CONCERNS**

Potential construction concerns include, but are not necessarily limited to:

- The peat layer must be fully removed within the entire limits of the culvert replacement to avoid settlement under the widened embankment slopes.
- Full dewatering to below the base of the culvert excavation may not be practical at this site and would also require a Category 3 PTTW. Accordingly, appropriate methods for constructing in the wet should be developed.
- The water level in the tributary may fluctuate and be at a higher elevation at the time of construction than indicated in the report.
- Due to the presence of shallow and sloping bedrock as well as the very dense nature of the glacial till, it may not be possible to drive sheet piles at this site.

#### 25. **CLOSURE**

Engineering analysis and preparation of the design 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.

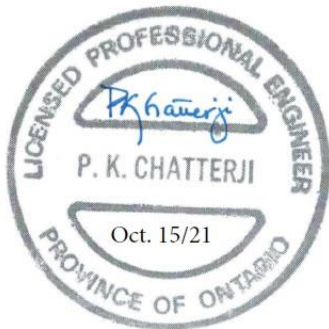




**THURBER ENGINEERING LTD.**



Mark Farrant, P.Eng.  
Senior Geotechnical Engineer



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





## **Appendix A**

### **Record of Borehole Sheets (Current Investigation)**



## 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.


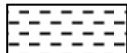





# UNIFIED SOILS CLASSIFICATION

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		Field Estimation of Hardness*
			(MPa)	(psi)	
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	Requires many blows of geological hammer to break
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.
		Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
		Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
		Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

<u>TERMS</u>	
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a 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 21-01

1 OF 2

METRIC

GWP# 6313-14-00 LOCATION Blackwater River Tributary Culvert Replacement; N 5 489 558.0 E 232 169.5 ORIGINATED BY MC  
DIST HWY 11 BOREHOLE TYPE Tricone/NQ Coring COMPILED BY AN  
DATUM Geodetic DATE 2021.03.27 - 2021.03.27 LATITUDE 49.539454 LONGITUDE -88.003593 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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE					
375.7	GROUND SURFACE												
0.0	ASPHALT: (150mm)												
0.2	SAND and GRAVEL to Gravelly SAND, some silt Very Dense to Compact Brown Wet (FILL)		1	SS	54								
			2	SS	43								
			3	SS	50/ 0.125								
	Becoming Grey		4	SS	25								
372.5													
3.2	PEAT, fibrous, some roots and wood fragments Firm Brown Wet		5	SS	6								
371.6													
4.1	SAND, trace gravel, trace silt Compact Grey Wet  No recovery		6	SS	22								
370.1													
5.6	SILT and SAND, some gravel Compact to Very Dense Grey Wet (TILL)		7	SS	53/ 0.075								
368.1	Rock fragments												
7.6	METABASALT BEDROCK, slightly weathered, strong to very strong, hard, grey Rubble zone from 7.6m to 7.7m and 7.9m  Horizontal fractures at 8.0m, 8.33m and 8.51m  Sub-horizontal fracture from 8.74m to 8.76m  Sub-horizontal fractures at 8.9m, 9.0m, 9.5m and 10.0m  Vertical fracture from 9.3m to 9.5m  Horizontal fracture at 10.2m		1	RUN									
			2	RUN									

Continued Next Page

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

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# RECORD OF BOREHOLE No 21-01

2 OF 2

METRIC

GWP# 6313-14-00 LOCATION Blackwater River Tributary Culvert Replacement; N 5 489 558.0 E 232 169.5 ORIGINATED BY MC  
 DIST HWY 11 BOREHOLE TYPE Tricone/NQ Coring COMPILED BY AN  
 DATUM Geodetic DATE 2021.03.27 - 2021.03.27 LATITUDE 49.539454 LONGITUDE -88.003593 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 $\gamma$ 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	W <sub>p</sub>	W	W <sub>L</sub>		
365.3	Continued From Previous Page														1		
10.4	END OF BOREHOLE AT 10.4m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.5m, SAND TO 0.2m, THEN ASPHALT COLD PATCH TO SURFACE.																

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

 20  
15 5  
10 (%) STRAIN AT FAILURE



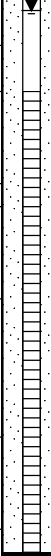








# RECORD OF BOREHOLE No 21-02

1 OF 1

METRIC

GWP# 6313-14-00 LOCATION Blackwater River Tributary Culvert Replacement; N 5 489 553.8 E 232 161.1 ORIGINATED BY MC  
DIST HWY 11 BOREHOLE TYPE Tricone/NQ Coring COMPILED BY AN  
DATUM Geodetic DATE 2021.03.23 - 2021.03.26 LATITUDE 49.539415 LONGITUDE -88.003708 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 (%)									
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa													
375.6	GROUND SURFACE							20 40 60 80 100	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT										
0.0	<b>SAND</b> and <b>GRAVEL</b> to Gravelly <b>SAND</b> , some silt Compact to Very Dense Dark Brown Moist to Wet (FILL)		1	SS	27		375	○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	W <sub>P</sub>	W	W <sub>L</sub>	WATER CONTENT (%)	34 54 12 (SI+CL)								
			2	SS	39																
			3	SS	70/ 0.150		374						38 48 14 (SI+CL)								
			4	SS	72		373														
372.6																					
3.0	<b>PEAT</b> , fibrous, some roots and wood fragments Soft Dark Brown Wet		5	SS	3		372						314								
371.5																					
4.1	<b>SILT</b> and <b>SAND</b> , some gravel Compact Grey Wet (TILL)		6	SS	10		371						FI								
370.2																					
5.4	<b>METABASALT BEDROCK</b> , slightly weathered, medium to strong, grey Highly broken zone from 5.4m to 5.5m and 5.8m to 5.9m  Horizontal fractures at 5.5m, 5.7m, 5.9m, 6.0m, 6.1m, 6.3m, 6.5m and 6.6m Vertical fractures from 5.9m to 6.0m, 6.6m and 6.6m to 6.8m  Rubble zone from 6.8m to 7.1m Vertical fracture from 7.1m to 7.3m Sub-horizontal fracture at 7.2m Sub-horizontal fractures at 7.4m and 8.2m Vertical fracture from 7.6m to 7.8m  Horizontal fractures at 7.6m, 7.9m, 8.1m and 8.6m		1	RUN			370						RUN #1 TCR=100% SCR=89% RQD=56% UCS=79.8MPa (Average)								
					2		RUN		369												
					3		RUN		368												

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

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# RECORD OF BOREHOLE No 21-03

1 OF 2

METRIC

GWP# 6313-14-00 LOCATION Blackwater River Tributary Culvert Replacement; N 5 489 544.5 E 232 169.4 ORIGINATED BY MC  
DIST HWY 11 BOREHOLE TYPE Tricone/NQ Coring COMPILED BY AN  
DATUM Geodetic DATE 2021.03.22 - 2021.03.23 LATITUDE 49.539333 LONGITUDE -88.003591 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																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
375.6	GROUND SURFACE							20	40	60	80	100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											

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

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# RECORD OF BOREHOLE No 21-03

2 OF 2

METRIC

GWP# 6313-14-00 LOCATION Blackwater River Tributary Culvert Replacement; N 5 489 544.5 E 232 169.4 ORIGINATED BY MC  
DIST HWY 11 BOREHOLE TYPE Tricone/NQ Coring COMPILED BY AN  
DATUM Geodetic DATE 2021.03.22 - 2021.03.23 LATITUDE 49.539333 LONGITUDE -88.003591 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	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								20 40 60 80 100										20 40 60		
	Continued From Previous Page																			
	Sub-horizontal fractures at 9.2m, 9.7m and 10.2m																			
	Horizontal fractures at 9.5m and 10.3m		3	RUN																
	Horizontal fractures at 10.4m, 10.9m, 11.5m and 11.6m																			
	Vertical fracture from 10.4m to 10.6m																			
	Sub-horizontal fractures at 10.5m, 10.6m, 10.8m, 10.9m, 11.0m, 11.2m and 11.4m																			
363.7							365													

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# RECORD OF BOREHOLE No 21-04

1 OF 1

METRIC

GWP# 6313-14-00 LOCATION Blackwater River Tributary Culvert Replacement; N 5 489 540.5 E 232 161.0 ORIGINATED BY MC  
DIST HWY 11 BOREHOLE TYPE Tricone/NQ Coring COMPILED BY AN  
DATUM Geodetic DATE 2021.03.26 - 2021.03.27 LATITUDE 49.539296 LONGITUDE -88.003707 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  <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>				GR	SA	SI	CL
375.7	GROUND SURFACE																		
0.0	<b>ASPHALT:</b> (100mm)  <b>SAND</b> and <b>GRAVEL</b> to Gravelly <b>SAND</b> , trace silt Very Dense to Compact Brown Wet (FILL)																		
0.1			1	SS	90														
			2	SS	41														
			3	SS	114/ 0.200														
			4	SS	35														
372.7	<b>PEAT</b> , fibrous Soft Dark Brown Wet																		
3.0			5	SS	3														
371.6	Sandy <b>SILT</b> , some clay, trace gravel, possible cobbles Dense Grey Wet (TILL)																		
4.1			6	SS	40														
369.9	<b>METABASALT BEDROCK</b> , slightly weathered, very strong to strong, grey  Vertical fracture from 5.8m to 5.9m  Horizontal fractures at 5.8m, 5.9m, 6.1m, 6.4m, 6.8m, 6.9m, 7.0m and 7.1m  Sub-horizontal fractures from 5.9m to 6.4m and 6.8m to 6.9m  Sub-horizontal fractures at 8.0m and 8.4m  Horizontal fracture at 8.6m																		
5.8			1	RUN															
				2	RUN														
366.9																			
8.8	END OF BOREHOLE AT 8.8m. Piezometer installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.  WATER LEVEL READINGS DATE        DEPTH(m)    ELEV.(m) 2021.03.27        1.7        374.0																		

ONTMT4S2 MTO-30543.GPJ 2017TEMPLATE(MTO).GDT 10/15/21

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

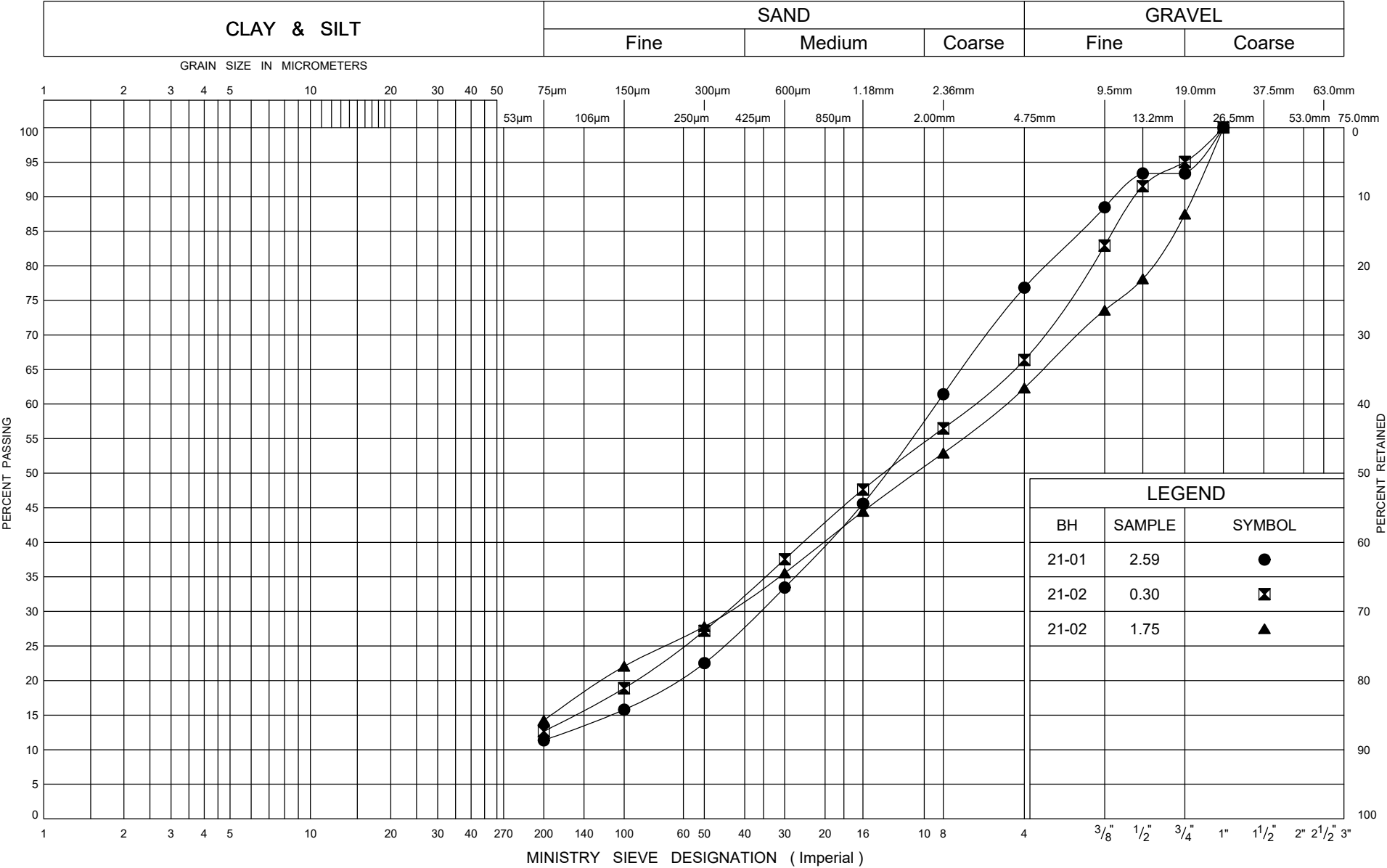




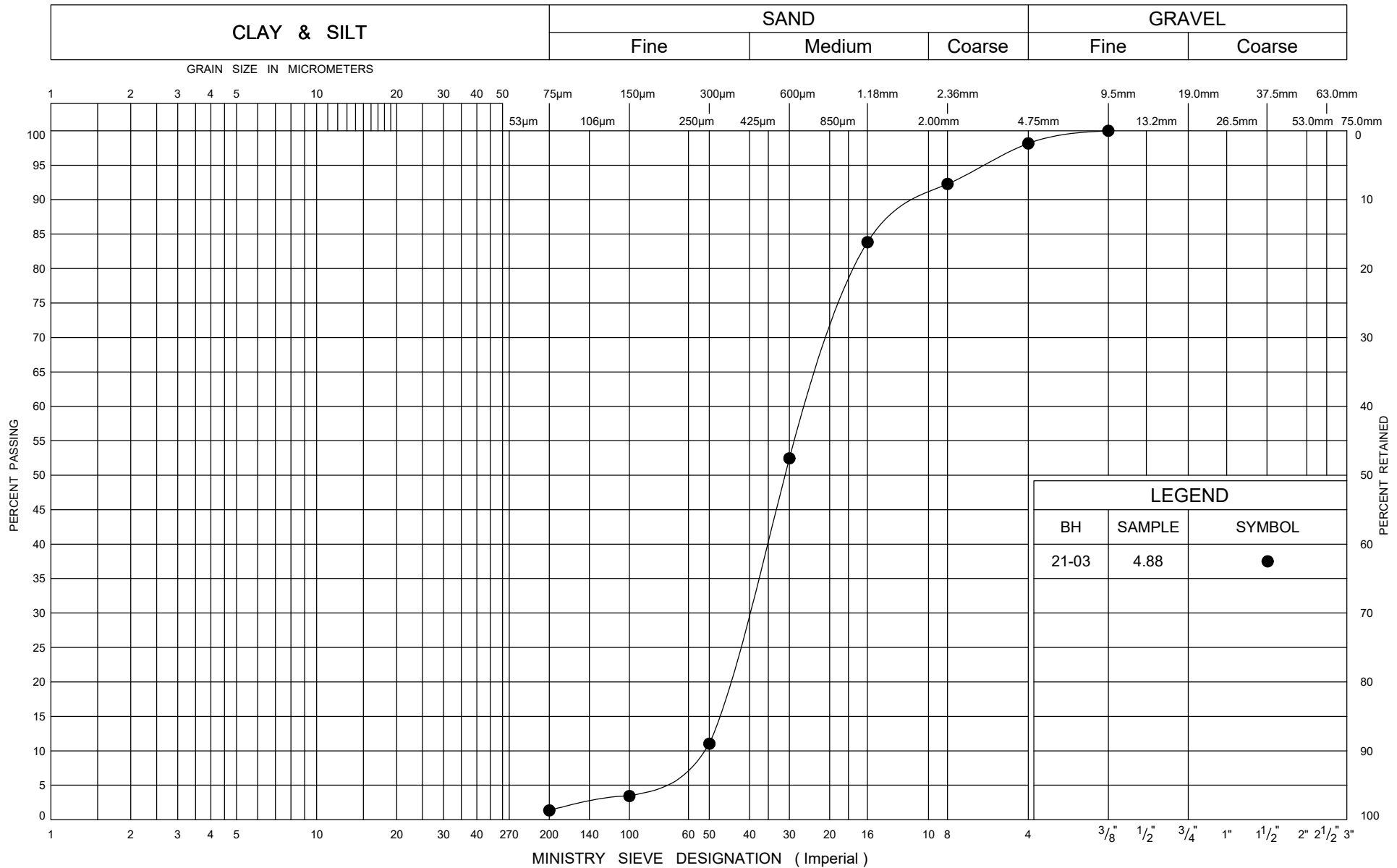
## **Appendix B**

### **Laboratory and Well Test Results**

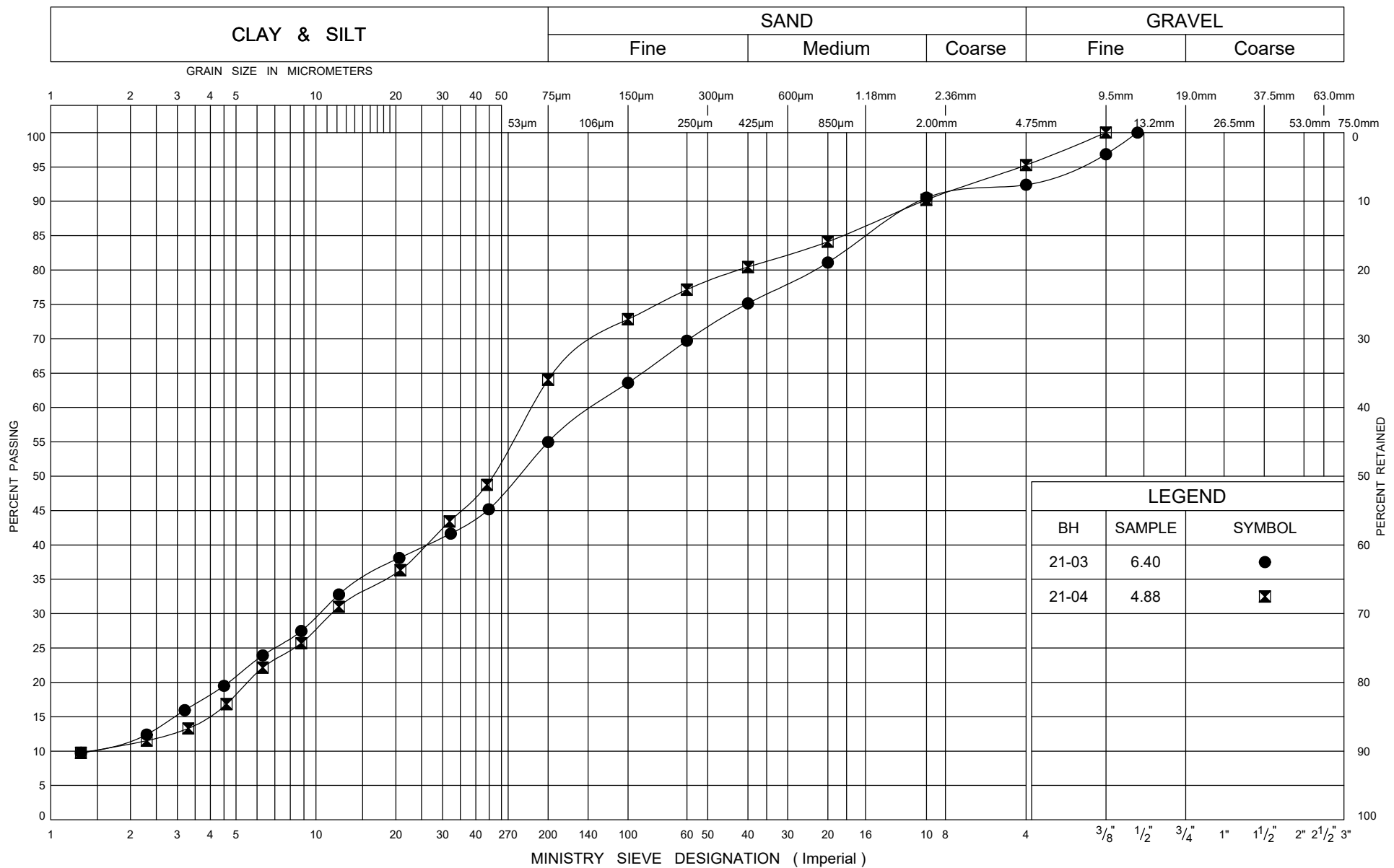














# POINT LOAD TEST SHEET

**ASTM D5731-08**

<b>Job No:</b>	30543
<b>Client:</b>	Hatch
<b>Project Name:</b>	Blackwater Tributary Culvert
<b>Core Size:</b>	HQ <b>BH No :</b> 21-01

Date Drilled:	27-Mar-21
Date Tested:	01-Apr-21
Tester:	MP
Reviewed by:	MEF

[illegible]



# POINT LOAD TEST SHEET

**ASTM D5731-08**

<b>Job No:</b>	30543
<b>Client:</b>	Hatch
<b>Project Name:</b>	Blackwater Tributary Culvert
<b>Core Size:</b>	HQ <b>BH No :</b> 21-02

Date Drilled:	23-Mar-21
Date Tested:	01-Apr-21
Tester:	MP
Reviewed by:	MEF

[illegible]



# POINT LOAD TEST SHEET

**ASTM D5731-08**

<b>Job No:</b>	30543
<b>Client:</b>	Hatch
<b>Project Name:</b>	Blackwater Tributary Culvert
<b>Core Size:</b>	HQ <b>BH No :</b> 21-03

Date Drilled:	26-Mar-21
Date Tested:	01-Apr-21
Tester:	MP
Reviewed by:	MEF

[illegible]



# POINT LOAD TEST SHEET

**ASTM D5731-08**

<b>Job No:</b>	30543
<b>Client:</b>	Hatch
<b>Project Name:</b>	Blackwater Tributary Culvert
<b>Core Size:</b>	HQ
<b>BH No :</b>	21-04

Date Drilled:	26-Mar-21
Date Tested:	01-Apr-21
Tester:	MP
Reviewed by:	MEF

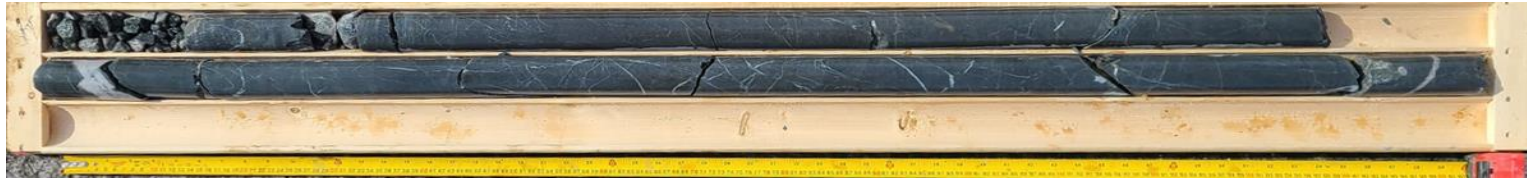
[illegible]



BOREHOLE:               **21-01**  
CORE RUN #1:       25' 0" – 29' 0"  
CORE RUN #2:       29' 0" – 34' 0"

**Run #1**

**Run #2**



BOREHOLE:               **21-02**  
CORE RUN #1:       17' 10" – 22' 4"  
CORE RUN #2:       22' 4" – 23' 10"  
CORE RUN #3:       23' 10" – 29' 0"

**Run #3**

**Run #2**

**Run #1**





BOREHOLE: 21-03  
CORE RUN #1: 28' 2" – 29' 0"  
CORE RUN #2: 29' 0" – 34' 0"  
CORE RUN #3: 34' 0" – 39' 0"

Run #1

Run #2

Run #3



BOREHOLE: 21-04  
CORE RUN #1: 19' 0" – 24' 0"  
CORE RUN #2: 24' 0" – 29' 1"

Run #1

Run #2

Run #2



BLACKWATER RIVER TRIBUTARY CULVERT  
HWY 11  
BEARDMORE, ON





**THURBER** ENGINEERING LTD.

**Slug Test Analysis Report**

Project: Blackwater Tributary Culvert Replacement

Number: 30543

Client: Hatch

Location: District of Thunder Bay

Slug Test: 21-02

Test Well: 21-02

Test Conducted by: MC

Test Date: 2021-03-26

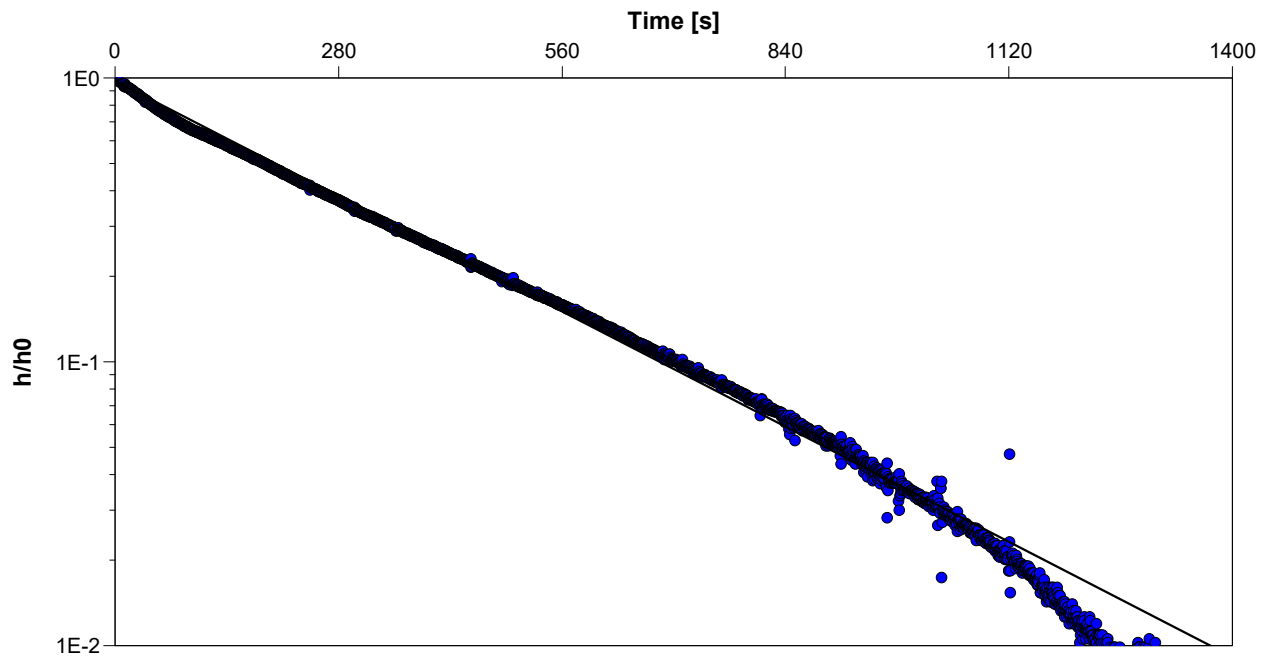
Analysis Performed by: PC

21-02 SWRT Analysis

Analysis Date: 2021-06-08

Aquifer Thickness:

Checked by: DH



Calculation using Hvorslev

Observation Well

Hydraulic  
Conductivity  
[m/s]

21-02

$1.7 \times 10^{-6}$





**THURBER** ENGINEERING LTD.

**Slug Test Analysis Report**

Project: Blackwater Tributary Culvert Replacement

Number: 30543

Client: Hatch

Location: District of Thunder Bay

Slug Test: 21-04

Test Well: 21-04

Test Conducted by: MC

Test Date: 2021-03-27

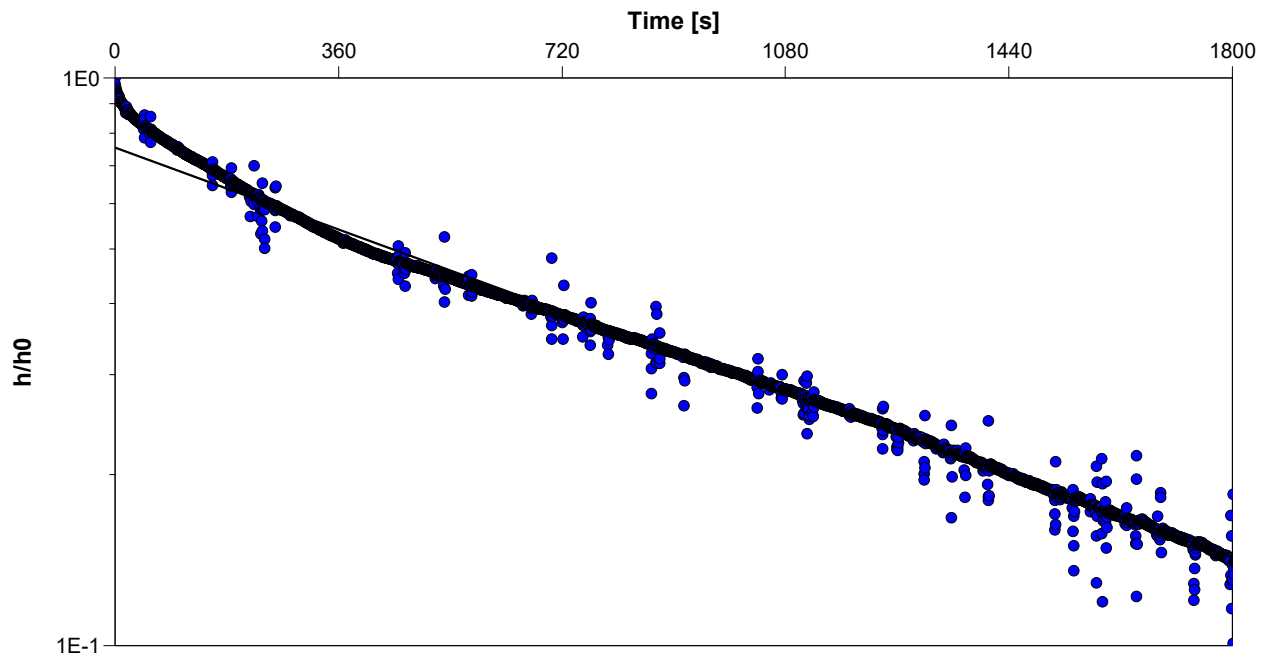
Analysis Performed by: PC

21-04 SWRT Analysis

Analysis Date: 2021-06-08

Aquifer Thickness:

Checked by: DH



Calculation using Hvorslev

Observation Well

Hydraulic  
Conductivity  
[m/s]

21-04

$4.7 \times 10^{-7}$





## FINAL REPORT

CA14675-MAR21 R1

30543, Blackwater Tributary

Prepared for

**Thurber Engineering Ltd.**



## First Page

### CLIENT DETAILS

Client Thurber Engineering Ltd.

Address 103, 2010 Winston Park Drive  
Oakville, ON  
L6H 5R7, Canada

Contact Joshua Alexander

Telephone 613-606-7303

Facsimile

Email jalexander@thurber.ca

Project 30543, Blackwater Tributary

Order Number

Samples Soil (2)

### LABORATORY DETAILS

Project Specialist Jill Campbell, B.Sc.,GISAS

Laboratory SGS Canada Inc.

Address 185 Concession St., Lakefield ON, K0L 2H0

Telephone 2165

Facsimile 705-652-6365

Email jill.campbell@sgs.com

SGS Reference CA14675-MAR21

Received 03/30/2021

Approved 04/01/2021

Report Number CA14675-MAR21 R1

Date Reported 04/06/2021

### COMMENTS

Temperature of Sample upon Receipt: 7 degrees C

Cooling Agent Present:Yes

Custody Seal Present:Yes

Chain of Custody Number:019149

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.

### SIGNATORIES

Jill Campbell, B.Sc.,GISAS







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# FINAL REPORT

CA14675-MAR21 R1

**Client:** Thurber Engineering Ltd.

**Project:** 30543, Blackwater Tributary

**Project Manager:** Joshua Alexander

**Samplers:** Madisan Chiroto

## PACKAGE: - Corrosivity Index (SOIL)

<b>Sample Number</b>	5	6
<b>Sample Name</b>	21-03, SS6	21-04, SS6
<b>Sample Matrix</b>	Soil	Soil
<b>Sample Date</b>	22/03/2021	27/03/2021

Parameter	Units	RL		Result	Result
<b>Corrosivity Index</b>					
Corrosivity Index	none	1		8	8
Soil Redox Potential	mV	-		217	131
Sulphide (Na <sub>2</sub> CO <sub>3</sub> )	%	0.04		0.06	0.05
pH	pH Units	0.05		8.78	8.62
Resistivity (calculated)	ohms.cm	-9999		6850	4650

## PACKAGE: - General Chemistry (SOIL)

<b>Sample Number</b>	5	6
<b>Sample Name</b>	21-03, SS6	21-04, SS6
<b>Sample Matrix</b>	Soil	Soil
<b>Sample Date</b>	22/03/2021	27/03/2021

Parameter	Units	RL		Result	Result
<b>General Chemistry</b>					
Conductivity	uS/cm	2		146	215

## PACKAGE: - Metals and Inorganics (SOIL)

<b>Sample Number</b>	5	6
<b>Sample Name</b>	21-03, SS6	21-04, SS6
<b>Sample Matrix</b>	Soil	Soil
<b>Sample Date</b>	22/03/2021	27/03/2021

Parameter	Units	RL		Result	Result
<b>Metals and Inorganics</b>					
Moisture Content	%	0.1		17.3	10.1
Sulphate	µg/g	0.4		12	11





FINAL REPORT

CA14675-MAR21 R1

**Client:** Thurber Engineering Ltd.  
**Project:** 30543, Blackwater Tributary  
**Project Manager:** Joshua Alexander  
**Samplers:** Madisan Chiroto

PACKAGE: - Other (ORP) (SOIL)

Sample Number	5	6
Sample Name	21-03, SS6	21-04, SS6
Sample Matrix	Soil	Soil
Sample Date	22/03/2021	27/03/2021

Parameter	Units	RL		Result	Result
Other (ORP)					
Chloride	µg/g	0.4		41	38





FINAL REPORT

CA14675-MAR21 R1

QC SUMMARY

Anions by IC  
Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-IENVIIC-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Chloride	DIO0488-MAR21	µg/g	0.4	<0.4	2	20	97	80	120	94	75	125
Sulphate	DIO0488-MAR21	µg/g	0.4	<0.4	5	20	95	80	120	89	75	125

Carbon/Sulphur  
Method: ASTM E1915-07A | Internal ref.: ME-CA-IENVIARD-LAK-AN-020

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Sulphide (Na2CO3)	ECS0059-MAR21	%	0.04	< 0.04	ND	20	99	80	120			

Conductivity  
Method: SM 2510 | Internal ref.: ME-CA-IENVIEWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0498-MAR21	uS/cm	2	< 2	0	20	98	90	110	NA		





FINAL REPORT

CA14675-MAR21 R1

QC SUMMARY

pH  
Method: SM 4500 | Internal ref.: ME-CA-|ENVIEWL-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0498-MAR21	pH Units	0.05	NA	0		102			NA		

Method Blank: a blank matrix that is carried through the entire analytical procedure. Used to assess laboratory contamination.

Duplicate: Paired analysis of a separate portion of the same sample that is carried through the entire analytical procedure. Used to evaluate measurement precision.

LCS/Spike Blank: Laboratory control sample or spike blank refer to a blank matrix to which a known amount of analyte has been added. Used to evaluate analyte recovery and laboratory accuracy without sample matrix effects.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate laboratory accuracy with sample matrix effects.

Reference Material: a material or substance matrix matched to the samples that contains a known amount of the analyte of interest. A reference material may be used in place of a matrix spike.

RL: Reporting limit

RPD: Relative percent difference

AC: Acceptance criteria

**Multielement Scan Qualifier:** as the number of analytes in a scan increases, so does the chance of a limit exceedance by random chance as opposed to a real method problem. Thus, in multielement scans, for the LCS and matrix spike, up to 10% of the analytes may exceed the quoted limits by up to 10% absolute and the spike is considered acceptable.

**Duplicate Qualifier:** for duplicates as the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

**Matrix Spike Qualifier:** for matrix spikes, as the concentration of the native analyte increases, the uncertainty of the matrix spike recovery increases. Thus, the matrix spike acceptance limits apply only when the concentration of the matrix spike is greater than or equal to the concentration of the native analyte.



## LEGEND

## FOOTNOTES

**NSS** Insufficient sample for analysis.

**RL** Reporting Limit.

↑ Reporting limit raised.

↓ Reporting limit lowered.

**NA** The sample was not analysed for this analyte

**ND** Non Detect

Samples analysed as received. Solid samples expressed on a dry weight basis. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

Analysis conducted on samples submitted pursuant to or as part of Reg. 153/04, are in accordance to the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act" published by the Ministry and dated March 9, 2004 as amended.

SGS provides criteria information (such as regulatory or guideline limits and summary of limit exceedances) as a service. Every attempt is made to ensure the criteria information in this report is accurate and current, however, it is not guaranteed. Comparison to the most current criteria is the responsibility of the client and SGS assumes no responsibility for the accuracy of the criteria levels indicated. This document is issued, on the Client's behalf, by the Company under its General Conditions of Service available on request and accessible at [http://www.sgs.com/terms\\_and\\_conditions.htm](http://www.sgs.com/terms_and_conditions.htm). The Client's attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any other holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents.

This report must not be reproduced, except in full. This report supersedes all previous versions.

-- End of Analytical Report --



## Request for Laboratory Services and CHAIN OF CUSTODY

Received By: Olga NovikReceived Date: 05/05/01 (mm/dd/yy)Received Time: 10:30 (hr : min)Received By (signature): [Signature]Custody Seal Present: Yes ☒ No ☐Cooling Agent Present: Yes ☐ No ☒Temperature Upon Receipt (°C): 7.77LAB LIMS # 011435-MA021

## REPORT INFORMATION

## INVOICE INFORMATION

Company: ThurberContact: Jessica AlexanderAddress: 103-2010 ConcessionPhone: 613-606-7303Fax: Email: jalexander@thurber.ca☐ (same as Report Information)Company: ThurberContact: Address: Phone: Email: ONaccounting@thurber.ca

## REGULATIONS

☐ O.Reg 153/04☐ O.Reg 406/19Table 1 ☐ Res/Park ☐ Soil Texture:Table 2 ☐ Ind/Com ☐ CoarseTable 3 ☐ Agr/Other ☐ Medium/FineSoil Volume ☐ <350m<sup>3</sup> ☐ >350m<sup>3</sup>

Other Regulations:

Reg 347/558 (3 Day min TAT)

PW/CO ☐ MM/ER ☐ StormCCME ☐ Other: ☐ MISA

Sewer By-Law:

☐ Sanitary☐ StormMunicipality: 

IODWS Not Reportable \*See note

## RECORD OF SITE CONDITION (RSC)

☐ YES ☐ NO

## SAMPLE IDENTIFICATION

DATE SAMPLED

TIME SAMPLED

# OF BOTTLES

MATRIX

Field Filtered (Y/N)

Metals &amp; Inorganics

Full Metals Suite

ICP Metals only

PAHs only

SVOCs

PCBs

F1-F4 + BTEX

F1-F4 only

VOCs

BTEX only

Pesticides

Appendix 2: 406/19 Leachate

Sewer Use:

Water Characterization Pkg

General ☐ Extended ☐

Specify pkg:

TCLP

Specify

## ANALYSIS REQUESTED

M &amp; I

SVOC

PCB

PHC

VOC

Pest

Other (please specify)

TCLP

Specify

TCLP

tests

M&amp;I

VOC

PCB

El(a)P

ABN

Ignit.

Comments:

Quotation #:

Project # 30543

P.O. #:

Site Location/ID: Redwater Tributary

## TURNAROUND TIME (TAT) REQUIRED

☒ Regular TAT (5-7 days)

RUSH TAT (Additional Charges May Apply):

PLEASE CONFIRM RUSH FEASIBILITY WITH SGS REPRESENTATIVE PRIOR TO SUBMISSION

Specify Due Date: 

\*NOTE: DRINKING (POTABLE) WATER SAMPLES FOR HUMAN CONSUMPTION MUST BE SUBMITTED WITH SGS DRINKING WATER CHAIN OF CUSTODY

## Observations/Comments/Special Instructions

Sampled By (NAME): Melissa CharottoSignature: [Signature]Relinquished by (NAME): Jessica AlexanderSignature: [Signature]Note: Submission of samples to SGS is acknowledgment that you have been provided direct on sample collection/handling and transportation of samples. (2) Submission of samples to SGS is considered authorization for completion of work. Signatures may appear on this form or be retained on file in the contract, or in an alternative format (e.g. shipping documents). (3) Results may be sent by email to an unlimited number of addresses for no additional cost. Fax is available upon request. This document is issued by the Company under its General Conditions of Service accessible at [http://www.sgs.com/terms\\_and\\_conditions.htm](http://www.sgs.com/terms_and_conditions.htm). (Printed copies are available upon request.) Attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein.Revision # 1.4  
Date of Issue: 22 May 2000





## FINAL REPORT

CA14639-MAR21 R1

30543

Prepared for

**Thurber Engineering Ltd.**



## First Page

### CLIENT DETAILS

Client Thurber Engineering Ltd.

Address 103, 2010 Winston Park Drive  
Oakville, ON  
L6H 5R7, Canada

Contact Joshua Alexander

Telephone 613-606-7303

Facsimile

Email jalexander@thurber.ca

Project 30543

Order Number

Samples Ground Water (1)

### LABORATORY DETAILS

Project Specialist Jill Campbell, B.Sc.,GISAS

Laboratory SGS Canada Inc.

Address 185 Concession St., Lakefield ON, K0L 2H0

Telephone 2165

Facsimile 705-652-6365

Email jill.campbell@sgs.com

SGS Reference CA14639-MAR21

Received 03/29/2021

Approved 04/07/2021

Report Number CA14639-MAR21 R1

Date Reported 04/07/2021

### COMMENTS

MAC - Maximum Acceptable Concentration  
AO/OG - Aesthetic Objective / Operational Guideline  
NR - Not reportable under applicable Provincial drinking water regulations as per client.

Temperature of Sample upon Receipt: 8 degrees C  
Cooling Agent Present:Yes  
Custody Seal Present:Yes

Chain of Custody Number:020817

Raise RL for NO2/Br due sample matrix interference

### SIGNATORIES

Jill Campbell, B.Sc.,GISAS







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# FINAL REPORT

CA14639-MAR21 R1

**Client:** Thurber Engineering Ltd.

**Project:** 30543

**Project Manager:** Joshua Alexander

**Samplers:** Madisan Chiarotto

PACKAGE: **General Chemistry (WATER)**

**Sample Number** 7  
**Sample Name** 21-02  
**Sample Matrix** Ground Water  
**Sample Date** 27/03/2021

L1 = PWQO / WATER / - - Table 2 - General - July 1999 PIBS 3303E

Parameter	Units	RL	L1	Result
<b>General Chemistry</b>				
UV Transmittance	%T			20.2
Alkalinity	mg/L as CaCO <sub>3</sub>	2		249
Bicarbonate	mg/L as CaCO <sub>3</sub>	2		249
Carbonate	mg/L as CaCO <sub>3</sub>	2		< 2
OH	mg/L as CaCO <sub>3</sub>	2		< 2
Colour	TCU	3		13
Conductivity	uS/cm	2		9540
Total Suspended Solids	mg/L	2		1580
Organic Nitrogen	mg/L	0.05		0.07
Total Kjeldahl Nitrogen (N)	as N mg/L	0.05		1.30
Ammonia+Ammonium (N)	as N mg/L	0.04		1.23
Dissolved Organic Carbon	mg/L	1		132
Total Organic Carbon	mg/L	1		137
Sulphide	µg/L	6		6.0





# FINAL REPORT

CA14639-MAR21 R1

**Client:** Thurber Engineering Ltd.

**Project:** 30543

**Project Manager:** Joshua Alexander

**Samplers:** Madisan Chiarotto

PACKAGE: **Metals and Inorganics (WATER)**

**Sample Number** 7  
**Sample Name** 21-02  
**Sample Matrix** Ground Water  
**Sample Date** 27/03/2021

L1 = PWQO / WATER / - - Table 2 - General - July 1999 PIBS 3303E

Parameter	Units	RL	L1	Result
<b>Metals and Inorganics</b>				
Fluoride	mg/L	0.06		< 0.06
Bromide	mg/L	0.05		<0.5 †
Nitrite (as N)	as N mg/L	0.003		<0.3 †
Nitrate (as N)	as N mg/L	0.006		0.624
Sulphate	mg/L	0.04		87
Mercury	µg/L	0.01	0.2	0.02
Hardness	mg/L as CaCO3	0.05		805
Aluminum	µg/L	1	15	6400
Arsenic	µg/L	0.2	5	14.8
Boron	µg/L	2	200	14
Barium	µg/L	0.02		409
Beryllium	µg/L	0.007	11	0.253
Bismuth	µg/L	0.007		0.078
Cobalt	µg/L	0.004	0.9	18.4
Calcium	mg/L	0.01		264
Cadmium	µg/L	0.003	0.1	1.03
Copper	µg/L	0.2	1	101
Chromium	µg/L	0.08		42.4
Iron	ug/L	7	300	11800
Potassium	mg/L	0.009		20.3
Magnesium	mg/L	0.001		35.2
Manganese	µg/L	0.01		859
Molybdenum	µg/L	0.04	40	3.50





# FINAL REPORT

CA14639-MAR21 R1

**Client:** Thurber Engineering Ltd.

**Project:** 30543

**Project Manager:** Joshua Alexander

**Samplers:** Madisan Chiarotto

PACKAGE: **Metals and Inorganics (WATER)**

**Sample Number** 7  
**Sample Name** 21-02  
**Sample Matrix** Ground Water  
**Sample Date** 27/03/2021

L1 = PWQO / WATER / - - Table 2 - General - July 1999 PIBS 3303E

Parameter	Units	RL	L1	Result
<b>Metals and Inorganics (continued)</b>				
Nickel	µg/L	0.1	25	37.0
Sodium	mg/L	0.01		2080
Phosphorus	mg/L	0.003	0.01	1.00
Lead	µg/L	0.01	1	3.56
Silicon	ug/L	20		8410
Silver	µg/L	0.05	0.1	3.61
Strontium	µg/L	0.02		753
Thallium	µg/L	0.005	0.3	0.057
Tin	µg/L	0.06		0.88
Titanium	ug/L	0.05		65.3
Antimony	µg/L	0.9	20	< 0.9
Selenium	µg/L	0.04	100	0.24
Uranium	µg/L	0.002	5	2.13
Vanadium	µg/L	0.01	6	24.5
Zinc	µg/L	2	20	41





FINAL REPORT

CA14639-MAR21 R1

**Client:** Thurber Engineering Ltd.  
**Project:** 30543  
**Project Manager:** Joshua Alexander  
**Samplers:** Madisan Chiarotto

PACKAGE: **Other (ORP)** (WATER)

**Sample Number** 7  
**Sample Name** 21-02  
**Sample Matrix** Ground Water  
**Sample Date** 27/03/2021

L1 = PWQO / WATER / - - Table 2 - General - July 1999 PIBS 3303E

Parameter	Units	RL	L1	Result
Other (ORP)				
pH	No unit	5	8.5	7.76
Chloride	mg/L	0.04		4200
Chromium VI	µg/L	0.2	1	< 0.2
Phenols				
4AAP-Phenolics	mg/L	0.002	0.001	< 0.002



## EXCEEDANCE SUMMARY

				PWQO / WATER / - - Table 2 - General - July 1999 PIBS 3303E L1
Parameter	Method	Units	Result	

### 21-02

Aluminum	SM 3030/EPA 200.8	µg/L	6400	15
Arsenic	SM 3030/EPA 200.8	µg/L	14.8	5
Cadmium	SM 3030/EPA 200.8	µg/L	1.03	0.1
Cobalt	SM 3030/EPA 200.8	µg/L	18.4	0.9
Copper	SM 3030/EPA 200.8	µg/L	101	1
Iron	SM 3030/EPA 200.8	ug/L	11800	300
Lead	SM 3030/EPA 200.8	µg/L	3.56	1
Nickel	SM 3030/EPA 200.8	µg/L	37.0	25
Phosphorus	SM 3030/EPA 200.8	mg/L	1.00	0.01
Silver	SM 3030/EPA 200.8	µg/L	3.61	0.1
Vanadium	SM 3030/EPA 200.8	µg/L	24.5	6
Zinc	SM 3030/EPA 200.8	µg/L	41	20
4AAP-Phenolics	SM 5530B-D	mg/L	< 0.002	0.001





FINAL REPORT

CA14639-MAR21 R1

QC SUMMARY

Alkalinity

Method: SM 2320 | Internal ref.: ME-CA-1ENVIEWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Alkalinity	EWL0498-MAR21	mg/L as CaCO3	2	< 2	0	20	102	80	120	NA		

Ammonia by SFA

Method: SM 4500 | Internal ref.: ME-CA-1ENVISFA-LAK-AN-007

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Ammonia+Ammonium (N)	SKA0279-MAR21	mg/L	0.04	<0.04	0	10	98	90	110	NV	75	125





# FINAL REPORT

CA14639-MAR21 R1

## QC SUMMARY

### Anions by IC

Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-IENVIIC-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Sulphate	DIO0487-MAR21	mg/L	0.04	<0.04	1	20	94	80	120	90	75	125
Bromide	DIO0501-MAR21	mg/L	0.05	<0.05	ND	20	99	80	120	88	75	125
Nitrite (as N)	DIO0501-MAR21	mg/L	0.003	<0.003	ND	20	97	80	120	101	75	125
Nitrate (as N)	DIO0501-MAR21	mg/L	0.006	<0.006	7	20	102	80	120	98	75	125
Chloride	DIO0502-MAR21	mg/L	0.04	<0.04	2	20	97	80	120	85	75	125

### Carbon by SFA

Method: SM 5310 | Internal ref.: ME-CA-IENVISFA-LAK-AN-009

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Dissolved Organic Carbon	SKA0019-APR21	mg/L	1	<1	1	10	94	90	110	94	75	125
Total Organic Carbon	SKA0019-APR21	mg/L	1	<1	1	10	94	90	110	94	75	125





FINAL REPORT

CA14639-MAR21 R1

QC SUMMARY

Carbonate/Bicarbonate

Method: SM 2320 | Internal ref.: ME-CA-ENVIEWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Carbonate	EWL0498-MAR21	mg/L as CaCO3	2	< 2	ND	10	NA	90	110	NA		
Bicarbonate	EWL0498-MAR21	mg/L as CaCO3	2	< 2	0	10	NA	90	110	NA		
OH	EWL0498-MAR21	mg/L as CaCO3	2	< 2	ND	10	NA	90	110	NA		

Colour

Method: SM 2120 | Internal ref.: ME-CA-ENVIEWL-LAK-AN-002

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Colour	EWL0505-MAR21	TCU	3	< 3	0	10	95	80	120	NA		





FINAL REPORT

CA14639-MAR21 R1

QC SUMMARY

Conductivity  
Method: SM 2510 | Internal ref.: ME-CA-IENVIEWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0498-MAR21	uS/cm	2	< 2	0	20	98	90	110	NA		

Fluoride by Specific Ion Electrode  
Method: SM 4500 | Internal ref.: ME-CA-IENVIEWL-LAK-AN-014

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Fluoride	EWL0501-MAR21	mg/L	0.06	<0.06	0	10	100	90	110	101	75	125

Hexavalent Chromium by SFA  
Method: EPA218.6/EPA3060A | Internal ref.: ME-CA-IENVISKA-LAK-AN-012

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Chromium VI	SKA0287-MAR21	ug/L	0.2	<0.2	ND	20	94	80	120	NV	75	125





FINAL REPORT

CA14639-MAR21 R1

QC SUMMARY

Mercury by CVAAS  
Method: SM3112/EPA 245 | Internal ref.: ME-CA-IENVISPE-LAK-AN-004

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Mercury	EHG0034-MAR21	ug/L	0.01	<0.01	ND	20	108	80	120	118	70	130





# FINAL REPORT

CA14639-MAR21 R1

## QC SUMMARY

Metals in aqueous samples - ICP-MS

Method: SM 3030/EPA 200.8 | Internal ref.: ME-CA-ENVISPE-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Silver	EMS0177-MAR21	ug/L	0.05	< 0.05	ND	20	105	90	110	102	70	130
Aluminum	EMS0177-MAR21	ug/L	1	< 1	5	20	104	90	110	124	70	130
Arsenic	EMS0177-MAR21	ug/L	0.2	< 0.2	ND	20	102	90	110	107	70	130
Barium	EMS0177-MAR21	ug/L	0.02	< 0.02	4	20	98	90	110	102	70	130
Beryllium	EMS0177-MAR21	ug/L	0.007	< 0.07	ND	20	96	90	110	80	70	130
Boron	EMS0177-MAR21	ug/L	2	< 2	4	20	108	90	110	NV	70	130
Bismuth	EMS0177-MAR21	ug/L	0.007	< 0.007	ND	20	101	90	110	82	70	130
Calcium	EMS0177-MAR21	mg/L	0.01	< 0.02	1	20	107	90	110	102	70	130
Cadmium	EMS0177-MAR21	ug/L	0.003	< 0.003	ND	20	103	90	110	92	70	130
Cobalt	EMS0177-MAR21	ug/L	0.004	< 0.004	3	20	106	90	110	98	70	130
Chromium	EMS0177-MAR21	ug/L	0.08	< 0.08	1	20	109	90	110	112	70	130
Copper	EMS0177-MAR21	ug/L	0.2	< 0.2	5	20	107	90	110	86	70	130
Iron	EMS0177-MAR21	ug/L	7	< 7	1	20	108	90	110	125	70	130
Potassium	EMS0177-MAR21	mg/L	0.009	< 0.009	0	20	106	90	110	NV	70	130
Magnesium	EMS0177-MAR21	mg/L	0.001	< 0.001	0	20	108	90	110	100	70	130
Manganese	EMS0177-MAR21	ug/L	0.01	< 0.01	1	20	104	90	110	103	70	130
Molybdenum	EMS0177-MAR21	ug/L	0.04	< 0.04	1	20	108	90	110	95	70	130
Nickel	EMS0177-MAR21	ug/L	0.1	< 0.1	ND	20	110	90	110	98	70	130
Lead	EMS0177-MAR21	ug/L	0.01	< 0.01	4	20	105	90	110	89	70	130
Phosphorus	EMS0177-MAR21	mg/L	0.003	< 0.003	0	20	101	90	110	NV	70	130





FINAL REPORT

CA14639-MAR21 R1

QC SUMMARY

Metals in aqueous samples - ICP-MS (continued)  
Method: SM 3030/EPA 200.8 | Internal ref.: ME-CA-1ENVISPE-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Antimony	EMS0177-MAR21	ug/L	0.9	< 0.09	ND	20	103	90	110	121	70	130
Selenium	EMS0177-MAR21	ug/L	0.04	< 0.04	ND	20	103	90	110	124	70	130
Silicon	EMS0177-MAR21	ug/L	20	< 0.02	4	20	108	90	110	NV	70	130
Tin	EMS0177-MAR21	ug/L	0.06	< 0.06	ND	20	107	90	110	NV	70	130
Strontium	EMS0177-MAR21	ug/L	0.02	< 0.02	2	20	102	90	110	99	70	130
Titanium	EMS0177-MAR21	ug/L	0.05	< 0.05	12	20	101	90	110	NV	70	130
Thallium	EMS0177-MAR21	ug/L	0.005	< 0.005	ND	20	105	90	110	94	70	130
Uranium	EMS0177-MAR21	ug/L	0.002	< 0.002	ND	20	108	90	110	88	70	130
Vanadium	EMS0177-MAR21	ug/L	0.01	< 0.01	7	20	103	90	110	108	70	130
Zinc	EMS0177-MAR21	ug/L	2	< 2	4	20	96	90	110	103	70	130
Sodium	EMS0185-MAR21	mg/L	0.01	<0.01	1	20	104	90	110	92	70	130

pH  
Method: SM 4500 | Internal ref.: ME-CA-1ENVIEWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0498-MAR21	No unit	5	NA	0		102			NA		





# FINAL REPORT

CA14639-MAR21 R1

## QC SUMMARY

### Phenols by SFA

Method: SM 5530B-D | Internal ref.: ME-CA-IENVISFA-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
4AAP-Phenolics	SKA0002-APR21	mg/L	0.002	<0.002	ND	10	96	80	120	100	75	125

### Sulphide by SFA

Method: SM 4500 | Internal ref.: ME-CA-IENVISFA-LAK-AN-008

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Sulphide	SKA0282-MAR21	ug/L	6	<0.006	ND	20	88	80	120	NA	75	125

### Suspended Solids

Method: SM 2540D | Internal ref.: ME-CA-IENVIEWL-LAK-AN-004

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Total Suspended Solids	EWL0509-MAR21	mg/L	2	< 2	0	10	96	90	110	NA		





QC SUMMARY

Total Nitrogen

Method: SM 4500-N C/4500-NO3- F | Internal ref.: ME-CA-IENVISFA-LAK-AN-002

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Total Kjeldahl Nitrogen (N)	SKA0004-APR21	mg/L	0.05	<0.05	5	10	100	90	110	104	75	125

Method Blank: a blank matrix that is carried through the entire analytical procedure. Used to assess laboratory contamination.

Duplicate: Paired analysis of a separate portion of the same sample that is carried through the entire analytical procedure. Used to evaluate measurement precision.

LCS/Spike Blank: Laboratory control sample or spike blank refer to a blank matrix to which a known amount of analyte has been added. Used to evaluate analyte recovery and laboratory accuracy without sample matrix effects.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate laboratory accuracy with sample matrix effects.

Reference Material: a material or substance matrix matched to the samples that contains a known amount of the analyte of interest. A reference material may be used in place of a matrix spike.

RL: Reporting limit

RPD: Relative percent difference

AC: Acceptance criteria

**Multielement Scan Qualifier:** as the number of analytes in a scan increases, so does the chance of a limit exceedance by random chance as opposed to a real method problem. Thus, in multielement scans, for the LCS and matrix spike, up to 10% of the analytes may exceed the quoted limits by up to 10% absolute and the spike is considered acceptable.

**Duplicate Qualifier:** for duplicates as the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

**Matrix Spike Qualifier:** for matrix spikes, as the concentration of the native analyte increases, the uncertainty of the matrix spike recovery increases. Thus, the matrix spike acceptance limits apply only when the concentration of the matrix spike is greater than or equal to the concentration of the native analyte.



## LEGEND

### FOOTNOTES

**NSS** Insufficient sample for analysis.

**RL** Reporting Limit.

↑ Reporting limit raised.

↓ Reporting limit lowered.

**NA** The sample was not analysed for this analyte

**ND** Non Detect

Samples analysed as received. Solid samples expressed on a dry weight basis. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

Analysis conducted on samples submitted pursuant to or as part of Reg. 153/04, are in accordance to the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act" published by the Ministry and dated March 9, 2004 as amended.

SGS provides criteria information (such as regulatory or guideline limits and summary of limit exceedances) as a service. Every attempt is made to ensure the criteria information in this report is accurate and current, however, it is not guaranteed. Comparison to the most current criteria is the responsibility of the client and SGS assumes no responsibility for the accuracy of the criteria levels indicated. This document is issued, on the Client's behalf, by the Company under its General Conditions of Service available on request and accessible at [http://www.sgs.com/terms\\_and\\_conditions.htm](http://www.sgs.com/terms_and_conditions.htm). The Client's attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any other holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents.

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-- End of Analytical Report --









## FINAL REPORT

CA15270-MAY21 R1

30543

Prepared for

**Thurber Engineering Ltd.**





# FINAL REPORT

CA15270-MAY21 R1

## First Page

### CLIENT DETAILS

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Project  
30543

Order Number

Samples  
Ground Water (1)

### LABORATORY DETAILS

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CA15270-MAY21

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CA15270-MAY21 R1

Date Reported  
05/26/2021

### COMMENTS

### SIGNATORIES

Jill Campbell, B.Sc.,GISAS





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# FINAL REPORT

CA15270-MAY21 R1

**Client:** Thurber Engineering Ltd.

**Project:** 30543

**Project Manager:** Joshua Alexander

**Samplers:** Madisan Chiarotto

PACKAGE: **Metals and Inorganics (WATER)**

**Sample Number** 7  
**Sample Name** 21-02  
**Sample Matrix** Ground Water  
**Sample Date** 27/03/2021

L1 = PWQO / WATER / - - Table 2 - General - July 1999 PIBS 3303E

Parameter	Units	RL	L1	Result
<b>Metals and Inorganics</b>				
Hardness (dissolved)	mg/L as CaCO <sub>3</sub>	0.05		629
Aluminum (dissolved)	mg/L	0.001	0.015	0.024
Arsenic (dissolved)	mg/L	0.0002		0.0021
Boron (dissolved)	mg/L	0.002		0.017
Barium (dissolved)	mg/L	0.00002		0.345
Beryllium (dissolved)	mg/L	0.00000		< 0.000007
		7		
Bismuth (dissolved)	mg/L	0.00001		0.00010
Cobalt (dissolved)	mg/L	0.00000		0.00299
		4		
Calcium (dissolved)	mg/L	0.01		218
Cadmium (dissolved)	mg/L	0.00000		0.000489
		3		
Copper (dissolved)	mg/L	0.0002		0.0218
Chromium (dissolved)	mg/L	0.00008		0.00099
Iron (dissolved)	mg/L	0.007		0.029
Potassium (dissolved)	mg/L	0.009		21.0
Magnesium (dissolved)	mg/L	0.001		20.4
Manganese (dissolved)	mg/L	0.00001		0.274
Molybdenum (dissolved)	mg/L	0.00004		0.00499
Nickel (dissolved)	mg/L	0.0001		0.0057
Sodium (dissolved)	mg/L	0.01		2210
Phosphorus (dissolved)	mg/L	0.003		0.015





FINAL REPORT

CA15270-MAY21 R1

Client: Thurber Engineering Ltd.

Project: 30543

Project Manager: Joshua Alexander

Samplers: Madisan Chiarotto

PACKAGE: Metals and Inorganics (WATER)

Sample Number 7  
Sample Name 21-02  
Sample Matrix Ground Water  
Sample Date 27/03/2021

L1 = PWQO / WATER / - - Table 2 - General - July 1999 PIBS 3303E

Parameter	Units	RL	L1	Result
Metals and Inorganics (continued)				
Lead (dissolved)	mg/L	0.00009		< 0.00009
Silicon (dissolved)	mg/L	0.02		3.52
Silver (dissolved)	mg/L	0.00005		0.00094
Strontium (dissolved)	mg/L	0.00002		0.659
Thallium (dissolved)	mg/L	0.00000 5		0.000039
Tin (dissolved)	mg/L	0.00006		0.00024
Titanium (dissolved)	mg/L	0.00005		0.00030
Antimony (dissolved)	mg/L	0.0009		< 0.0009
Selenium (dissolved)	mg/L	0.00004		0.00034
Uranium (dissolved)	mg/L	0.00000 2		0.00178
Vanadium (dissolved)	mg/L	0.00001		0.00125
Zinc (dissolved)	mg/L	0.002		0.002





EXCEEDANCE SUMMARY

				PWQO / WATER / - - Table 2 - General - July 1999 PIBS 3303E L1
Parameter	Method	Units	Result	

21-02

Aluminum (dissolved)	SM 3030/EPA 200.8	mg/L	0.024	0.015
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FINAL REPORT

CA15270-MAY21 R1

QC SUMMARY

Metals in aqueous samples - ICP-MS  
Method: SM 3030/EPA 200.8 | Internal ref.: ME-CA-ENVISPE-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Silver (dissolved)	EMS0103-MAY21	mg/L	0.00005	<0.00005	ND	20	100	90	110	99	70	130
Aluminum (dissolved)	EMS0103-MAY21	mg/L	0.001	<0.001	1	20	94	90	110	106	70	130
Arsenic (dissolved)	EMS0103-MAY21	mg/L	0.0002	<0.0002	11	20	102	90	110	100	70	130
Barium (dissolved)	EMS0103-MAY21	mg/L	0.00002	<0.00002	1	20	100	90	110	100	70	130
Beryllium (dissolved)	EMS0103-MAY21	mg/L	0.000007	<0.00007	ND	20	93	90	110	88	70	130
Boron (dissolved)	EMS0103-MAY21	mg/L	0.002	<0.002	5	20	96	90	110	99	70	130
Bismuth (dissolved)	EMS0103-MAY21	mg/L	0.00001	<0.00001	5	20	90	90	110	81	70	130
Calcium (dissolved)	EMS0103-MAY21	mg/L	0.01	<0.01	2	20	102	90	110	102	70	130
Cadmium (dissolved)	EMS0103-MAY21	mg/L	0.000003	<0.000003	2	20	101	90	110	108	70	130
Cobalt (dissolved)	EMS0103-MAY21	mg/L	0.000004	<0.000004	1	20	99	90	110	98	70	130
Chromium (dissolved)	EMS0103-MAY21	mg/L	0.00008	<0.00008	5	20	100	90	110	101	70	130
Copper (dissolved)	EMS0103-MAY21	mg/L	0.0002	<0.0002	4	20	100	90	110	94	70	130
Iron (dissolved)	EMS0103-MAY21	mg/L	0.007	<0.007	0	20	102	90	110	100	70	130
Potassium (dissolved)	EMS0103-MAY21	mg/L	0.009	<0.009	1	20	104	90	110	100	70	130
Magnesium (dissolved)	EMS0103-MAY21	mg/L	0.001	<0.001	2	20	110	90	110	100	70	130
Manganese (dissolved)	EMS0103-MAY21	mg/L	0.00001	<0.00001	1	20	101	90	110	106	70	130
Molybdenum (dissolved)	EMS0103-MAY21	mg/L	0.00004	<0.00004	7	20	95	90	110	108	70	130
Nickel (dissolved)	EMS0103-MAY21	mg/L	0.0001	<0.0001	2	20	103	90	110	102	70	130
Lead (dissolved)	EMS0103-MAY21	mg/L	0.00009	<0.00001	3	20	109	90	110	104	70	130
Phosphorus (dissolved)	EMS0103-MAY21	mg/L	0.003	<0.003	6	20	99	90	110	NV	70	130





# FINAL REPORT

CA15270-MAY21 R1

## QC SUMMARY

Metals in aqueous samples - ICP-MS (continued)

Method: SM 3030/EPA 200.8 | Internal ref.: ME-CA-ENVISPE-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Antimony (dissolved)	EMS0103-MAY21	mg/L	0.0009	<0.0009	2	20	100	90	110	120	70	130
Selenium (dissolved)	EMS0103-MAY21	mg/L	0.00004	<0.00004	12	20	101	90	110	105	70	130
Silicon (dissolved)	EMS0103-MAY21	mg/L	0.02	<0.02	4	20	109	90	110	NV	70	130
Tin (dissolved)	EMS0103-MAY21	mg/L	0.00006	<0.00006	2	20	98	90	110	NV	70	130
Strontium (dissolved)	EMS0103-MAY21	mg/L	0.00002	<0.00002	2	20	98	90	110	101	70	130
Titanium (dissolved)	EMS0103-MAY21	mg/L	0.00005	<0.00005	5	20	104	90	110	NV	70	130
Thallium (dissolved)	EMS0103-MAY21	mg/L	0.000005	<0.000005	ND	20	104	90	110	100	70	130
Uranium (dissolved)	EMS0103-MAY21	mg/L	0.000002	<0.000002	2	20	102	90	110	96	70	130
Vanadium (dissolved)	EMS0103-MAY21	mg/L	0.00001	<0.00001	0	20	99	90	110	102	70	130
Zinc (dissolved)	EMS0103-MAY21	mg/L	0.002	<0.002	3	20	99	90	110	108	70	130
Sodium (dissolved)	EMS0116-MAY21	mg/L	0.01	<0.01	2	20	94	90	110	108	70	130



## QC SUMMARY

---

**Method Blank:** a blank matrix that is carried through the entire analytical procedure. Used to assess laboratory contamination.

**Duplicate:** Paired analysis of a separate portion of the same sample that is carried through the entire analytical procedure. Used to evaluate measurement precision.

**LCS/Spike Blank:** Laboratory control sample or spike blank refer to a blank matrix to which a known amount of analyte has been added. Used to evaluate analyte recovery and laboratory accuracy without sample matrix effects.

**Matrix Spike:** A sample to which a known amount of the analyte of interest has been added. Used to evaluate laboratory accuracy with sample matrix effects.

**Reference Material:** a material or substance matrix matched to the samples that contains a known amount of the analyte of interest. A reference material may be used in place of a matrix spike.

**RL:** Reporting limit

**RPD:** Relative percent difference

**AC:** Acceptance criteria

**Multielement Scan Qualifier:** as the number of analytes in a scan increases, so does the chance of a limit exceedance by random chance as opposed to a real method problem. Thus, in multielement scans, for the LCS and matrix spike, up to 10% of the analytes may exceed the quoted limits by up to 10% absolute and the spike is considered acceptable.

**Duplicate Qualifier:** for duplicates as the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

**Matrix Spike Qualifier:** for matrix spikes, as the concentration of the native analyte increases, the uncertainty of the matrix spike recovery increases. Thus, the matrix spike acceptance limits apply only when the concentration of the matrix spike is greater than or equal to the concentration of the native analyte.



## LEGEND

## FOOTNOTES

**NSS** Insufficient sample for analysis.

**RL** Reporting Limit.

↑ Reporting limit raised.

↓ Reporting limit lowered.

**NA** The sample was not analysed for this analyte

**ND** Non Detect

Samples analysed as received. Solid samples expressed on a dry weight basis. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

Analysis conducted on samples submitted pursuant to or as part of Reg. 153/04, are in accordance to the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act" published by the Ministry and dated March 9, 2004 as amended.

SGS provides criteria information (such as regulatory or guideline limits and summary of limit exceedances) as a service. Every attempt is made to ensure the criteria information in this report is accurate and current, however, it is not guaranteed. Comparison to the most current criteria is the responsibility of the client and SGS assumes no responsibility for the accuracy of the criteria levels indicated. This document is issued, on the Client's behalf, by the Company under its General Conditions of Service available on request and accessible at [http://www.sgs.com/terms\\_and\\_conditions.htm](http://www.sgs.com/terms_and_conditions.htm). The Client's attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any other holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents.

This report must not be reproduced, except in full. This report supersedes all previous versions.

-- End of Analytical Report --





## **Appendix C**

### **Site Photographs**





**Figure 1: Looking north at south approach on Highway 11 (March 2021)**



**Figure 2: Looking south at north approach on Highway 11 (March 2021)**





**Figure 3: Culvert inlet and east embankment slope looking north (March 2021)**



**Figure 4: Looking southeast from culvert inlet (March 2021)**





**Figure 5: Looking southeast at culvert outlet (west side) (March 2021)**



**Figure 6: Looking south along west embankment at culvert outlet (March 2021)**

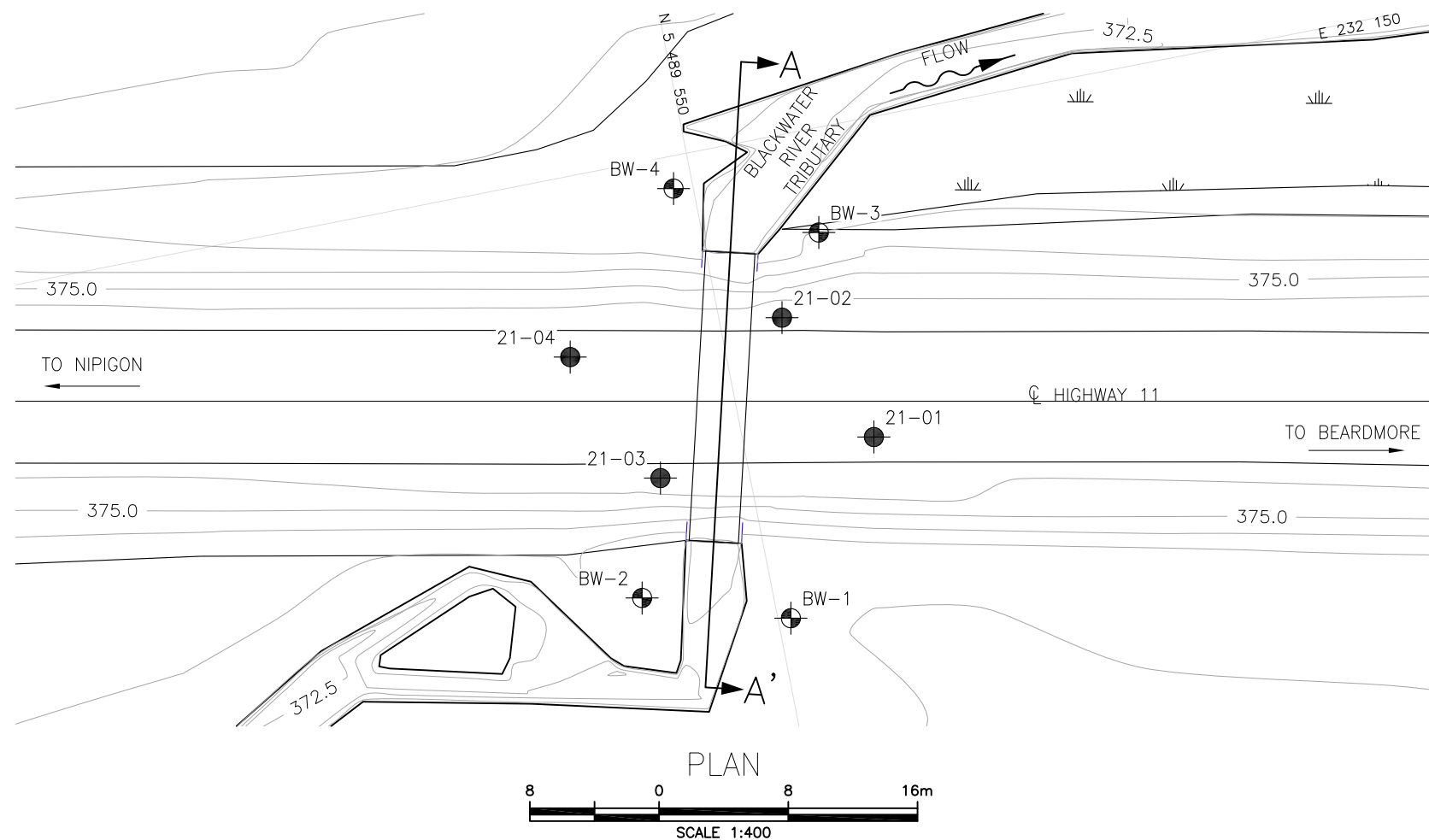




## **Appendix D**

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





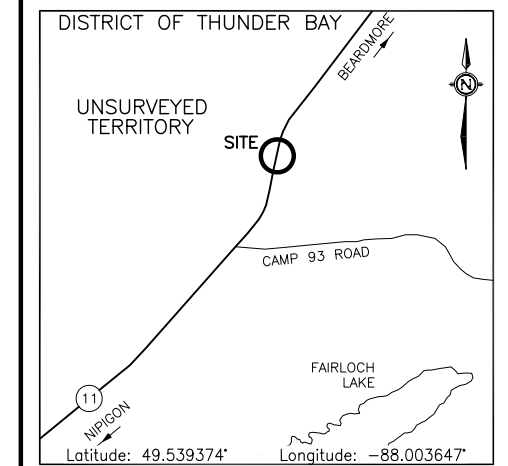
METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN



CONT No  
GWP No 6313-14-00

HIGHWAY 11  
BLACKWATER RIVER  
TRIBUTARY CULVERT REPLACEMENT  
BOREHOLE LOCATIONS AND SOIL STRATA

**HATCH**



KEYPLAN  
LEGEND

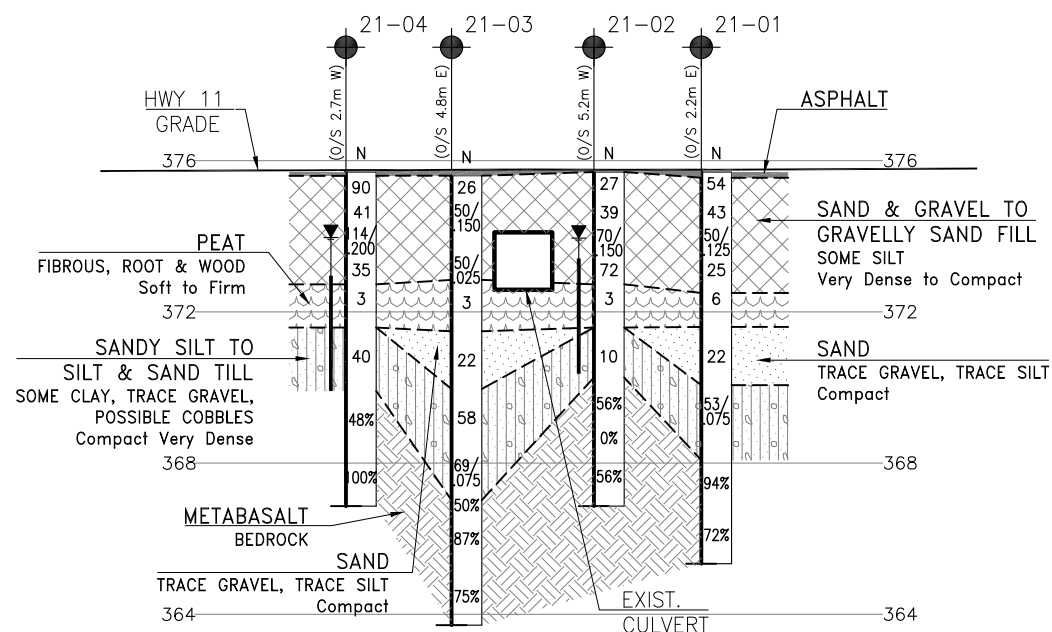
●	Borehole
⊙	Borehole (By Others)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
☼	Water Level
☼	Head Artesian Water
⬇	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
21-01	375.7	5 489 558.0	232 169.5
21-02	375.6	5 489 553.8	232 161.1
21-03	375.6	5 489 544.5	232 169.4
21-04	375.7	5 489 540.5	232 161.0
BW-1	374.3	5 489 550.8	232 179.5
BW-2	374.2	5 489 542.0	232 176.5
BW-3	374.0	5 489 557.1	232 156.4
BW-4	373.9	5 489 548.8	232 152.0

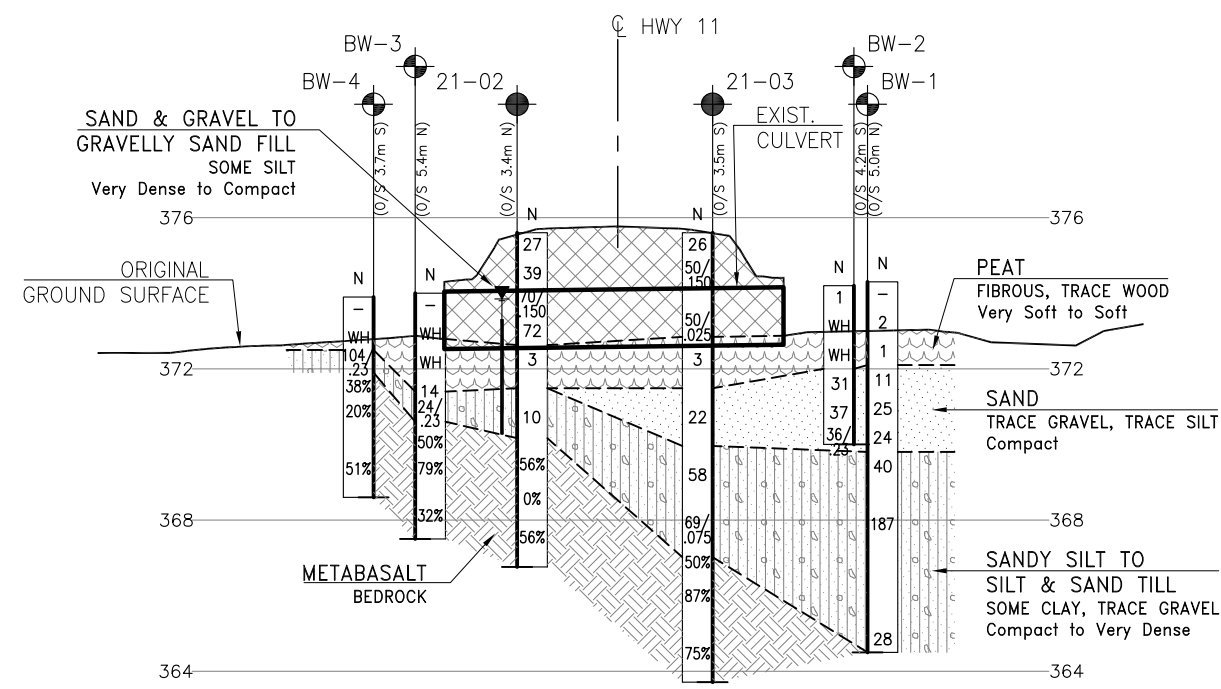
**-NOTES-**

- 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 14.

**GEOCRES No. 52H-50**



PROFILE ALONG Q HIGHWAY 11



SECTION ALONG A-A'



H 1:400  
V 1:200

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	MEF	CHK PKC	CODE
DRAWN	AN	CHK MEF	SITE 48C-0180/CO/STRUCT
DATE	OCT 2021	DWG	1

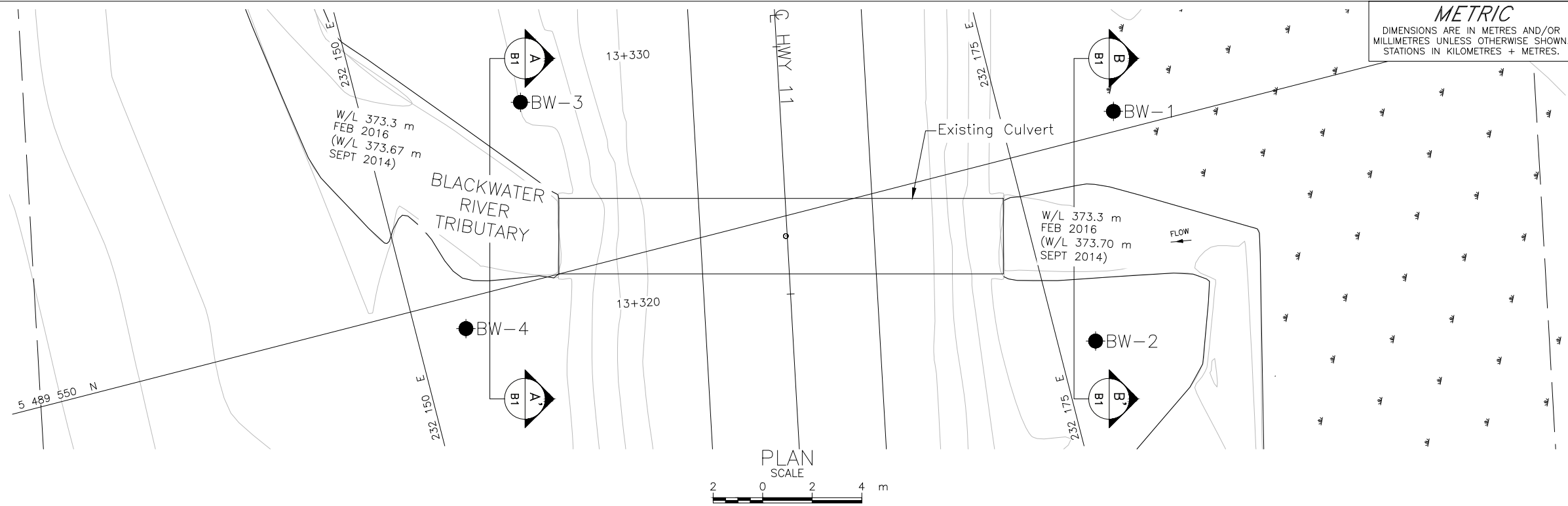




## **Appendix E**

### **Record of Borehole Sheets (Previous Investigation)**

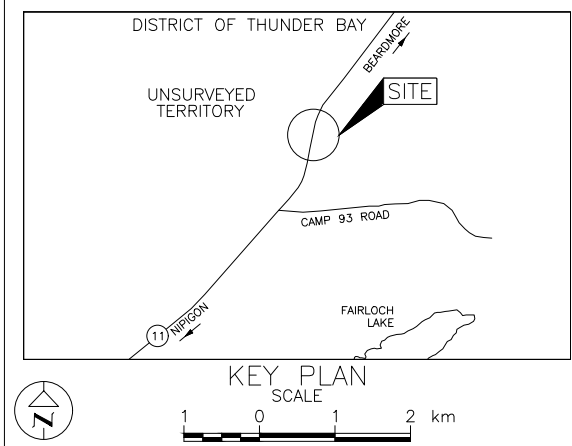




**METRIC**  
DIMENSIONS ARE IN METRES AND/OR  
MILLIMETRES UNLESS OTHERWISE SHOWN.  
STATIONS IN KILOMETRES + METRES.

CONT No.  
GWP No. 6166-04-00

HIGHWAY 11  
BLACKWATER RIVER TRIBUTARY CULVERT STA 13+322  
BOREHOLE LOCATIONS AND  
SOIL STRATA



LEGEND

- Borehole - Current Investigation
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- R Refusal
- ∇ WL upon completion of drilling

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
BW-1	374.3	5489550.8	232179.5
BW-2	374.2	5489542.0	232176.5
BW-3	374.0	5489557.1	232156.4
BW-4	373.9	5489548.8	232152.0

NOTES

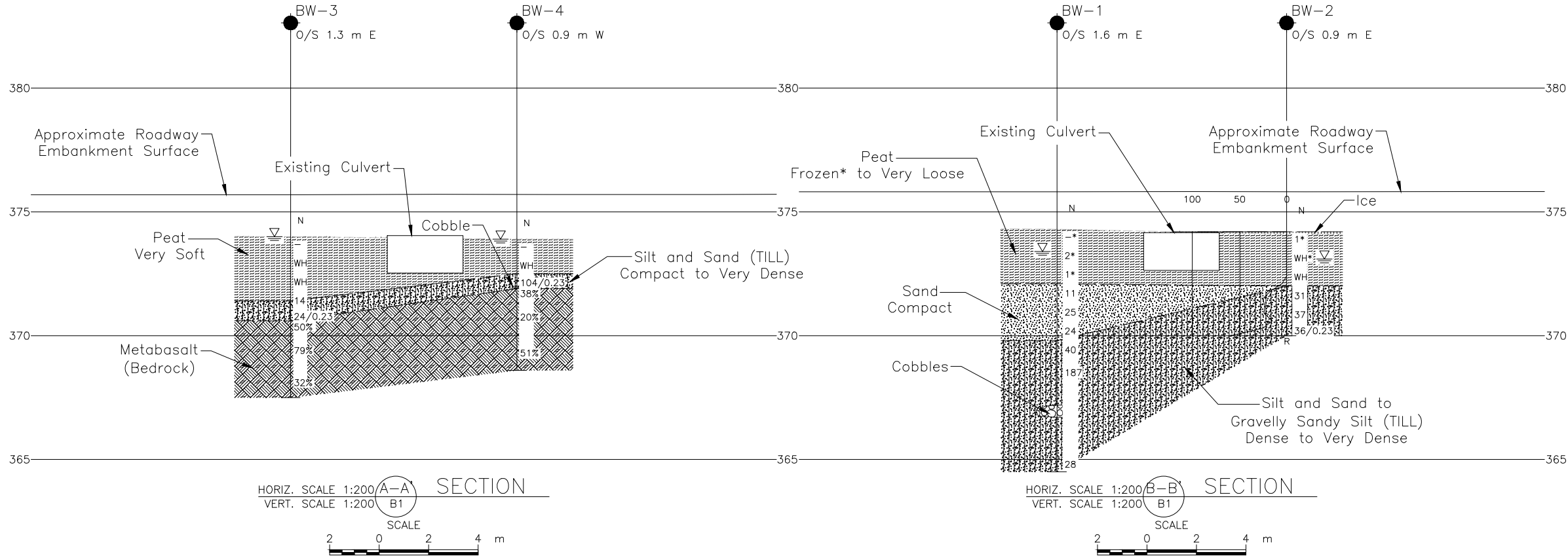
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Base plans provided in digital format by MTO, drawing file nos. E493880111.dwg received Dec. 11, 2015.



NO.	DATE	BY	REVISION
Geocres No. 52H-41			
HWY. 11	PROJECT NO. 1533879		DIST. .
SUBM'D. AC	CHKD. .	DATE: 10/7/2016	SITE: 48C-180/C
DRAWN: J.J.L.	CHKD. DAM	APPD. JMAC	DWG. B1



PROJECT 1533879		RECORD OF BOREHOLE No BW-1				1 OF 1 METRIC											
G.W.P. 6166-04-00		LOCATION N 5489550.8; E 232179.5				ORIGINATED BY MR											
DIST _____ HWY 11		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers, HW Casing and NQ/HQ Coring				COMPILED BY AC											
DATUM GEODETIC		DATE February 18, 2016				CHECKED BY DAM											
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									
374.3	GROUND SURFACE																
0.0	PEAT (Amorphous), trace wood Black Frozen* to wet		1	AS	-*												
			2	SS	2*												
			3	SS	1*												
372.1																	
2.2	SAND, trace silt Compact Dark grey to black Wet  Trace organics in Sample 4.		4	SS	11												
			5	SS	25												
			6	SS	24												
369.8																	
4.5	SILT and SAND, some clay, trace to some gravel (TILL) Dense to very dense Grey Wet		7	SS	40												
			8	SS	187												
	Switched to HW casing and wash boring at 5.4 m depth. Advanced borehole from 6.1 to 9.1 m depth using NQ core barrel.																
	Cobbles encountered from 7.1 m to 7.6 m depth as follows.																
	Size (mm)    Depth (m) 150            7.10 180            7.25 180            7.44																
	Switched to HQ Core barrel below 7.6 m depth.																
			9	SS	28												
364.5																	
9.8	END OF BOREHOLE																
	Note:  1. Water level at a depth of 0.9 m below ground surface (Elev. 373.4 m) upon completion of drilling.																

SUD-MTO 001 1533879.GPJ GAL-MISS.GDT 10/08/16 DATA INPUT:



PROJECT 1533879		RECORD OF BOREHOLE No BW-2				1 OF 1 METRIC								
G.W.P. 6166-04-00		LOCATION N 5489542.0; E 232176.5				ORIGINATED BY SA								
DIST _____ HWY 11		BOREHOLE TYPE NW Casing and Wash Boring				COMPILED BY AC								
DATUM GEODETIC		DATE February 10, 2016				CHECKED BY DAM								
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						
374.2	GROUND SURFACE													
0.0	ICE (100 mm)													
0.1	PEAT (Fibrous) Very loose Black Frozen* to wet		1	SS	1*									
			2	SS	WH*									
			3	SS	WH									
372.0														
2.2	Gravelly Sandy SILT, trace to some clay (TILL) Dense Grey Wet		4	SS	31									
			5	SS	37									
			6	SS	36/0.23									
370.0														
4.2	END OF BOREHOLE SPLIT-SPOON REFUSAL AND REFUSAL TO FURTHER CASING PENETRATION  Note:  1. Water level at a depth of 1.1 m below ground surface (Elev. 373.1 m) upon completion of drilling.  2. Advanced DCPT 0.8 m west of borehole. DCPT refusal (i.e. DCPT bouncing) at a depth of 4.2 m below ground surface (Elev. 370.0 m).													



PROJECT 1533879		<b>RECORD OF BOREHOLE No BW-3</b>				1 OF 2 <b>METRIC</b>											
G.W.P. 6166-04-00		LOCATION N 5489557.1; E 232156.4				ORIGINATED BY MR											
DIST _____ HWY 11		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers, HW Casing and HQ Coring				COMPILED BY AC											
DATUM GEODETIC		DATE February 16, 2016				CHECKED BY DAM											
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									
374.0	GROUND SURFACE																
0.0	PEAT (Amorphous) Very soft Black Wet		1	AS	-												
			2	SS	WH												
			3	SS	WH												
371.4			4A	SS	14												
2.6	SILT and SAND, some clay, trace to some gravel (TILL) Compact Grey Wet		4B														
370.6			5	SS	24/0.23												
3.4	Trace organics in Sample 4B. METABASALT (BEDROCK)		1	RC	REC 100%												11 36 41 12
	Bedrock cored from 3.4 m depth to 6.5 m depth.  For coring details see Record of Drillhole BW-3.		2	RC	REC 100%												RQD = 50%
			3	RC	REC 100%												RQD = 79%
367.5																	RQD = 32%
6.5	END OF BOREHOLE																
	Note:  1. Water level at ground surface upon completion of drilling.																

SUD-MTO 001 1533879.GPJ GAL-MISS.GDT 10/08/16 DATA INPUT:



SHEET 2 OF 2

DATUM: GEODETIC

DRILLING CONTRACTOR: Cartwright Drilling

CHECKED: DAM

SUD-RCK 1533879.GPJ GAL-MISS.GDT 10/08/16 DATA INPUT:



PROJECT 1533879		<b>RECORD OF BOREHOLE No BW-4</b>				1 OF 2 <b>METRIC</b>											
G.W.P. 6166-04-00		LOCATION N 5489548.8; E 232152.0				ORIGINATED BY MR											
DIST _____ HWY 11		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers, HW Casing and HQ Coring				COMPILED BY AC											
DATUM GEODETIC		DATE February 17, 2016				CHECKED BY DAM											
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									
373.9	GROUND SURFACE																
0.0	PEAT (Fibrous) Very loose Black Wet  Amorphous below 0.7 m depth.		1	AS	-												
372.5			2	SS	WH												
1.4	SILT and SAND, some clay, trace to some gravel (TILL) Very dense Grey Wet		3	SS	104/0.23												
371.9																	
2.0	A 75 mm cobble encountered at 1.9 m depth. METABASALT (BEDROCK)  Bedrock cored from 2.0 m depth to 5.3 m depth.  For coring details see Record of Drillhole BW-4.		1	RC	REC 100%												RQD = 38%
			2	RC	REC 100%												RQD = 20%
			3	RC	REC 100%												RQD = 51%
368.6	END OF BOREHOLE																
5.3	Note:  1. Water level at ground surface upon completion of drilling.																

SUD-MTO 001 1533879.GPJ GAL-MISS.GDT 10/08/16 DATA INPUT:



SHEET 2 OF 2

DATUM: GEODETIC

DRILLING CONTRACTOR: Cartwright Drilling

CHECKED: DAM

SUD-RCK 1533879.GPJ GAL-MISS.GDT 10/08/16 DATA INPUT:





## **Appendix F**

### **Foundation Comparison**



## COMPARISON OF ALTERNATIVE CULVERT TYPES

Corrugated Steel Pipe (CSP) Culvert or Twin CSPs	Concrete Box Culvert	Concrete Open Footing Culvert
<p><u>Advantages:</u></p> <ul style="list-style-type: none"> <li>i. Ease of construction.</li> <li>ii. Segmented pipes can accommodate some potential differential settlement along culvert axis</li> <li>iii. Steel pipes may be more cost effective than concrete box or open footing culverts.</li> </ul>	<p><u>Advantages:</u></p> <ul style="list-style-type: none"> <li>i. Relatively rapid installation and less disturbance to subgrade soils if pre-cast segments are used.</li> <li>ii. Segmental option can accommodate some potential differential settlement along culvert axis.</li> <li>iii. Able to be constructed in the wet.</li> </ul>	<p><u>Advantages:</u></p> <ul style="list-style-type: none"> <li>i. Conventional construction.</li> <li>ii. Possibly less disturbance of creek channel / less environmental issues such as those involving spawning fish species.</li> </ul>
<p><u>Disadvantages:</u></p> <ul style="list-style-type: none"> <li>i. Steel pipes may have shorter design life than concrete culverts.</li> <li>ii. Multiple pipes maybe needed to meet hydraulic requirements.</li> <li>iii. Not recommended to be placed in the wet.</li> </ul>	<p><u>Disadvantages:</u></p> <ul style="list-style-type: none"> <li>i. More expensive than a Concrete pipe or CSP culvert.</li> </ul>	<p><u>Disadvantages:</u></p> <ul style="list-style-type: none"> <li>i. Greater potential for differential settlement.</li> <li>ii. Deeper excavation and potentially longer dewatering requirements in cohesionless soils.</li> </ul>
<b>FEASIBLE</b>	<b>RECOMMENDED</b>	<b>NOT RECOMMENDED</b>





## **Appendix G**

### **Slope Stability Analysis Figures**



FIGURE 1

HIGHWAY 11 WEST SIDE SLOPE  
PEAT LEFT IN PLACE

Color	Name	Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Bedrock (Impenetrable)			
	Existing Sand & Gravel Fill - V. Dense to Compact	Mohr-Coulomb	21	0	32
	Granular B Type II	Mohr-Coulomb	22	0	35
	Peat	Mohr-Coulomb	14	2	25
	Sand - Compact	Mohr-Coulomb	21	0	32
	Sandy Silt to Silt & Sand Till - Compact to V. Dense	Mohr-Coulomb	22	0	34

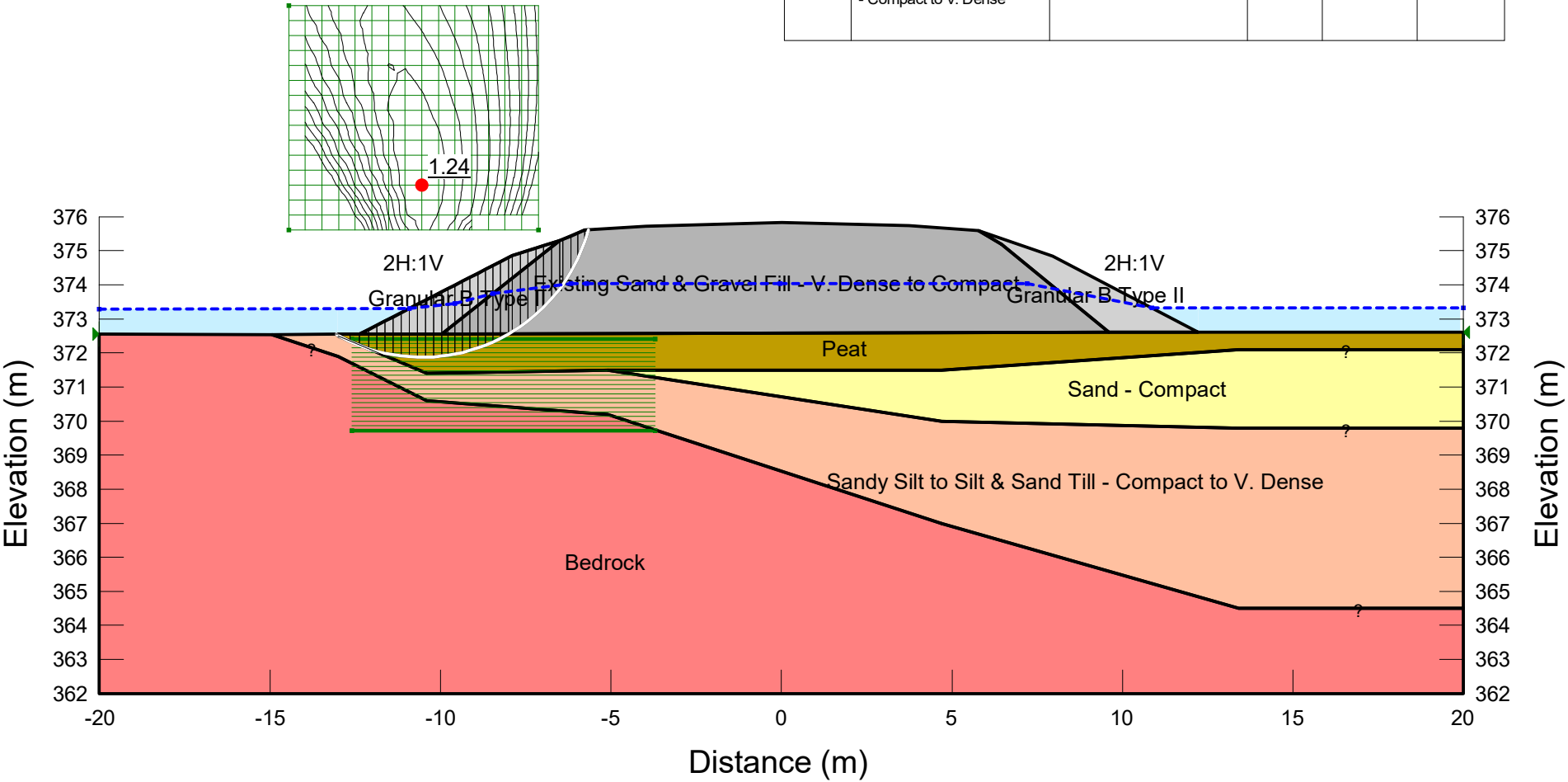
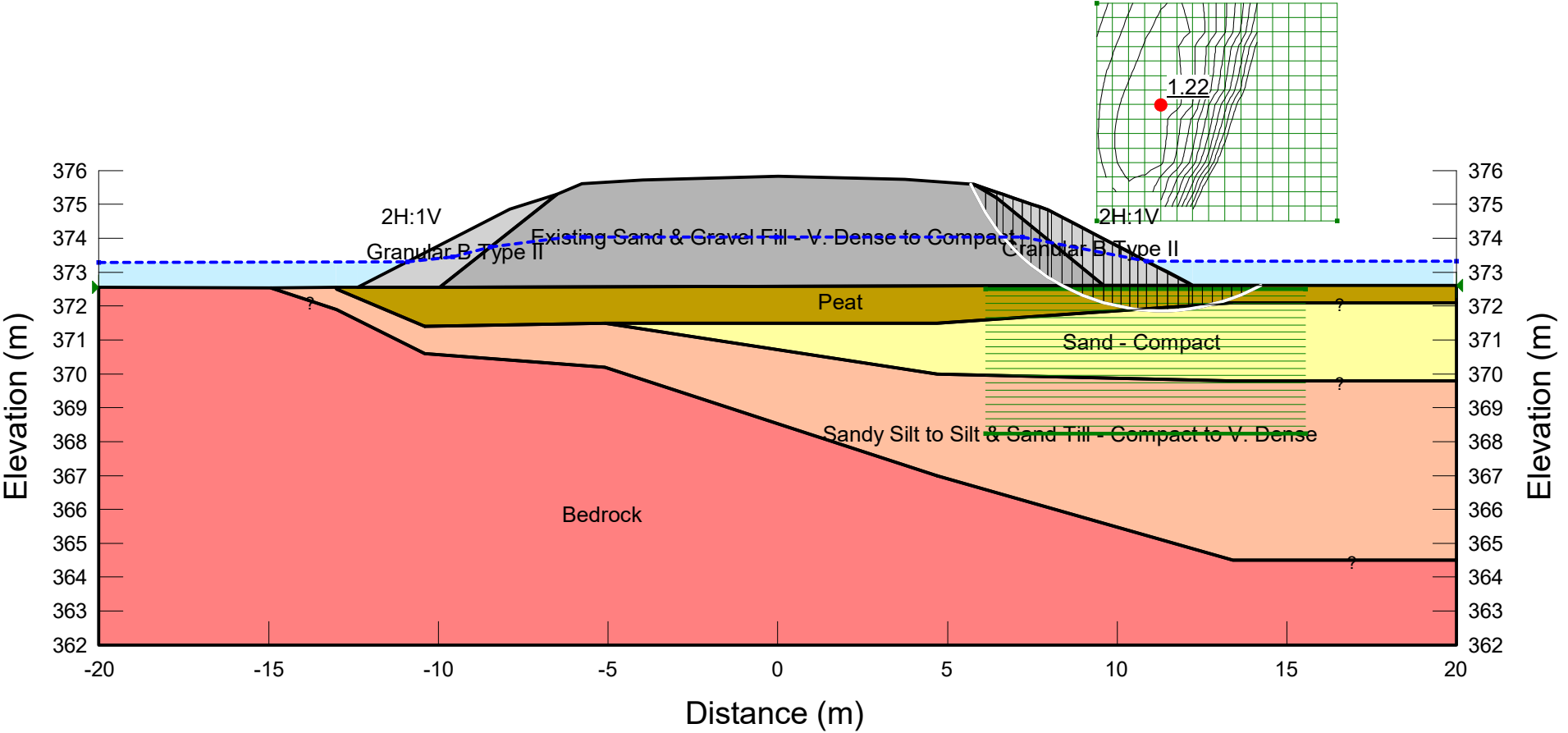




FIGURE 2

HIGHWAY 11 EAST SIDE SLOPE  
PEAT LEFT IN PLACE

Color	Name	Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
<div></div>	Bedrock	Bedrock (Impenetrable)			
<div></div>	Existing Sand & Gravel Fill - V. Dense to Compact	Mohr-Coulomb	21	0	32
<div></div>	Granular B Type II	Mohr-Coulomb	22	0	35
<div></div>	Peat	Mohr-Coulomb	14	2	25
<div></div>	Sand - Compact	Mohr-Coulomb	21	0	32
<div></div>	Sandy Silt to Silt & Sand Till - Compact to V. Dense	Mohr-Coulomb	22	0	34

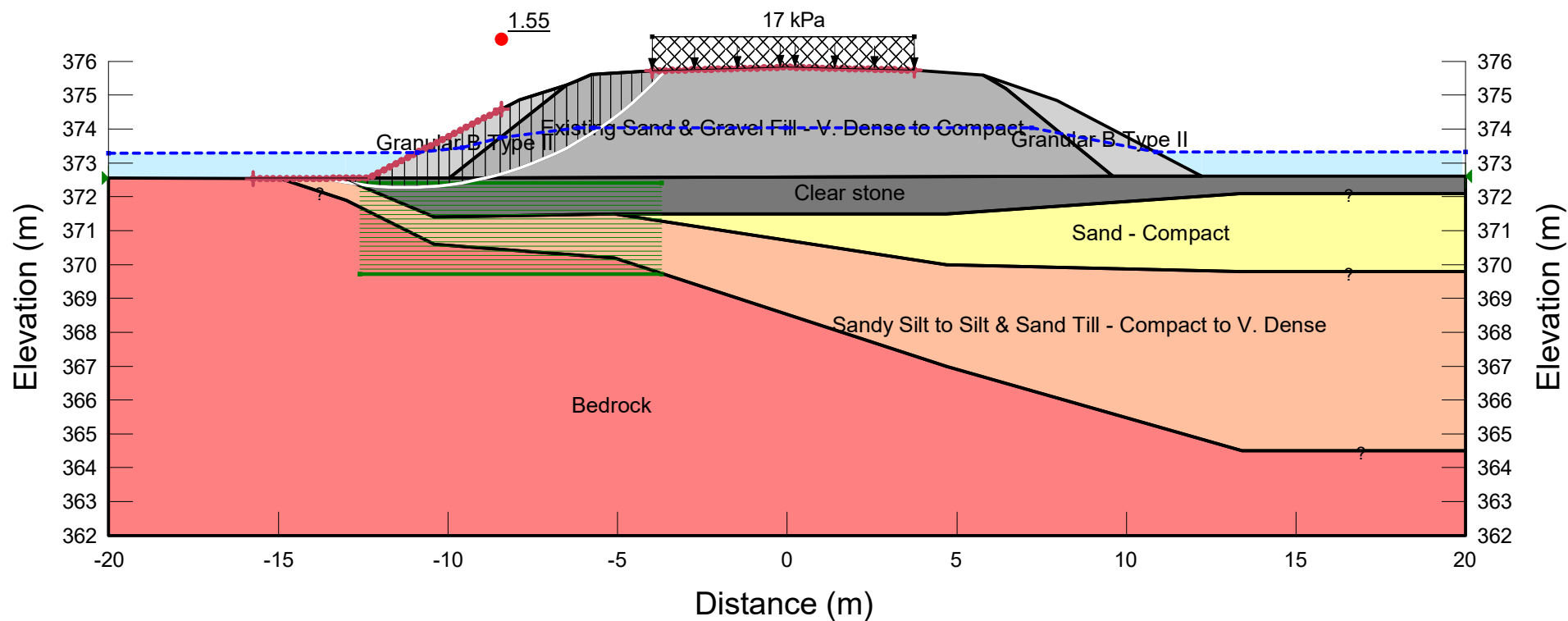




# FIGURE 3

## HIGHWAY 11 WEST SIDE SLOPE PEAT REPLACEMENT

Color	Name	Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
<span style="color: red;">■</span>	Bedrock	Bedrock (Impenetrable)			
<span style="color: gray;">■</span>	Clear stone	Mohr-Coulomb	22	0	35
<span style="color: lightgray;">■</span>	Existing Sand & Gravel Fill - V. Dense to Compact	Mohr-Coulomb	21	0	32
<span style="color: lightgray;">■</span>	Granular B Type II	Mohr-Coulomb	22	0	35
<span style="color: yellow;">■</span>	Sand - Compact	Mohr-Coulomb	21	0	32
<span style="color: orange;">■</span>	Sandy Silt to Silt & Sand Till - Compact to V. Dense	Mohr-Coulomb	22	0	34

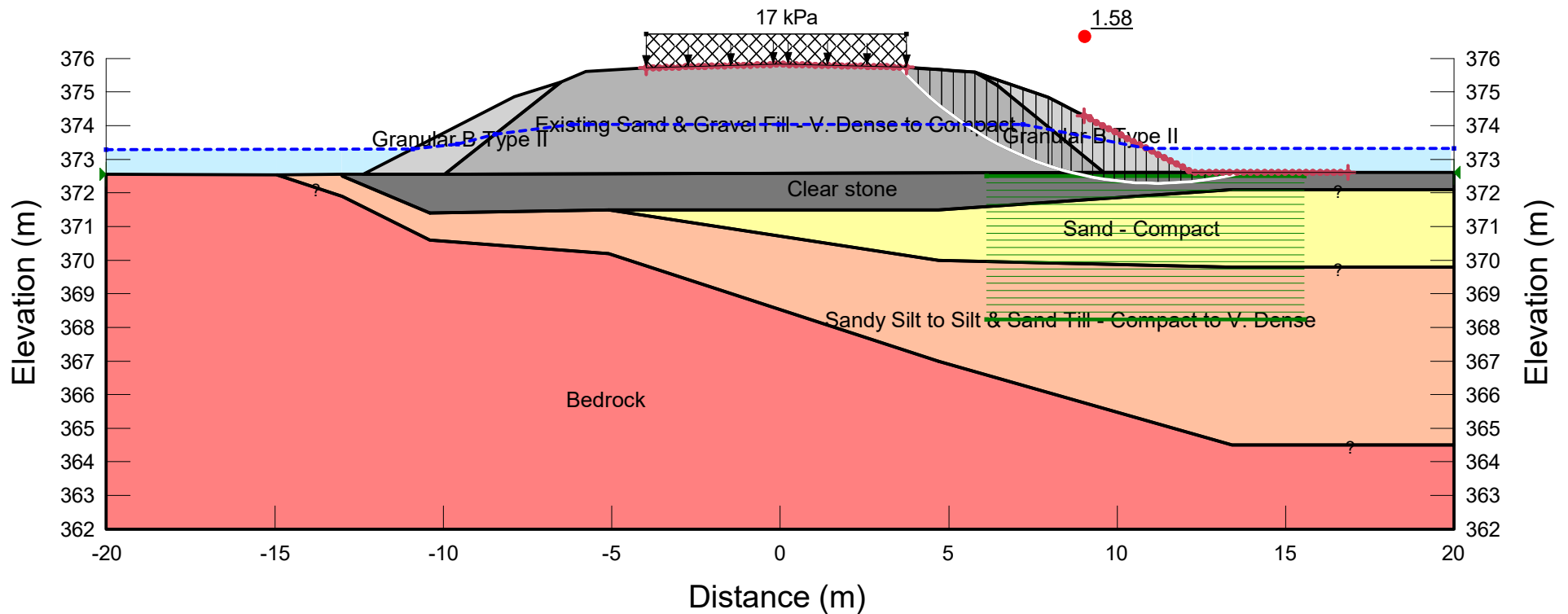




**FIGURE 4**

# **HIGHWAY 11 EAST SIDE SLOPE PEAT REPLACEMENT**

Color	Name	Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
<span style="color: red;">■</span>	Bedrock	Bedrock (Impenetrable)			
<span style="color: gray;">■</span>	Clear stone	Mohr-Coulomb	22	0	35
<span style="color: lightgray;">■</span>	Existing Sand & Gravel Fill - V. Dense to Compact	Mohr-Coulomb	21	0	32
<span style="color: lightgray;">■</span>	Granular B Type II	Mohr-Coulomb	22	0	35
<span style="color: yellow;">■</span>	Sand - Compact	Mohr-Coulomb	21	0	32
<span style="color: orange;">■</span>	Sandy Silt to Silt & Sand Till - Compact to V. Dense	Mohr-Coulomb	22	0	34







## **Appendix H**

### **List of Referenced OPSS and OPSD Documents and Suggested Wording for NSSP**





**1. The following Special Provisions and OPSS Documents are referenced in this report:**

OPSS.PROV 206	Construction Specification for Grading
OPSS.PROV 209	Embankments over Swamps and Compressible Soils
OPSS.PROV 401	Construction Specification for Trenching, Backfilling, and Compacting
OPSS 422	Construction Specification for Precast Reinforced Concrete Box Culverts in Open Cut
OPSS.PROV 501	Construction Specification for Compacting
OPSS 511	Construction Specification for Rip-Rap, Rock Protection, and Granular Sheetting
OPSS.PROV 517	Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation
SP 517F01	Dewatering System – Temporary Flow Passage System
SP FOUN0003	Dewatering Structure Excavations
OPSS.PROV 539	Construction Specification for Temporary Protection Systems
OPSS.PROV 804	Construction Specification for Seed and Cover
OPSS 902	Construction Specification for Excavating and Backfilling Structures
SP 109S12	QVE, Backfilling Compaction, and Certificate of Conformance
OPSS.PROV 1004	Material Specification for Aggregates – Miscellaneous
OPSS 1005	Material Specification for Aggregates – Streambed Material
OPSS.PROV 1010	Material Specification for Aggregates Base, Subbase, Select Subgrade, and Backfill Material
OPSS.PROV 1205	Material Specification for Clay Seal
OPSS.PROV 1860	Material Specification for Geotextiles
OPSD 601.010	Asphalt Curb and Asphalt Curb with Gutter
OPSD 802.010	Flexible Pipe Embedment and Backfill Earth Excavation
OPSD 803.010	Backfill and Cover for Concrete Culverts with Spans Less Than or Equal to 3.0 m





OPSD 810.010	General Rip-Rap Layout for Sewer and Culvert Outlets
OPSD 3090.100	Foundation Frost Penetration Depths for Northern Ontario

## **2. Suggested Wording for NSSP**

- **Suggested Text for NSSP on Dewatering**

It is anticipated that the culvert will be constructed in the wet. It should be noted that this option of constructing in the wet will still require some dewatering in order to lower the groundwater level to a sufficient depth to allow for placement of the culvert bedding in the dry.

The dewatering system is to be designed in accordance with SP FOUN0003 and OPSS.PROV. 517. A preconstruction survey is not required, thus Designer Fill-In \*\* in SP FOUN0003 should be "N/A". Special Provision FOUN0003 is included below. Considering the conditions on site, it is recommended that a dewatering engineer with a minimum of 5 years of experience in designing dewatering systems should be retained by the contractor for design of an effective dewatering system.

- **Suggested Text for NSSP on Obstructions**

Excavations and installation of piles may encounter obstructions such as cobbles and boulders embedded in the fill and native very dense sandy silt to silt and sand glacial till. Such obstructions may impede excavation progress and/or pile installations, if employed. The Contractor shall be prepared to remove, drill through and/or penetrate these obstructions to achieve the design depths.





## **Appendix I**

### **Seismic Hazard Calculation**



# 2015 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836  
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Site: 49.539N 88.004W

2021-06-18 13:46 UT

Probability of exceedance per annum	0.000404	0.001	0.0021	0.01
Probability of exceedance in 50 years	2 %	5 %	10 %	40 %
Sa (0.05)	0.045	0.022	0.012	0.002
Sa (0.1)	0.063	0.033	0.019	0.004
Sa (0.2)	0.059	0.032	0.019	0.005
Sa (0.3)	0.048	0.028	0.017	0.004
Sa (0.5)	0.036	0.021	0.013	0.003
Sa (1.0)	0.019	0.011	0.006	0.001
Sa (2.0)	0.008	0.004	0.003	0.001
Sa (5.0)	0.002	0.001	0.001	0.000
Sa (10.0)	0.001	0.001	0.000	0.000
PGA (g)	0.034	0.018	0.010	0.002
PGV (m/s)	0.025	0.014	0.008	0.002

**Notes:** Spectral ( $S_a(T)$ , where  $T$  is the period in seconds) and peak ground acceleration (PGA) values are given in units of  $g$  ( $9.81 \text{ m/s}^2$ ). Peak ground velocity is given in  $\text{m/s}$ . Values are for "firm ground" (NBCC2015 Site Class C, average shear wave velocity  $450 \text{ m/s}$ ). NBCC2015 and CSAS6-14 values are highlighted in yellow. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. **These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.**

## References

**National Building Code of Canada 2015 NRCC no. 56190;** Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

**Structural Commentaries (User's Guide - NBC 2015: Part 4 of Division B)**  
**Commentary J:** Design for Seismic Effects

**Geological Survey of Canada Open File 7893** Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites [www.EarthquakesCanada.ca](http://www.EarthquakesCanada.ca) and [www.nationalcodes.ca](http://www.nationalcodes.ca) for more information