



**THURBER** ENGINEERING LTD.

**FOUNDATION INVESTIGATION AND DESIGN REPORT  
OMER LAKE CULVERT REPLACEMENT  
HIGHWAY 11, DISTRICT OF THUNDER BAY, ONTARIO  
AGREEMENT 6019-E-0009, WORK ORDER 16  
G.W.P. 6911-12-00, SITE NO. 48C-0181/C0  
LATITUDE: 49.377205°, LONGITUDE: -88.133495 °**

**GEOCRES No.: 52H-051**

**Report**

to

**HATCH**

Date: January 6, 2023  
File: 31344



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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 Omer Lake Culvert replacement. The Omer Lake Culvert is located on Highway 11, south of Macdiarmid, in the 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 Corporation (Hatch), under the Ministry of Transportation Ontario (MTO) Retainer Agreement Number 6019-E-0009, Work Order 16.

It is a condition of this report that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions.

**2. SITE DESCRIPTION**

The site is located on Highway 11, approximately 32 km south of Highway 580, in the Unsurveyed Territory, District of Thunder Bay, Ontario. The existing culvert allows Omer Lake Creek to flow in an east to west direction under Highway 11. Highway 11 generally runs in a north-south direction at the culvert site. The creek connects Omer Lake on the east side of Highway 11 to Lake Nipigon on the west site.

The available base plan drawing provided by Hatch indicates that the existing structure is a concrete box culvert. The drawing does not confirm whether the culvert is an open or closed bottom box, which the structural site investigations did not verify. The base plan indicates that the



span of the structure is 3.1 m, the height is 1.5 m and the length is 32.8 m. The estimated culvert invert is at approximate Elevation 259.1 m at both the inlet (east) and the outlet (west). The existing road grade at the culvert location is at approximate Elev. 264.7 m, which indicates approximately 4.1 m of fill above the culvert. The local creek water level was reportedly measured at Elev. 259.9 m in November 2018. The site topography within the culvert area is generally sloped down from north to south, with low lying grassy/marshy land and treed areas surrounding the culvert site.

The highway embankment side slopes near the existing culvert appear to be performing satisfactorily and range in inclination from approximately 1.3H:1V to 2H:1V or flatter. No significant evidence of instability, settlement or erosion was observed. Trees were observed to be growing above the inlet of the existing culvert structure.

Photographs in Appendix C show the general nature of the site and the existing culvert.

Based on published geological mapping, the quaternary geology in the area of the culvert site consists of undifferentiated till with predominantly sand to silty sand matrix. The bedrock in the area is described as metasedimentary rocks with mafic dikes and related intrusive rocks.

### **3. INVESTIGATION PROCEDURES**

The site investigation and field-testing program for this project was carried out in two phases, from April 20 to 25, 2021 and from May 6 to 8, 2021. The field program consisted of drilling and sampling nine (9) boreholes (21-01, 21-02, 21-03A, 21-03B, and 21-04 to 21-08) to depths from 2.7 to 17.4 m below the ground surface (Elevation 253.2 to 246.2 m). Dynamic Cone Penetration Tests (DCPTs) were advanced from the base of Boreholes 21-01, 21-03A, 21-03B, 21-07 and 21-08 to depths from 8.8 to 24.4 m below the ground surface (Elevation 251.0 to 239.5 m).

Boreholes 21-01, 21-02 and 21-05 to 21-08 were drilled through the paved portion of Highway 11. Boreholes 21-03A, 21-03B and 21-04 were drilled off-road near the inlet and outlet of the existing culvert. The approximate borehole locations are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix D.

The Record of Borehole sheets are included in Appendix A. The approximate locations of the boreholes 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 and the topographic drawings provided to Thurber by Hatch. The coordinate system MTM NAD 83, Zone 14 was used for the boreholes.



The boreholes through the road surface were advanced using a rubber track-mounted CME55 drill rig, using solid stem auger and/or wash boring techniques, as well as Dynamic Cone Penetration Tests (DCPTs). The off-road boreholes (21-03A, 21-03B and 21-04) were advanced using a portable Hilti drill and tripod equipment using wash boring techniques. Water was pumped from the existing watercourse for using in the wash boring drilled. In all boreholes, soil samples were obtained at selected intervals with a 50 mm outside diameter split spoon sampler driven in conjunction with the Standard Penetration Test (SPT).

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

Monitoring wells were installed in Boreholes 21-01 and 20-02. 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. 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 from the well at Borehole 21-01 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 wells installed in both Boreholes 21-01 and 21-02. Upon collection of the final water level readings on April 25, 2021, the wells were decommissioned in accordance with MOECP O.Reg. 903.

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

**Table 3.1: Borehole Completion Details**

<b>Borehole Number</b>	<b>Borehole Depth / Base Elevation (m)</b>	<b>Monitoring Well Tip Depth / Elevation (m)</b>	<b>Completion Details</b>
21-01	17.4 / 247.1	13.7 / 250.8	Borehole caved to 13.7 m, filter sand from 13.7 m to 10.4 m, bentonite holeplug from 10.4 m to 0.6 m, concrete from 0.6 m to 0.2 m, and cold patch asphalt to ground surface.



Borehole Number	Borehole Depth / Base Elevation (m)	Monitoring Well Tip Depth / Elevation (m)	Completion Details
21-02	17.4 / 247.6	10.7 / 254.3	Borehole caved to 10.7 m, filter sand from 10.7 m to 7.3 m, bentonite holeplug from 7.3 m to 0.6 m, concrete from 0.6 m to 0.2 m, and cold patch asphalt to ground surface.
21-03A	6.7 / 253.2	None installed	Borehole caved to 2.3 m and was backfilled with bentonite holeplug from 2.3 m to ground surface.
21-03B	2.7 / 257.1	None installed	Borehole backfilled with bentonite holeplug from 2.7 m to ground surface.
21-04	14.0 / 246.2	None installed	Borehole caved to 10.0 m and was backfilled with bentonite holeplug from 10.0 m to ground surface.
21-05	17.4 / 246.9	None installed	Borehole caved to 11.4 m and was backfilled with bentonite holeplug from 11.4 m to 0.6 m, concrete from 0.6 m to 0.2 m, and cold patch asphalt to ground surface.
21-06	17.4 / 247.8	None installed	Borehole caved to 5.3 m and was backfilled with bentonite holeplug from 5.3 m to 0.6 m, concrete from 0.6 m to 0.2 m, and cold patch asphalt to ground surface.
21-07	17.4 / 248.3	None installed	Borehole caved to 6.1 m and was backfilled with bentonite holeplug from 6.1 m to 0.6 m, concrete from 0.6 m to 0.2 m, and cold patch asphalt to ground surface.
21-08	17.4 / 246.5	None installed	Borehole caved to 5.9 m and was backfilled with bentonite holeplug from 5.9 m to 0.6 m, concrete from 0.6 m to 0.2 m, and cold patch asphalt to ground 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), and 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 samples of the soil and a sample of the creek water were collected during the investigation and submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, 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 21-01. 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 included in Appendix A. Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets and on the Borehole Locations and Soil Strata drawings 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.

In general, the subsurface stratigraphy below the asphalt typically consists of sand to silty sand fill underlain by a layer of peat to sand and silt mixed with peat. Underlying the peat, the native soils consisted of sand to silt and sand, with lower deposits of silt. More detailed descriptions of individual strata are presented below.

##### **5.1 Asphalt**

Boreholes 21-01, 21-02 and 21-05 to 21-08 were drilled through the paved portion of Highway 11. The asphalt ranged in thickness from 150 to 225 mm at these locations.

A thin layer of asphalt (approximately 25 mm thick) was also encountered at a depth of 0.6 m in Boreholes 21-02 and 21-08 within the fill.





## 5.2 Silty Sand Fill

Silty sand fill was encountered below the asphalt in Boreholes 21-01, 21-02 and 21-05 to 21-08. The fill generally consisted of silty sand with some gravel, and ranged to gravelly sand fill with some silt in Borehole 21-07.

The silty sand fill ranged in thickness from 0.6 m to 1.2 m, with an underside depth ranging from 0.8 m to 1.4 m below ground surface (Elevation 264.4 to 263.1 m).

SPT 'N' values in the silty sand fill generally ranged from 28 to 100 blows per 0.3 m penetration, indicating a compact to very dense relative density; typically very dense.

The measured moisture contents generally ranged from 2 to 7%.

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

Soil Particle	Percentage (%)
Gravel	13 to 27
Sand	60 to 64
Silt & Clay	13 to 23

## 5.3 Sand and Silt Fill

Sand and silt embankment fill was encountered below the silty sand fill in Boreholes 20-01, 21-02 and 21-05 to 21-08. The sand and silt fill contained trace gravel and trace clay. The embankment fill transitioned to silty sand fill at a depth of 4.1 m (Elevation 261.2 m) in Borehole 21-07.

The sand and silt fill ranged in thickness from 3.3 m to 4.8 m, with an underside depth ranging from 4.1 m to 6.1 m below ground surface (Elevation 261.6 to 259.4 m).

SPT 'N' values in the fill ranged from 4 to 43 blows per 0.3 m penetration, indicating a very loose to dense relative density; typically compact.

The measured moisture contents generally ranged from 4 to 21%.



The results of grain size analyses conducted on selected samples of the sand and silt fill are provided on the Record of Borehole sheets in Appendix A and plotted on Figure B2 in Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0 to 1
Sand	37 to 56
Silt	44 to 62
Clay	0 to 6

#### 5.4 Peat to Sand and Silt mixed with Peat

A surficial layer of peat was encountered at the ground surface in Boreholes 21-03A and 21-04, and a buried layer of peat ranging to sand and silt mixed with peat was encountered below the sand and silt fill in Boreholes 21-01, 21-02 and 21-05 to 21-08. The peat generally contained sand and silt, as well as wood fragments and some clay lenses.

In Borehole 21-03A and 21-04, the depth and thickness of the surficial peat ranged from 150 mm to 1.4 m (Elevation 260.0 to 258.5 m). In Boreholes 21-01, 21-02, and 21-05 to 21-08, the thickness of the buried peat ranged from 1.1 m to 3.1 m, with an underside depth ranging from 5.6 m to 7.7 m below ground surface (Elevation 258.5 to 257.1 m).

SPT 'N' Values in the peat to sand and silt mixed with peat ranged from 1 to 11 blows per 0.3 m penetration, indicating a very loose to compact density; typically loose.

Measured moisture contents ranged from 27 to 122%.

The results of a grain size analysis conducted on a sample of silty sand mixed with peat are provided on the Record of Borehole sheets in Appendix A and plotted on Figure B3 in Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0
Sand	73
Silt	26
Clay	1

## 5.5 Sand to Silt and Sand

A deposit ranging in composition from sand with some silt, to silty sand, to silt and sand was encountered below the peat in all of the boreholes. The deposit also generally contained trace gravel and trace clay.

Boreholes 21-02 and 21-06 were terminated in the sand to silt and sand layer at a depth of 17.4 m (Elevation 247.8 to 247.6 m). The thickness of the sand to silt and sand deposit where fully penetrated in Boreholes 21-01, 21-04, 21-05 and 21-07 ranged from 5.4 to 8.1 m, with an underside depth ranging from 5.6 to 14.8 m (Elevation 254.6 to 249.7 m).

SPT 'N' Values in the sand to silt and sand ranged from 2 blow to 31 blows, indicating a very loose to dense relative density; typically compact.

Measured moisture contents generally ranged from 15 to 38%. The results of grain size analyses conducted on samples of the sand to silt and sand deposit are provided on the Record of Borehole sheets in Appendix A, and plotted on Figures B4 and B5 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0 to 4
Sand	35 to 88
Silt	11 to 64
Clay	0 to 2

## 5.6 Silt

A silt deposit was encountered below the sand to silt and sand layer in Boreholes 21-01, 21-04, 21-05 and 21-07. The silt contained trace to some sand, trace to some clay, and trace gravel.



A 1.4 m thick upper layer of silt was also encountered in Borehole 21-04 within the sand to silt and sand deposit at a depth of 3.2 m (Elevation 257.0 m).

Sampling was terminated in Boreholes 21-01, 21-04, 21-05 and 21-07 within the silt deposit at depths ranging from 14.0 to 17.4 m below ground surface (Elevation 248.3 to 246.2 m). Dynamic Cone Penetration Tests (DCPTs) were conducted at the base of the sampled portions of Boreholes 21-01, 21-03A, 21-03B, 21-07 and 21-08. The DCPTs were terminated within or below the silt deposit at depths ranging from 8.8 to 24.4 m below the ground surface (Elevation 251.0 to 239.5 m). The DCPTs did not encounter 100 blow per 0.3 m penetration refusal, except for at Borehole 21-03B at a depth of 8.8 m (Elevation 251.0 m).

SPT 'N' Values in the silt deposit ranged from 11 blow to 38 blows, indicating a compact to dense relative density.

Recorded moisture contents in the silt ranged from 19 to 22%. The results of grain size analyses conducted on samples of the silt deposit are provided on the Record of Borehole sheets in Appendix A and plotted in Figure B6 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0
Sand	0 to 17
Silt	72 to 96
Clay	2 to 20

## 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 21-01 and 21-02. The measured groundwater levels are summarized in Table 5.1 below. The monitoring wells were decommissioned on April 25, 2021 following final water level readings and slug testing.

**Table 5.1: Groundwater Measurements**

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
21-01	April 22, 2021	5.5	259.0	In monitoring well
	April 23, 2021	4.7	259.8	
	April 25, 2021	4.7	259.8	

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
21-02	April 23, 2021 April 25, 2021	5.2 5.2	259.8 259.8	In monitoring well
21-03A	May 8, 2021	0.1	259.3	Open Borehole
21-04	May 6, 2021	0.9	260.3	Open Borehole
21-05	April 22, 2021	*	-	Open Borehole
21-06	April 23, 2021	*	-	Open Borehole
21-07	April 23, 2021	*	-	Open Borehole
21-08	April 25, 2021	*	-	Open Borehole

\*Water level not recorded due to residual drilling water in the borehole.

The groundwater level is likely to reflect the local creek water level. The local creek water level was measured at Elevation 259.9 m in November 2018.

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 sand and silt mixed with peat and the native sand from Boreholes 21-01 and 21-02 respectively, and a sample of surface water collected from the watercourse were submitted for analytical testing of corrosivity parameters and sulphate. The laboratory certificates of analysis are presented in Appendix B. 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		
			21-01, SS6B (16'-17') (4.9 – 5.2 m)	21-02, SS8 (25" – 27") (7.6 – 8.2 m)	Omer Lake Watercourse
			(Native Sand and Silt mixed with Peat)	(Native Sand)	(Surface Water)
Redox Potential	mV	mV	210	199	243
Sulphide	%	µg/L	<0.04	<0.04	8
pH	-	-	7.52	8.74	7.65
Chloride	µg/g	mg/L	4700	190	39
Sulphate	µg/g	mg/L	51	5.2	2.1
Conductivity	µS/cm	µS/cm	4230	436	210
Resistivity	ohm-cm	ohm-cm	236	2290	4762*

\* Calculated based on conductivity result

## 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 21-01 was collected on April 25, 2021. The water sample was analyzed for selected inorganic parameters included in the Ontario Provincial Water Quality Objectives (PWQO). 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.

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

Sample ID	Parameter	Criteria	Parameter Limit (µg/L)	Result (µg/L)
BH21-01	Total Cobalt	PWQO	0.9	2.51
	Total Phosphorus	PWQO	10	121
	Total Copper	PWQO	1	12.2
	Total Aluminum	PWQO	15	1470
	Total Iron	PWQO	300	3120



Sample ID	Parameter	Criteria	Parameter Limit (µg/L)	Result (µg/L)
	Total Phenols	PWQO	1	<2*
BH21-01 (Filtered sub-sample)	Dissolved Phosphorus	PWQO	10	16
	Dissolved Copper	PWQO	1	3.4
	Dissolved Aluminum	PWQO	15	31

\*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 (SWRT) (“slug” tests) were carried out on the 50 mm diameter wells installed in Boreholes 21-01 and 21-02. The well installed in Borehole 21-01 was screened across sand and silt to silty sand. The well installed in Borehole 21-02 was screened across sand, some silt. 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 0.125 to 0.5 seconds, based on the anticipated rate of recovery of the wells.
- A slug of groundwater was removed from the well with a dedicated bailer 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 slug tests were completed and analyzed using the Hvorslev method. The 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 the following table.



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

Monitoring Well	Hydraulic Conductivity (m/s)	Screened Formation
21-01	$6.1 \times 10^{-5}$	Sand and silt to silty sand
21-02	$4.7 \times 10^{-5}$	Sand, some silt

## **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 track-mounted CME55 drill rig and Ohlmann Geotechnical Services (OGS) Inc. of Almonte, Ontario supplied a portable Hilti drill, to conduct the drilling, sampling and in-situ testing operations for the boreholes. Traffic control services conforming to Ontario Book 7 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 Canada Inc.

The field investigation was supervised on a full-time basis by Ms. Rachel Bourassa, E.I.T. and Mr. Greg Stanhope of Thurber. Overall supervision of the field program was provided by Mr. Joshua Alexander, E.I.T. and Mr. Mark Farrant, P. Eng. of Thurber.

The report was prepared by Mr. Joshua Alexander, E.I.T. and Mr. Mark Farrant, P.Eng, and reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.





**THURBER ENGINEERING LTD.**

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Designated MTO Principal Contact



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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 geotechnical recommendations for the proposed replacement of the existing Omer Lake culvert crossing Highway 11. The discussion and recommendations presented in this report are based on the information provided by Hatch and on the factual data obtained during the course of the investigation.

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 construction or design-build contractor 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 indicates that the existing structure is a concrete box culvert. The drawing does not confirm whether the culvert is an open or closed bottom box, which the structural site investigations did not verify. The base plan indicates that the span of the structure is 3.1 m, the height is 1.5 m and the length is 32.8 m. The estimated culvert invert is at approximate Elevation 259.1 m at both the inlet (east) and the outlet (west). The existing road grade at the culvert location is at approximate Elev. 264.7 m, which indicates approximately 4.1 m of fill above the culvert. The local creek water level was reportedly measured at Elev. 259.9 m in November 2018. The site topography within the culvert area is generally sloped down from north to south, with low lying grassy/marshy land and treed areas surrounding the culvert site.



The highway embankment side slopes near the existing culvert appear to be performing satisfactorily and range in inclination from approximately 1.3H:1V to 2H:1V or flatter. No significant evidence of instability, settlement or erosion was observed. Trees were observed to be growing above the inlet of the existing culvert structure.

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 culvert options considered for the culvert replacement at this site are listed below:

- Corrugated steel pipe (CSP), structural plate corrugated steel pipe (SPCSP) or twin pipes
- Concrete box (closed) culvert composed of pre-cast segments
- Concrete box, open footing culvert
- Structural plate corrugated steel pipe arch, supported on sheet piles

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

- Pre-cast closed box, pipe culverts, and arch culvert would require shallower depth of excavation compared with the open footing concrete box culvert;
- Pre-cast concrete box, pipe, or arch 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 can accommodate some potential differential settlement along the culvert axis; and



- An arch culvert supported on sheet piles can reduce the need for removal of buried peat below the groundwater table at this site.

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.

Preliminary draft General Arrangement (GA) drawings were provided by Hatch for the twin SPCSPs, box culvert and arch culvert options. These drawings are attached in Appendix H. Each of these options includes lengthening of the culvert and widening of the embankment with additional fill at each end. Recommendations for the design and installation of these culvert options are presented below.

## 11.2 Summary of Subsurface Conditions

In general, the subsurface conditions encountered in the boreholes consisted of asphalt and sand to silty sand fill underlain by a layer of peat to sand and silt mixed with peat. Underlying the peat, the native soils consisted of sand to silt and sand, with lower deposits of silt.

The groundwater level in the open boreholes and monitoring wells ranged from approximate Elevation 259.0 to 260.3 m. The local creek surface water level was measured at an Elevation of 259.9 m in November 2018. The culvert site is located in a low lying grassy/marshy area, with generally high surface water levels.

## 11.3 Foundation Design for Culverts

The invert level of the existing culvert is at approximate Elevation 259.1 m.

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

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

### 11.3.1 Corrugated Steel Pipe, Structural Plate CSP or Multiple Pipes

Replacement of the culvert with a single or multiple Corrugated Steel Pipes (CSPs) or Structural Plates CSPs (SPCSPs) 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. The GA attached in Appendix H shows twin 3.05 m diameter pipes.

If this alternative is selected, the pipes 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, 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 11.3.5. 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 11.3.6. The granular fill or rock fill below the culvert must be placed on the native compact sand to silt and sand 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 on the prepared subgrade following peat removal, or at or below Elevation 257.8 m on the compact sand to silt and sand. 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. The GA attached in Appendix H shows a 4.5 m x 3.3 m box 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 11.3.5. 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 11.3.6. The granular fill or rock fill below the culvert must be placed on the native compact sand to silt and sand 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 on the prepared subgrade following the peat removal, or at or below Elevation 257.8 m on the compact sand to silt and sand. 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 design of a box culvert with an approximately 4 to 5 m bearing width founded at or below Elevation 257.8 m on the compact sand to silt and sand, or on the prepared subgrade following removal of all peat:

<b>Geotechnical Resistance</b>	<b>Approx. 4 to 5 m Wide Culvert</b>
Factored Geotechnical Resistance at ULS	270 kPa
Geotechnical Resistance at SLS (for up to 25 mm settlement)	180 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 2019, 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 SPCSP Arch Supported on Sheet Piles

An alternative culvert replacement option under consideration at this site is a structural plate corrugated steel pipe (SPCSP) arch, located along the same alignment as the existing culvert. The preliminary GA drawing provided by Hatch indicates that the SPCSP arch would have a span of 5.8 m and would be supported on sheet pile walls.

The GA drawing shows a sheet pile cut-off elevation of 260.2 m, and a base of excavation for backfill around the arch culvert of approximate Elevation 259.5 m. The base of the creek channel between the sheet pile walls is shown at approximate Elevation 258 m.

An arch culvert supported on sheet piles is a feasible option at this site. This option reduces the need for removal of buried peat under the existing embankment since the replacement culvert would not be founded directly on the subgrade soils (i.e. no excavation for bedding placement required) and the excavation to install the arch culvert would only extend to about the top of the peat layer.

Although removal of peat will not be required below the culvert for subgrade preparation for the arch option, all peat encountered beyond the existing embankment where the culvert will be lengthened must be removed and replaced, as described in Section 11.3.5. The peat must be removed for a width of 1.5 m beyond the outside of the arch culvert, and extend for 1.5 m beyond the toe of slope of the final embankment.



### 11.3.3.1 Axial Resistance of Sheet Piles

Driven steel sheet piles will develop resistance to vertical loads through frictional resistance along the sides of the sheet piles within the native compact sand and silt. The upper 2 to 3 m of the sheet piles will be embedded in the peat and therefore will provide very little axial or lateral resistance.

Based on discussions with Hatch, we understand that AZ 44-700N sheet pile sections are proposed. Based on this information, the following table provides the recommended geotechnical axial resistances for 10 to 15 m driven sheet pile lengths:

Sheet Pile Length (m)	Approximate Tip Elevation (m)	Factored ULS (per m of wall) (kN/m)	SLS (per m of wall) (kN/m)
10	250	180	150
12	248	275	225
15	245	450	375

Please note that the boreholes for this investigation were terminated at approximate Elevation 246 m or higher, with only DCPT information below this to Elevation 239.5 m or higher. Furthermore, the subsurface information along the alignment of the sheet pile walls is limited. If the SPCSP arch supported on sheet piles option is selected, it is recommended that additional deeper boreholes be drilled during the detailed design stage to confirm the soil conditions at the proposed tip depths along the alignment of the sheet pile foundations.

The SLS values are based on a vertical pile settlement of 25 mm at the base of the embankment fill. Elastic compression of the sheet pile will be in addition to this settlement.

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.

### 11.3.3.2 Pile Installation

Pile installation should be in accordance with OPSS.PROV 903.

Sheet piles should be driven to the specified elevation noted above for the selected sheet pile length. The appropriate pile driving note is "Sheet piles to be driven to Elevation XXX m" (to be completed by designer).





Tip protection should not be used for sheet piles at this site as the load bearing sheet piles will derive vertical resistance mostly from shaft friction.

Design of the sheet pile foundations must consider environmental conditions such as road salts or fluctuating water levels that may cause long term corrosion and reduce the service life of the structure.

The sheet piles will be driven through the embankment fill prior to excavation and removal of the existing culvert. It should be recognized that fill materials including embankment fills are heterogeneous in nature and may contain obstructions such as wood, boulders or rock fill. If such obstructions are encountered at the proposed location of the sheet pile walls, they will have to be removed to facilitate sheet pile installation. Suggested text for an NSSP is included in Appendix F.

#### 11.3.3.3 Lateral Resistance of Sheet Piles

The depth of penetration of the sheet piles will be governed not only by the axial resistance/capacity, but also by the lateral pressure imposed by the soils retained behind the sheet piles. The sheet pile design must satisfy the lateral stability requirement.

The recommended soil parameters for lateral sheet pile design are given in the table below. These parameters should be used in conjunction with the equations provided below the table. The lateral resistance in the peat should be ignored.

Soil Unit	Approximate Elevation (m)	Effective Unit Weight $\gamma'$ (kN/m <sup>3</sup> )	$N_h$ (kN/m <sup>3</sup> )	$K_p$
Peat	260 – 257.5	5	-	-
Sand and Silt	Below 257.5	10	2,500	3.1

The coefficient of horizontal subgrade reaction ( $k_s$ ) and ultimate lateral resistance ( $p_{ult}$ ) for sheet pile design can be calculated as follows:

$$\begin{aligned} k_s &= n_h * z && (\text{kN/m}^2/\text{m}) \\ p_{ult} &= \gamma' * z * K_p && (\text{kPa}) \end{aligned}$$

where

$$\begin{aligned} z &= \text{depth of embedment of sheet pile (m)} \\ n_h &= \text{coefficient related to soil relative density (kN/m}^3\text{)} \\ \gamma' &= \text{effective unit weight of soil (kN/m}^3\text{)} \\ K_p &= \text{coefficient of passive earth pressure} \end{aligned}$$



The spring constant,  $K_s$ , and ultimate lateral resistance,  $P_{ult}$ , can be obtained from the following expressions:

$$\begin{aligned} K_s &= k_s * L && (\text{kN/m per metre wall}) \\ P_{ult} &= p_{ult} * L && (\text{kN per metre wall}) \end{aligned}$$

where  $L$  = length (m) of the pile segment/element along depth of embedment

To maintain the computed passive resistance, protection must be provided in front of the sheet piles to prevent material loss due to creek erosion.

#### 11.3.4 Frost Cover

The depth of frost penetration at this site is approximately 2.4 m based on OPSD 3090.100. The base of any concrete footings if employed should be provided with a minimum of 2.4 m of earth cover as protection against frost action. The frost cover requirement does not apply to the pipe, box culvert and SPCSP arch culvert options.

#### 11.3.5 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 1.1 to 3.1 m of peat to sand and silt mixed with peat was encountered below the embankment fill, with peat also encountered beyond the existing inlet and outlet. The base elevation of the peat deposit ranges from 258.5 to 257.1 m.

The peat must be sub-excavated to expose the native compact sand to silt and sand. The peat should be completely removed below the full width of the pipe or box culvert replacement options and the peat removal should extend a minimum of 1.5 m beyond the width of the replacement culvert for the entire length of the culvert. The peat removal should also extend for 1.5 m beyond the toe of slope of the final embankment.

For the SPCSP arch culvert option, where the culvert will be lengthened beyond the existing embankment, the peat must be removed for a width of 1.5 m beyond the outside of the arch culvert, and extend for 1.5 m beyond the toe of slope of the final embankment.

As the scope of the foundation investigation did not include boreholes for widening the highway embankment, it is recommended that additional borehole investigations be conducted near the embankment toes to assess the extent and depth of peat removal where the embankment will be



widened. Additional stability assessment should be carried out to assess the method of peat removal that does not adversely impact the stability of the highway embankment. Removal of peat in short sections may be required to maintain the highway embankment stability.

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 11.3.6.

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

#### 11.3.6 Construction in Wet Conditions

Given that removal and replacement of peat below the water table may be required, and that seepage of groundwater through the foundation sand to silt and 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:

Sieve Size	Percent Passing (%)
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 to silt and sand and the 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 (with the exception of 19 mm clear stone bedding, which may be placed in the wet).

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, unless 19 mm clear stone bedding is utilized.

#### 11.3.7 Settlement

The replacement culvert is anticipated to 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 approximately 1 to 2.5 m. Due to the presence of native peat in the widened

areas, foundation settlement under this fill in the order of 40 to 65 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 for the pipe or box replacement options, and from the widened embankment areas for all replacement options, the foundation settlement would be reduced to less than 25 mm, which would be completed by the end of construction. Peat removal is recommended in the areas of embankment widening. During detailed design, it is recommended that additional borehole investigations be conducted near the embankment toes to assess the extent and depth of peat removal where the embankment will be widened. Additional stability assessment should be carried out to assess the method of peat removal that does not adversely impact the stability of the highway embankment. Removal of peat in short sections may be required to maintain the highway embankment stability.

#### 11.3.8 Recommended Approach for Culvert Replacement

From a foundation engineering perspective, the circular pipe, concrete box culvert, and SPCSP arch culvert are all considered feasible culvert replacement options. However, the concrete box culvert and SPCSP arch culvert supported on sheet piles options are recommended from a geotechnical perspective as they may be constructed in the wet without the requirement for significant dewatering (compared to the pipe option). It is recommended however that additional deeper boreholes be advanced during the detailed design stage to confirm the soil conditions if the sheet pile culvert option is selected.

## 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 silty sand and sand and silt fills 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 fill soils would be classified as Type 4 soils. The native peat to sand and silt mixed with peat and other surficial alluvial deposits that are anticipated in the inlet and outlet areas should be classified as Type 4 soils. The native sand and silt deposits underlying the peat and below the water table are also 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 fill and to the base of the native peat.

It is anticipated that excavation for culvert replacement will be carried out below the creek water level, and diversion of the surface water 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, sand and silt layers, full dewatering to the base of the temporary excavations is likely to be difficult at this site. Watertight sheet pile cofferdam enclosures driven sufficiently deep into the underlying native sands and silts may form a groundwater cut-off, however additional seepage analysis would be required to assess their effectiveness at this site. 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 F.

The groundwater level will fluctuate and the minimum groundwater elevation at the time of the proposed work should be taken as the creek 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 259.5 m, which corresponds to the base of the sand and silt 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. On July 1, 2021, changes to EASR registrations came into effect, and storm water values no longer contribute to EASR maximum water taking rates. They are still, however, applicable to maximum water taking rates for PTTWs. 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 attached in Appendix H, the dimensions and conditions that were assumed for the preliminary dewatering assessment for the pipe and box culvert options are provided in Table 14.1 below. For full dewatering to the base of the temporary excavation, the geologic units that will need to be dewatered are sand and silt fill, native peat to sand and silt mixed with peat, and native sand to silt and sand foundation soils.

**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
Omer Lake Culvert Replacement	52 x 25	257	259.76	Fill, peat, sand to sand and silt

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

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. It is assumed the water level will be required to be lowered to about 1 m below the proposed excavation, or to elevation 256 m, in order to facilitate a dry, stable work area.





The preliminary peak water taking rate for the pipe and box culvert options was estimated to be greater than 1,200,000 litres per day including a safety factor and rainfall allowance. The preliminary radius of influence was estimated to be approximately 90 m from the edge of the excavation. The SPCSP arch culvert option supported on sheet piles does not require excavation below the water table to remove peat and prepare the culvert bedding within the culvert footprint. Therefore, the above water taking rate does not apply to this option. Some dewatering will be required however near the toes of the embankment for the SPCSP arch culvert option for peat removal.

Considering the estimated peak water taking rate is greater than 400,000 L/day, a Category 3 Permit to Take Water will be required for full dewatering of the temporary excavation for the pipe or box culvert options. 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.

Controlling this volume of groundwater flow would require significant dewatering effort and a Category 3 PTTW. To reduce this volume of groundwater flow to less than what would require a PTTW, a dewatering scheme including watertight sheet pile shoring driven sufficiently deep into the native sand and silt layers would be required to cut-off groundwater flow. Additional seepage analysis would be required to assess the effectiveness of such a system and design the depth of the sheet piles.

Based on the above factors, it is recommended that consideration be given to constructing the replacement culvert in the wet, as described in Section 11.3.6, or selecting the SPCSP arch culvert option supported on sheet piles.

## **15. WATER QUALITY**

For assessment of the general groundwater quality in the project area, a sample of the groundwater from the monitoring well at Borehole 21-01 was collected. As noted in Section 7, the water sample was tested and the results were compared to the Ontario Provincial Water Quality Objectives (PWQO). 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 five 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 three 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 2019, 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 generally compact fill and native soils, 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).

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 Silt and Sand to Sandy Silt Fill $\phi = 31^\circ, \gamma = 21 \text{ kN/m}^3$	Existing Peat to Sand and Silt mixed with Peat $\phi = 29^\circ, \gamma = 16 \text{ kN/m}^3$
Active ( $K_{AE}$ ) <sup>1</sup>	0.29	0.32	0.34	0.37
Passive ( $K_{PE}$ ) <sup>2</sup>	3.6	3.2	3.1	2.8
At Rest ( $K_{OE}$ ) <sup>3</sup>	0.49	0.53	0.54	0.57

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. Sheet pile cofferdams are anticipated to be feasible at this site as they can be driven into the native sands and silts. The recommendations provided in Section 19 below for Temporary Protection Systems are also applicable to sheet pile cofferdams.

## 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. 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 Silt and Sand to Sandy Silt Fill	Native Peat to Peat Mixed with Sand and Silt	Native Silt and Sand
$\phi$ (angle of internal friction)	31°	29°	30°
$\gamma$ (total unit weight)	21 kN/m <sup>3</sup>	16 kN/m <sup>3</sup>	20 kN/m <sup>3</sup>
$\gamma_w$ (submerged unit weight)	11 kN/m <sup>3</sup>	6 kN/m <sup>3</sup>	10 kN/m <sup>3</sup>
$K_a$	0.32	0.35	0.33
$K_p$	3.1	2.9	3.0

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

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. TEMPORARY MODULAR BRIDGE**

An inline temporary modular bridge is another viable option at this site for traffic staging purposes during construction of the replacement culvert. The design of the temporary bridge is the responsibility of the contractor. The contractor must retain a Professional Engineer, experienced in bridge design, to design the temporary bridge.

The modular bridge may be supported on precast concrete bearing pads founded on engineered granular fill pads. The base of the engineered fill pads may be placed on the existing embankment fill (typically dense silty sand to sand and silt fill) at approximate Elevations of 262 and 263 m at the west and east abutments respectively.



The granular fill pads should be a minimum of 1 m thick and consist of OPSS Granular A or Granular B Type II, placed in 150 mm thick lifts and compacted to 100% of the SPMDD at  $\pm 2\%$  of Optimum Moisture Content (OMC).

The minimum footing width should be 2 m and the footing should be embedded a minimum of 0.5 m below the finished grade in front of the footing. The front edge of the footing should be set back a minimum of 2 m from the crest of the temporary excavation slope at the top of the footing level.

The following geotechnical resistances are recommended for design of minimum 2 m wide concrete spread footings placed on minimum 1 m thick engineered granular fill pads prepared as outlined above with the underside at approximate Elevations of 262 to 263 m:

Geotechnical Resistance	Temporary Modular Bridge with Spread Footings on 1.0 m Thick Engineered Fill Pads		
	2.0 m Wide Footings	2.5 m Wide Footings	3.0 m Wide Footings
Factored Geotechnical Resistance at ULS	210	180	150
Geotechnical Resistance at SLS (for up to 25 mm settlement)	135	120	100

Resistance to lateral forces/sliding resistance between the concrete pad and the underlying Granular A or B Type II engineered fill should be calculated assuming an ultimate coefficient of friction of 0.55.

The above Geotechnical Resistances assume the footings are embedded a minimum of 0.5 m below the ground surface surrounding the footings. However, in order to achieve a stability safety factor of 1.3 for the temporary excavation slopes in front of the footings, the footings should be embedded a minimum of 1.4 m below ground instead (for temporary slopes inclined at 2H:1V). Slope stability is discussed further in Section 21 below. The temporary excavation slopes for the modular bridge must be protected from erosion by covering the slopes with tarp.

It is recommended that the contractor retain a geotechnical consultant who is RAQs qualified at the medium complexity level (RAQs Category – Geotechnical Structures and Embankment – Medium Complexity) to design the footings and stable slopes in front of the footings for the temporary modular bridge. All final reports and drawings must be sealed and signed by a



Professional Engineer, who shall also be a RAQs Designated Contact. An NSSP for this effect is attached in Appendix F.

## **21. SLOPE STABILITY**

As the replacement culvert will be longer than the existing culvert, some placement of additional fill (ranging from approximately 1 to 2.5 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. Figure 1 in Appendix G indicates 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 1.35). 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 1.5 for the side slopes (Figure 2). It may be necessary to remove the peat in short sections and backfill immediately to maintain stability of the embankment slope. Additional investigation of the extent and depth of the peat in the widened areas as well as stability assessment is recommended during detailed design.

As described in Section 20, in order to achieve a stability safety factor of 1.3 for the temporary excavation slopes in front of the temporary modular bridge footings, the footings should be embedded a minimum of 1.4 m below the surrounding ground instead of 0.5 m. Figures 3 to 8 in Appendix G depict the forward slope stability for 2, 2.5 and 3 m wide footings at 0.5 and 1.4 m embedment for temporary slopes inclined at 2H:1V.

## **22. 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.

### **23. 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.

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.

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

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

- The potential for corrosion on metal or concrete foundations from the surrounding native sand or surface water is considered to be mild to moderate due to the low concentrations of sulphate and chloride in the samples tested. The effect of road deicing salt should be considered while selecting the class of concrete.
- The potential for corrosion on metal and concrete from the peat to peat mixed with silt and sand is considered to be high, due to the high concentration of chloride and the low resistivity.
- The potential for sulphate attack on concrete from the surrounding soil or surface water is considered to be negligible due to the low sulphate concentration in the samples tested.



- 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. Consideration should also be given to removing the buried peat below and in the vicinity of the replacement culvert.

## **25. CONSTRUCTION CONCERNS**

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

- To avoid settlement under the widened embankment slopes, the peat layer must be fully removed to the limits discussed in Section 11.3.5.
- Full dewatering to below the base of the culvert excavation for the pipe or box culvert options 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. An NSSP on dewatering is attached in Appendix F.
- The water level in the watercourse may fluctuate and be at a higher elevation at the time of construction than indicated in the report.
- Temporary modular bridge footings must be setback a minimum of 2 m behind the crest of the forward slopes, with the footing bases embedded a minimum of 1.4 m below the ground surface (as described in Sections 20 and 21) in order to maintain stable temporary excavation slopes in front of the TMB foundations. An NSSP on the TMB is attached in Appendix F.
- Obstructions may be present within the existing embankment fill, with may impede the driving of sheet piles if used for roadway protection, cofferdams or SPCSP arch culvert foundations. An NSSP on sheet pile installation is provided in Appendix F.

## **26. RECOMMENDED ADDITIONAL INVESTIGATION**

The original scope of the foundation investigation outlined in the Terms of Reference did not include the SPCSP arch culvert supported on sheet piles option. Therefore, as noted in Sections 11.3.3.1 and 11.3.8, not all of the boreholes extend deep enough to confirm the soil conditions at the proposed sheet pile tip depths along the sheet pile foundations. Therefore, if the SPCSP arch supported on sheet piles option is selected, it is recommended that additional deeper boreholes be advanced during the detailed design stage to confirm the soil conditions below at least





Elevation 245 m along the alignment of the sheet pile foundations. It is recommended that 4 boreholes be advanced along the proposed sheet pile wall alignments.

As the original scope of the foundation investigation also did not include boreholes for widening of the highway embankment, it is recommended that additional borehole investigations be conducted near the embankment toes to assess the extent and depth of peat removal where the embankment will be widened. Portable drilling or handheld equipment may be necessary for determining the depth of peat in these locations. Additional stability assessment should be carried out to assess the method of peat removal that does not adversely impact the stability of the highway embankment. Removal of peat in short sections may be required to maintain the highway embankment stability.

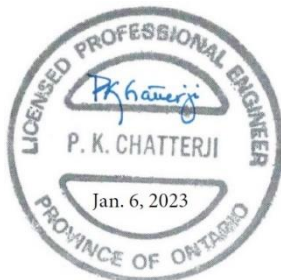
## 27. CLOSURE

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, M.Eng., P.Eng.  
Associate, Senior Geotechnical Engineer



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

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- a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.
- b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.
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- d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

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## **Appendix A**

### **Record of Borehole Sheets**

## SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

### 1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

### 3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT <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 <sub>L</sub> < 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 <sub>L</sub> < 30%).
		CI	Inorganic clays of medium plasticity, silty clays. (30% < W <sub>L</sub> < 50%).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS W <sub>L</sub> > 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			

# RECORD OF BOREHOLE No 21-01

1 OF 3

METRIC

W.P. 6118-17-01 LOCATION Omer Lake Tributary Culvert; MTM NAD83-14 N 5 471 642.7 E 222 489.4 ORIGINATED BY RB  
DIST Thunder Bay HWY 11 BOREHOLE TYPE Solid Stem Augers/DCPT COMPILED BY AN  
DATUM Geodetic DATE 2021.04.20 - 2021.04.21 LATITUDE 49.377150 LONGITUDE -88.133602 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE								WATER CONTENT (%)		
264.5	GROUND SURFACE						20	40	60	80	100	20	40	60	GR	SA	SI	CL
0.0	ASPHALT: (175mm)																	
0.2	Silty SAND, some gravel Very Dense Brown		1	SS	100													
263.7	Moist (FILL)																	
0.8	SAND and SILT, trace clay Dense to Loose Brown Moist (FILL)		2	SS	32													
				3	SS	17												
			4	SS	16													
			5	SS	7													
259.8																		
4.7	SAND and SILT mixed with PEAT, some clay lenses, wood fragments Loose to Compact Brown to Black Wet		6	SS	9													
			7	SS	11													
257.8																		
6.7	SAND and SILT, trace clay Compact Grey Wet																	
				8	SS	17												
			9	SS	23													

Continued Next Page

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

20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 21-01

2 OF 3

METRIC

W.P. 6118-17-01 LOCATION Omer Lake Tributary Culvert; MTM NAD83-14 N 5 471 642.7 E 222 489.4 ORIGINATED BY RB  
DIST Thunder Bay HWY 11 BOREHOLE TYPE Solid Stem Augers/DCPT COMPILED BY AN  
DATUM Geodetic DATE 2021.04.20 - 2021.04.21 LATITUDE 49.377150 LONGITUDE -88.133602 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 ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE								WATER CONTENT (%)			GR	SA	SI
	Continued From Previous Page						20	40	60	80	100	20	40	60							
	<b>SAND</b> and <b>SILT</b> , trace clay Compact Grey Wet																				
			10	SS	23							○				0	35	64	1		
252.8																					
11.7	Silty <b>SAND</b> Compact Brown Wet																				
			11	SS	22							○									
			12	SS	16							○									
249.7																					
14.8	<b>SILT</b> , trace clay, trace sand Compact Grey Wet																				
			13	SS	22							○									
			14	SS	17							○						0	4	86	10
247.1																					
17.4	End of sampling at 17.4m and start DCPT																				

Continued Next Page

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

ONTMT4S2 MTO-31344.GPJ 2017TEMPLATE(MTO).GDT 9/28/21

# RECORD OF BOREHOLE No 21-01

3 OF 3

METRIC

W.P. 6118-17-01 LOCATION Omer Lake Tributary Culvert; MTM NAD83-14 N 5 471 642.7 E 222 489.4 ORIGINATED BY RB  
DIST Thunder Bay HWY 11 BOREHOLE TYPE Solid Stem Augers/DCPT COMPILED BY AN  
DATUM Geodetic DATE 2021.04.20 - 2021.04.21 LATITUDE 49.377150 LONGITUDE -88.133602 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL										
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80						100	20	40	60						
	Continued From Previous Page																									
240.1																										
24.4	<p>END OF DCPT AT 24.4m. BOREHOLE CAVED TO 13.7 m BEFORE MONITORING WELL INSTALLATION.</p> <p>Piezometer installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.</p> <p>WATER LEVEL READINGS</p> <table border="1"> <thead> <tr> <th>DATE</th> <th>DEPTH(m)</th> <th>ELEV.(m)</th> </tr> </thead> <tbody> <tr> <td>2021.04.22</td> <td>5.5</td> <td>259.0</td> </tr> <tr> <td>2021.04.23</td> <td>4.7</td> <td>259.8</td> </tr> <tr> <td>2021.04.25</td> <td>4.7</td> <td>259.8</td> </tr> </tbody> </table>	DATE	DEPTH(m)	ELEV.(m)	2021.04.22	5.5	259.0	2021.04.23	4.7	259.8	2021.04.25	4.7	259.8													
DATE	DEPTH(m)	ELEV.(m)																								
2021.04.22	5.5	259.0																								
2021.04.23	4.7	259.8																								
2021.04.25	4.7	259.8																								

ONTMT4S2 MTO-31344.GPJ 2017TEMPLATE(MTO).GDT 9/28/21



# RECORD OF BOREHOLE No 21-02

1 OF 2

METRIC

W.P. 6118-17-01 LOCATION Omer Lake Tributary Culvert; MTM NAD83-14 N 5 471 655.5 E 222 507.6 ORIGINATED BY RB  
DIST Thunder Bay HWY 11 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
DATUM Geodetic DATE 2021.04.22 - 2021.04.22 LATITUDE 49.377267 LONGITUDE -88.133355 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa												
265.0	GROUND SURFACE							20	40	60	80	100								
0.0	ASPHALT: (225mm)							20	40	60	80	100								
0.2	Silty <b>SAND</b> , some to trace gravel Very Dense to Compact Brown Moist (FILL)		1	SS	98															13 64 23 (SI+CL)
	25mm thick layer of asphalt at 0.6m		2	SS	28		264													
263.6																				
1.4	<b>SAND</b> and <b>SILT</b> , trace clay, trace gravel Dense to Loose Brown Moist (FILL)		3	SS	43		263													
			4	SS	17		262													
			5	SS	4		261													1 43 55 1
	Trace organics, rootlets and wood fragments		6	SS	21		260													
259.4																				
5.6	<b>PEAT</b> , fibrous, trace sand, trace silt Loose Brown to Black Wet		7	SS	9		259													
							258													
257.8																				
7.2	<b>SAND</b> , some silt Compact Grey Wet		8	SS	10		257													0 88 12 0
							256													
			9	SS	17															

Continued Next Page

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

# RECORD OF BOREHOLE No 21-02

2 OF 2

METRIC

W.P. 6118-17-01 LOCATION Omer Lake Tributary Culvert; MTM NAD83-14 N 5 471 655.5 E 222 507.6 ORIGINATED BY RB  
DIST Thunder Bay HWY 11 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
DATUM Geodetic DATE 2021.04.22 - 2021.04.22 LATITUDE 49.377267 LONGITUDE -88.133355 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
Continued From Previous Page																	
251.7	SAND, some silt Compact Grey Wet		10	SS	16												
			11	SS	19												
252																	
13.3	Silty SAND Compact Grey Wet		12	SS	17												
			13	SS	23											0 64 36 0	
249																	
			14	SS	21												
248																	
247.6	END OF BOREHOLE AT 17.4m.																
17.4	Piezometer installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.  WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2021.04.23 5.2 259.8 2021.04.25 5.2 259.8																

ONTMT4S2 MTO-31344.GPJ 2017TEMPLATE(MTO).GDT 9/28/21

## METRIC

[illegible]

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

CONTMT4S2 MTO-31344.GPJ 2017TEMPLATE(MTO).GDT 9/28/21

# RECORD OF BOREHOLE No 21-03A

2 OF 2

METRIC

W.P. 6118-17-01 LOCATION Omer Lake Tributary Culvert; MTM NAD83-14 N 5 471 636.7 E 222 517.6 ORIGINATED BY GS  
DIST Thunder Bay HWY 11 BOREHOLE TYPE Casing/DCPT COMPILED BY AN  
DATUM Geodetic DATE 2021.05.08 - 2021.05.08 LATITUDE 49.377100 LONGITUDE -88.133213 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			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	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	20 40 60			
	Continued From Previous Page													
244.7														
15.2	END OF BOREHOLE AT 15.2m. BOREHOLE CAVED TO 2.3m AND WATER LEVEL AT 0.1m. BOREHOLE BACKFILLED WITH BENOTNITE HOLEPLUG TO SURFACE.													

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

20  
15  
10

(%) STRAIN AT FAILURE

## METRIC

[illegible]

ONTMT4S2 MTO-31344.GPJ 2017TEMPLATE(MTO).GDT 9/28/21

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

# RECORD OF BOREHOLE No 21-04

1 OF 2

METRIC

W.P. 6118-17-01 LOCATION Omer Lake Tributary Culvert; MTM NAD83-14 N 5 471 661.8 E 222 482.1 ORIGINATED BY GS  
DIST Thunder Bay HWY 11 BOREHOLE TYPE Casing/Tripod COMPILED BY AN  
DATUM Geodetic DATE 2021.05.06 - 2021.05.06 LATITUDE 49.377321 LONGITUDE -88.133706 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)		
								○ UNCONFINED	+	FIELD VANE						● QUICK TRIAXIAL	×	LAB VANE
260.2	GROUND SURFACE					▽		20	40	60	80	100		20	40	60		
0.0	PEAT: (150mm)																	
0.2	Sandy SILT, some roots, organics Loose to Compact Brown to Grey Moist		1	SS	4		260											
			2	SS	15		259											
258.8																		
1.4	SILT and SAND, trace clay, trace gravel Loose to Compact Grey Wet		3	SS	6		258											
			4	SS	10													
257.0							257											
3.2	SILT, some clay, some sand, trace gravel Compact Grey Moist		5	SS	13		256											
255.6																		
4.6	Silty SAND Compact Brown Moist		6	SS	24		255											
254.6																		
5.6	SILT, some to trace clay, trace sand Compact to Dense Grey Moist		7	SS	27		254											
			8	SS	16		253											
						252												
			9	SS	38	251												

Continued Next Page

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

# RECORD OF BOREHOLE No 21-04

2 OF 2

METRIC

W.P. 6118-17-01 LOCATION Omer Lake Tributary Culvert; MTM NAD83-14 N 5 471 661.8 E 222 482.1 ORIGINATED BY GS  
DIST Thunder Bay HWY 11 BOREHOLE TYPE Casing/Tripod COMPILED BY AN  
DATUM Geodetic DATE 2021.05.06 - 2021.05.06 LATITUDE 49.377321 LONGITUDE -88.133706 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL									
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa														
								20 40 60 80 100														
Continued From Previous Page							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W <sub>P</sub> W W <sub>L</sub> WATER CONTENT (%)											
							20 40 60 80 100				20 40 60											
246.2 14.0	SILT, some to trace clay, trace sand Compact Grey Moist	<div><div></div><div></div><div></div><div></div><div></div><div></div></div>					250									0 2 96 2						
			10	SS	23																	
			11	SS	11																	
			12	SS	27																	
END OF BOREHOLE AT 14.0m. BOREHOLE CAVED TO 10.0m AND WATER LEVEL AT 0.9m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.																						

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

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 21-05

1 OF 2

METRIC

W.P. 6118-17-01 LOCATION Omer Lake Tributary Culvert; MTM NAD83-14 N 5 471 636.6 E 222 483.6 ORIGINATED BY RB  
DIST Thunder Bay HWY 11 BOREHOLE TYPE Wash Boring COMPILED BY AN  
DATUM Geodetic DATE 2021.04.22 - 2021.04.22 LATITUDE 49.377095 LONGITUDE -88.133682 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	WATER CONTENT (%)					
264.3	GROUND SURFACE						20 40 60 80 100							
0.0	ASPHALT: (150mm)													
0.2	Silty SAND, some gravel Very Dense Brown		1	SS	91		264							
263.5	Moist (FILL)													
0.8	SAND and SILT, trace gravel Compact to Loose Brown Moist (FILL)		2	SS	22		263							
			3	SS	18		262							
			4	SS	13		261							
			5	SS	7		260							
260.2														
4.1	Silty SAND mixed with PEAT, some wood fragments Loose Brown to Black Wet (FILL)		6	SS	4		259							
			7	SS	8		258							
257.1							257							
7.2	Silty SAND Compact Brown Wet		8	SS	17		256							
			9	SS	22		255							

Continued Next Page

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

20  
15  
10

(%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No 21-05

2 OF 2

METRIC

W.P. 6118-17-01 LOCATION Omer Lake Tributary Culvert; MTM NAD83-14 N 5 471 636.6 E 222 483.6 ORIGINATED BY RB  
DIST Thunder Bay HWY 11 BOREHOLE TYPE Wash Boring COMPILED BY AN  
DATUM Geodetic DATE 2021.04.22 - 2021.04.22 LATITUDE 49.377095 LONGITUDE -88.133682 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
	Continued From Previous Page												
	Silty <b>SAND</b> Compact Brown Wet		10	SS	22		254						
							253						
			11	SS	24		252						
							251						
			12	SS	20		250						
249.5													
14.8	<b>SILT</b> , some sand, some clay Compact Grey Wet		13	SS	16		249						
							248						
			14	SS	20		247						
246.9													
17.4	END OF BOREHOLE AT 17.4M. BOREHOLE CAVED TO 11.2m. NO WATER LEVEL MEASUREMENT DUE TO RESIDUAL DRILLING WATER IN BOREHOLE. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.6m, DRY CONCRETE TO 0.2m, THEN ASPHALT TO SURFACE UPON COMPLETION.												

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# RECORD OF BOREHOLE No 21-06

1 OF 2

METRIC

W.P. 6118-17-01 LOCATION Omer Lake Tributary Culvert; MTM NAD83-14 N 5 471 661.2 E 222 512.4 ORIGINATED BY RB  
DIST Thunder Bay HWY 11 BOREHOLE TYPE Solid Stem Augers/Wash Boring COMPILED BY AN  
DATUM Geodetic DATE 2021.04.23 - 2021.04.23 LATITUDE 49.377320 LONGITUDE -88.133290 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						WATER CONTENT (%)			
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE						W <sub>P</sub> W      W <sub>L</sub>			
265.2	GROUND SURFACE						20	40	60	80	100	20	40	60			
0.0	ASPHALT: (150mm)																
0.2	Silty SAND, some gravel Very Dense Brown Moist (FILL)		1	SS	92							○					
264.4												○					
0.8	SAND and SILT Dense to Compact Brown Moist (FILL)		2	SS	31												
												○					
			3	SS	35												
												○					
			4	SS	23												
												○					
			5	SS	18												
												○					
	Trace organics		6	SS	21												
259.6																	
5.6	PEAT, fibrous, silty sand layers Compact Brown to Black Wet		7	SS	10												
257.5																	
7.7	SAND, some silt Compact Brown to Grey Wet		8	SS	14							○					
			9	SS	11							○					

Continued Next Page

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

ONTMT4S2 MTO-31344.GPJ 2017TEMPLATE(MTO).GDT 9/28/21

# RECORD OF BOREHOLE No 21-06

2 OF 2

METRIC

W.P. 6118-17-01 LOCATION Omer Lake Tributary Culvert; MTM NAD83-14 N 5 471 661.2 E 222 512.4 ORIGINATED BY RB  
DIST Thunder Bay HWY 11 BOREHOLE TYPE Solid Stem Augers/Wash Boring COMPILED BY AN  
DATUM Geodetic DATE 2021.04.23 - 2021.04.23 LATITUDE 49.377320 LONGITUDE -88.133290 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
	Continued From Previous Page						20 40 60 80 100							
	<b>SAND</b> , some silt Compact Grey Wet													
			10	SS	10									
			11	SS	19									
251.9														
13.3	Silty <b>SAND</b> Compact Grey Wet													
			12	SS	21									
			13	SS	19									
			14	SS	24									
247.8														
17.4	END OF BOREHOLE AT 17.4m. BOREHOLE CAVED TO 5.3m. NO WATER MEASUREMENT DUE TO RESIDUAL DRILLING WATER IN BOREHOLE. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.6m, DRY CONCRETE TO 0.2m, THEN ASPHALT TO SURFACE UPON COMPLETION.													

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

20  
15  
10

(%) STRAIN AT FAILURE

ONTMT4S2 MTO-31344.GPJ 2017TEMPLATE(MTO).GDT 9/28/21

# RECORD OF BOREHOLE No 21-07

1 OF 3

METRIC

W.P. 6118-17-01 LOCATION Omer Lake Tributary Culvert; MTM NAD83-14 N 5 471 674.9 E 222 518.8 ORIGINATED BY RB  
DIST Thunder Bay HWY 11 BOREHOLE TYPE Solid Stem Augers/Wash Boring/DCPT COMPILED BY AN  
DATUM Geodetic DATE 2021.04.23 - 2021.04.23 LATITUDE 49.377444 LONGITUDE -88.133205 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				W <sub>P</sub> W                      W <sub>L</sub>								
								○ UNCONFINED                      + FIELD VANE ● QUICK TRIAXIAL                      × LAB VANE				WATER CONTENT (%)								
265.7	GROUND SURFACE						20	40	60	80	100						GR	SA	SI	CL
0.0	ASPHALT: (150mm)						20	40	60	80	100									
0.2	Gravelly <b>SAND</b> , some silt Very Dense to Dense Brown Moist (FILL)		1	SS	70															
			2	SS	39															
264.3																				
1.4	<b>SAND</b> and <b>SILT</b> , trace clay Compact Brown Moist (FILL)		3	SS	11															
			4	SS	17															
			5	SS	23															
261.6																				
4.1	Silty <b>SAND</b> , trace oxidation Compact Brown Moist (FILL)		6	SS	14															
259.6																				
6.1	Low recovery due to wood fragments, Anticipated <b>PEAT</b> , mixed with silty sand		7	SS	11															
258.5																				
7.2	<b>SAND</b> , some silt Compact Brown Moist		8	SS	20															
			9	SS	27															

Continued Next Page

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

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 21-07

2 OF 3

METRIC

W.P. 6118-17-01 LOCATION Omer Lake Tributary Culvert; MTM NAD83-14 N 5 471 674.9 E 222 518.8 ORIGINATED BY RB  
DIST Thunder Bay HWY 11 BOREHOLE TYPE Solid Stem Augers/Wash Boring/DCPT COMPILED BY AN  
DATUM Geodetic DATE 2021.04.23 - 2021.04.23 LATITUDE 49.377444 LONGITUDE -88.133205 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80					
	Continued From Previous Page															
	SAND, some silt Compact Brown Moist		10	SS	28		255									0 86 14 0
							254									
			11	SS	25		253									
							252									
			12	SS	21		251									
250.9							250									
14.8	SILT, some sand, trace clay Compact Grey Wet		13	SS	17		249									0 15 80 5
							248									
			14	SS	15		247									
248.3	End of sampling at 17.4m and start DCPT						246									
17.4																

Continued Next Page

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

ONTMT4S2 MTO-31344.GPJ 2017TEMPLATE(MTO).GDT 9/28/21

# RECORD OF BOREHOLE No 21-07

3 OF 3

METRIC

W.P. 6118-17-01 LOCATION Omer Lake Tributary Culvert; MTM NAD83-14 N 5 471 674.9 E 222 518.8 ORIGINATED BY RB  
DIST Thunder Bay HWY 11 BOREHOLE TYPE Solid Stem Augers/Wash Boring/DCPT COMPILED BY AN  
DATUM Geodetic DATE 2021.04.23 - 2021.04.23 LATITUDE 49.377444 LONGITUDE -88.133205 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40					
	Continued From Previous Page													
241.3														
24.4	END OF DCPT AT 24.4m. BOREHOLE CAVED TO 6.1m. NO WATER MEASUREMENT DUE TO RESIDUAL DRILLING WATER IN BOREHOLE. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.6m, DRY CONCRETE TO 0.2m, THEN ASPHALT TO SURFACE UPON COMPLETION.													

# RECORD OF BOREHOLE No 21-08

1 OF 3

METRIC

W.P. 6118-17-01 LOCATION Omer Lake Tributary Culvert; MTM NAD83-14 N 5 471 623.1 E 222 477.9 ORIGINATED BY RB  
DIST Thunder Bay HWY 11 BOREHOLE TYPE Solid Stem Augers/Wash Boring/DCPT COMPILED BY AN  
DATUM Geodetic DATE 2021.04.25 - 2021.04.25 LATITUDE 49.376973 LONGITUDE -88.133757 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 $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								
263.9	GROUND SURFACE						20	40	60	80	100					
0.0	ASPHALT: (175mm)						20	40	60	80	100					
0.2	Silty SAND, some gravel Very Dense Brown Moist (FILL)		1	SS	84											
263.1	Layer of asphalt at 0.6m		2	SS	19											
0.8	SAND and SILT, trace gravel, trace clay Compact Brown Moist (FILL)		3	SS	22											
	Trace oxidation		4	SS	25											
	Trace organics		5	SS	11											
259.8	PEAT, fibrous to amorphous, interbedded with sandy silt, trace clay Loose Brown to Black Wet		6	SS	6											
258.3	SAND, some silt, trace clay Loose to Compact Grey Wet		7	SS	9											
5.6	Trace wood fragments		8	SS	22											
			9	SS	18											

Continued Next Page

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

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 21-08

2 OF 3

METRIC

W.P. 6118-17-01 LOCATION Omer Lake Tributary Culvert; MTM NAD83-14 N 5 471 623.1 E 222 477.9 ORIGINATED BY RB  
DIST Thunder Bay HWY 11 BOREHOLE TYPE Solid Stem Augers/Wash Boring/DCPT COMPILED BY AN  
DATUM Geodetic DATE 2021.04.25 - 2021.04.25 LATITUDE 49.376973 LONGITUDE -88.133757 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
	Continued From Previous Page												
	<b>SAND</b> , some silt, trace clay Compact to Dense Grey Wet		10	SS	22		253						
							252						
			11	SS	22		251						0 85 14 1
			12	SS	31		250						
249.0													
14.9	Sandy <b>SILT</b> , trace clay Compact Grey Wet		13	SS	14		249						0 38 60 2
							248						
			14	SS	25		247						
246.5													
17.4	End of sampling at 17.4m and start DCPT						246						
							245						
							244						

Continued Next Page

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



# RECORD OF BOREHOLE No 21-08

3 OF 3

METRIC

W.P. 6118-17-01 LOCATION Omer Lake Tributary Culvert; MTM NAD83-14 N 5 471 623.1 E 222 477.9 ORIGINATED BY RB  
DIST Thunder Bay HWY 11 BOREHOLE TYPE Solid Stem Augers/Wash Boring/DCPT COMPILED BY AN  
DATUM Geodetic DATE 2021.04.25 - 2021.04.25 LATITUDE 49.376973 LONGITUDE -88.133757 CHECKED BY MEF

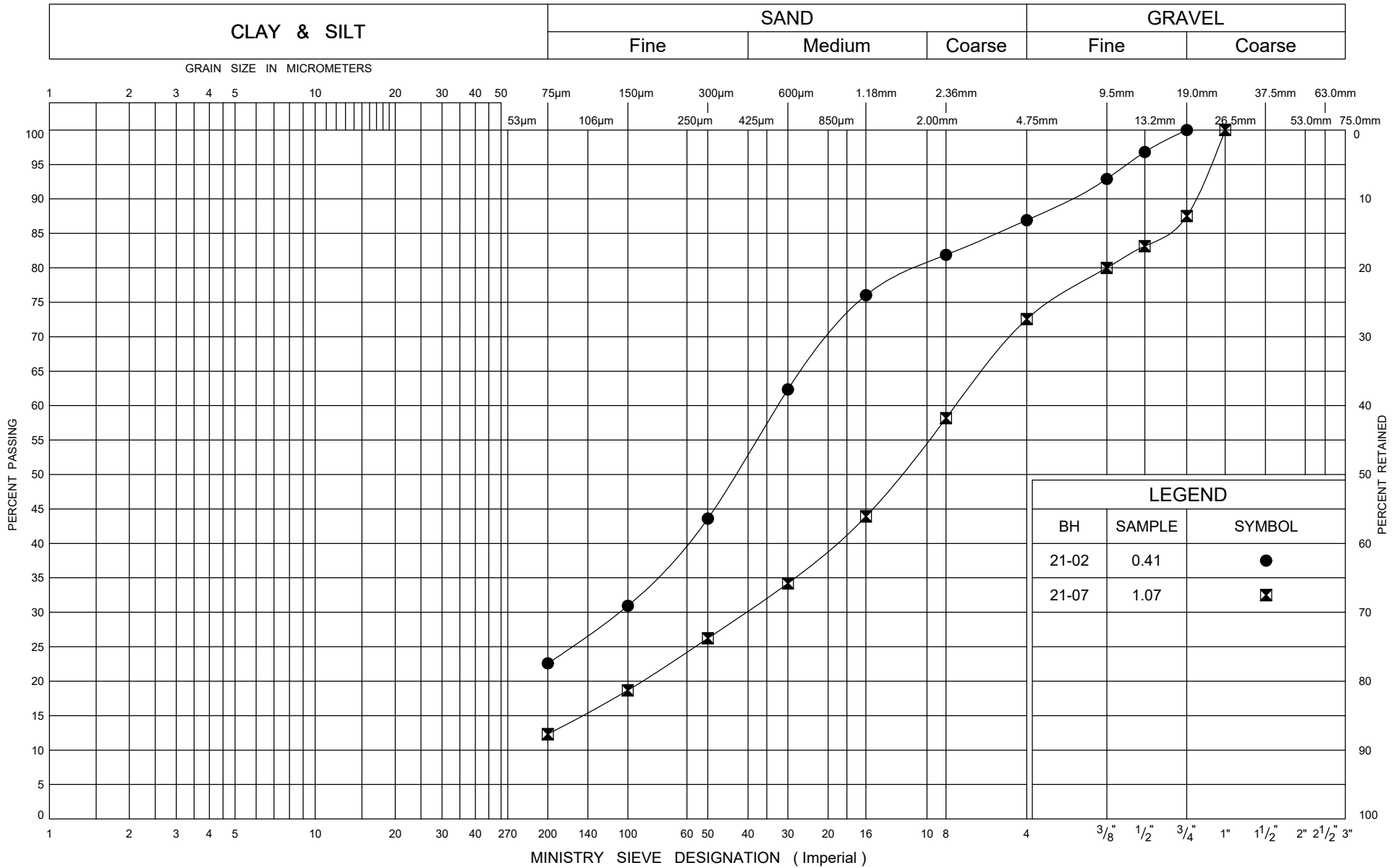
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	20 40 60					
	Continued From Previous Page						243								
							242								
							241								
							240								
239.5															
24.4	END OF DCPT AT 24.4m. BOREHOLE CAVED TO 5.9m. NO WATER MEASUREMENT DUE TO RESIDUAL DRILLING WATER IN BOREHOLE. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.6m, DRY CONCRETE TO 0.2m, THEN ASPHALT TO SURFACE UPON COMPLETION.														

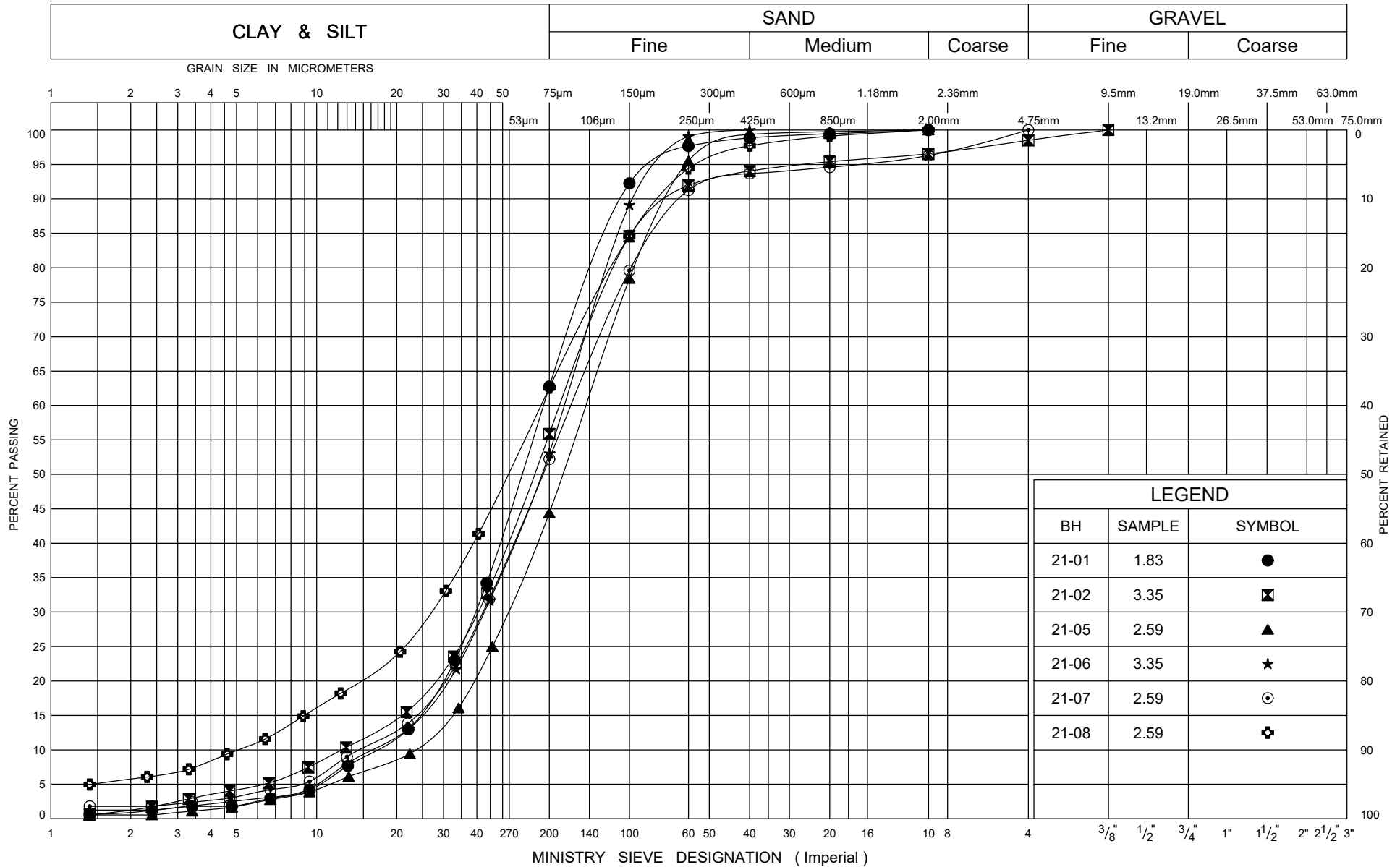
ONTMT4S2 MTO-31344.GPJ 2017TEMPLATE(MTO).GDT 9/28/21



## **Appendix B**

### **Laboratory Test Results**





Ministry of  
Transportation

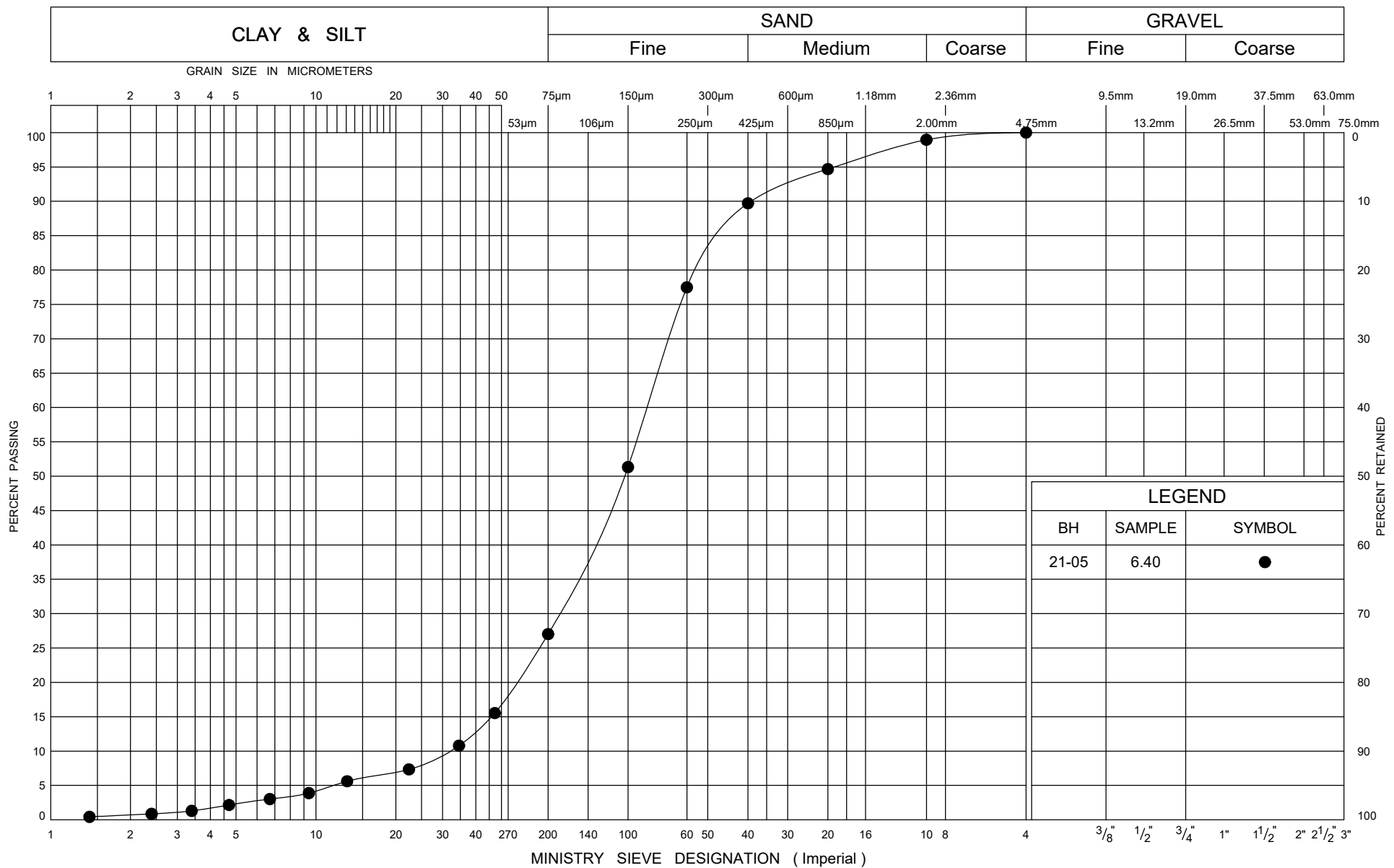
## GRAIN SIZE DISTRIBUTION

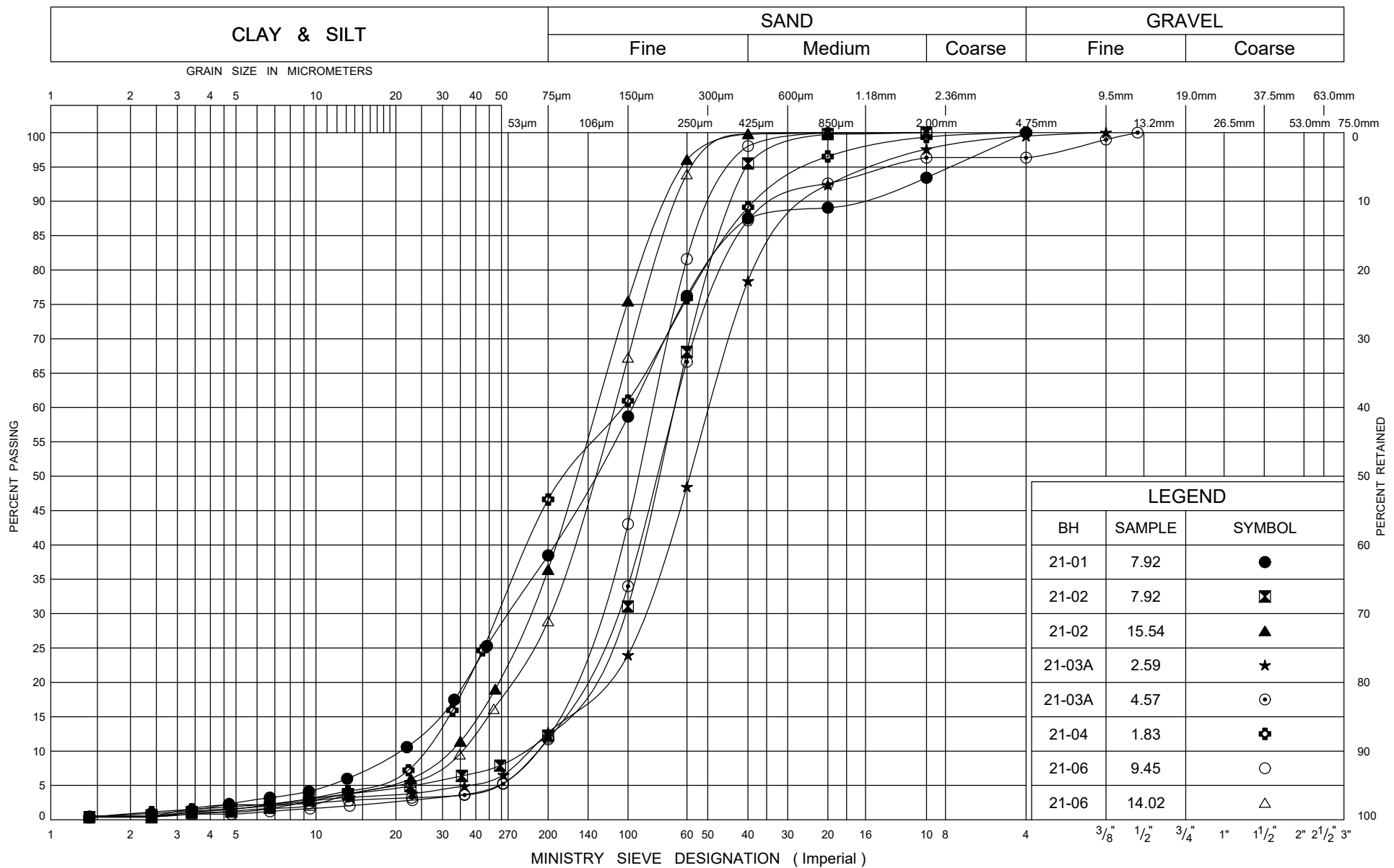
### SAND and SILT FILL

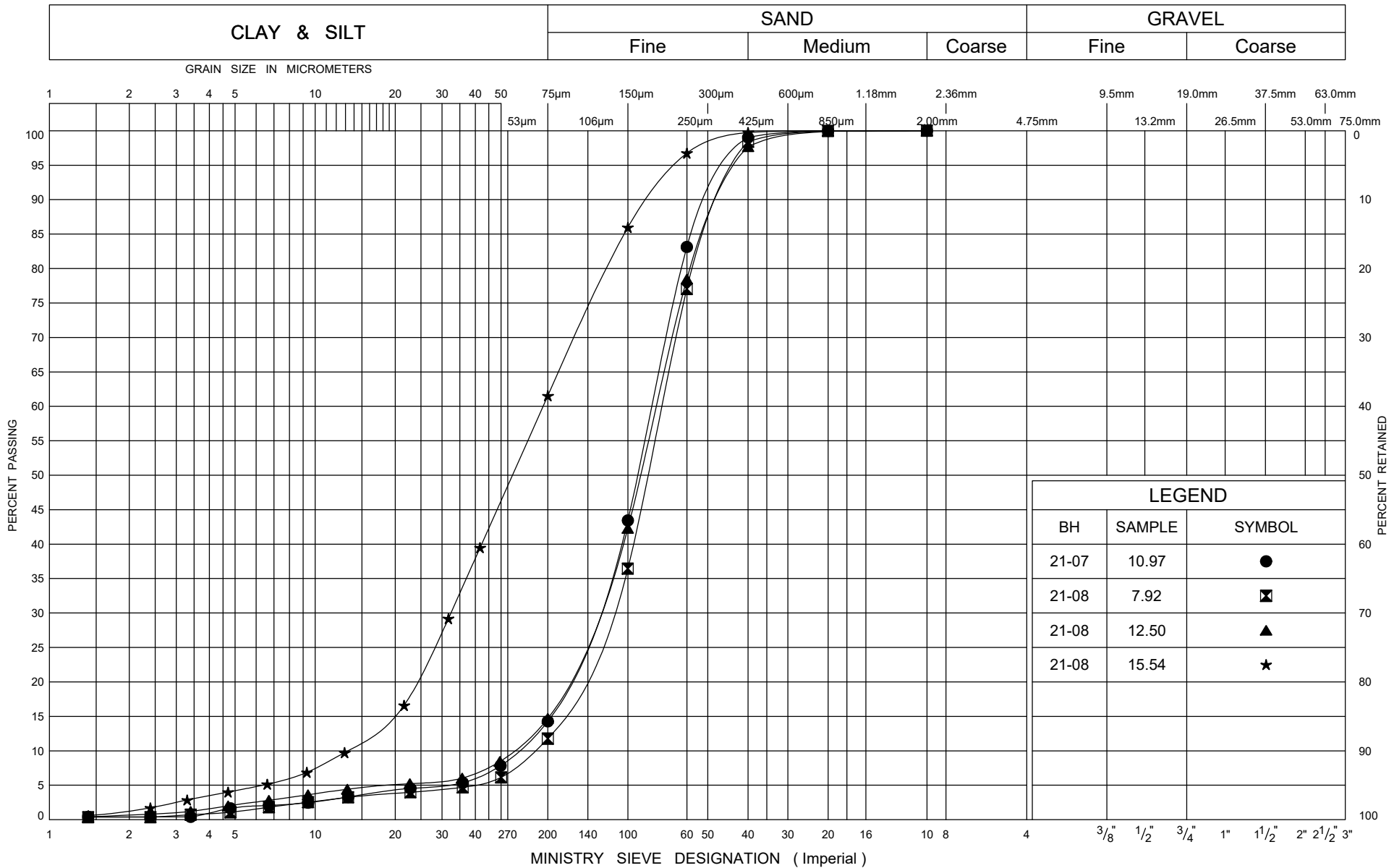
FIG No B2

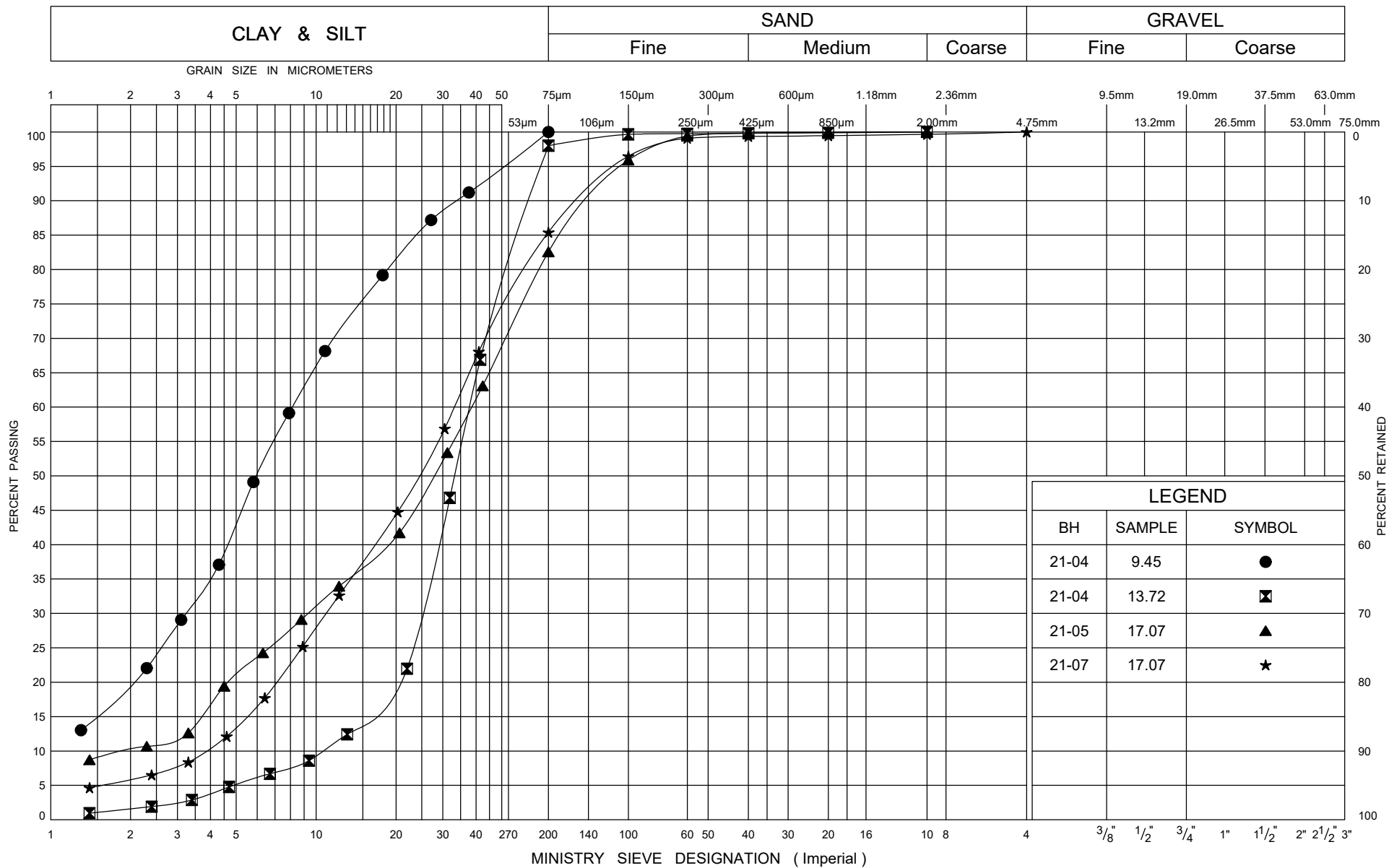
W.P. 6118-17-01

Omer Lake Tributary Culvert













**THURBER ENGINEERING LTD.**

**Slug Test Analysis Report**

Project: Omer Lake Tributary Culvert

Number: 31344

Client: Hatch

Location: District of Thunder Bay

Slug Test: 21-01

Test Well: 21-01

Test Conducted by: RB

Test Date: 2021-04-23

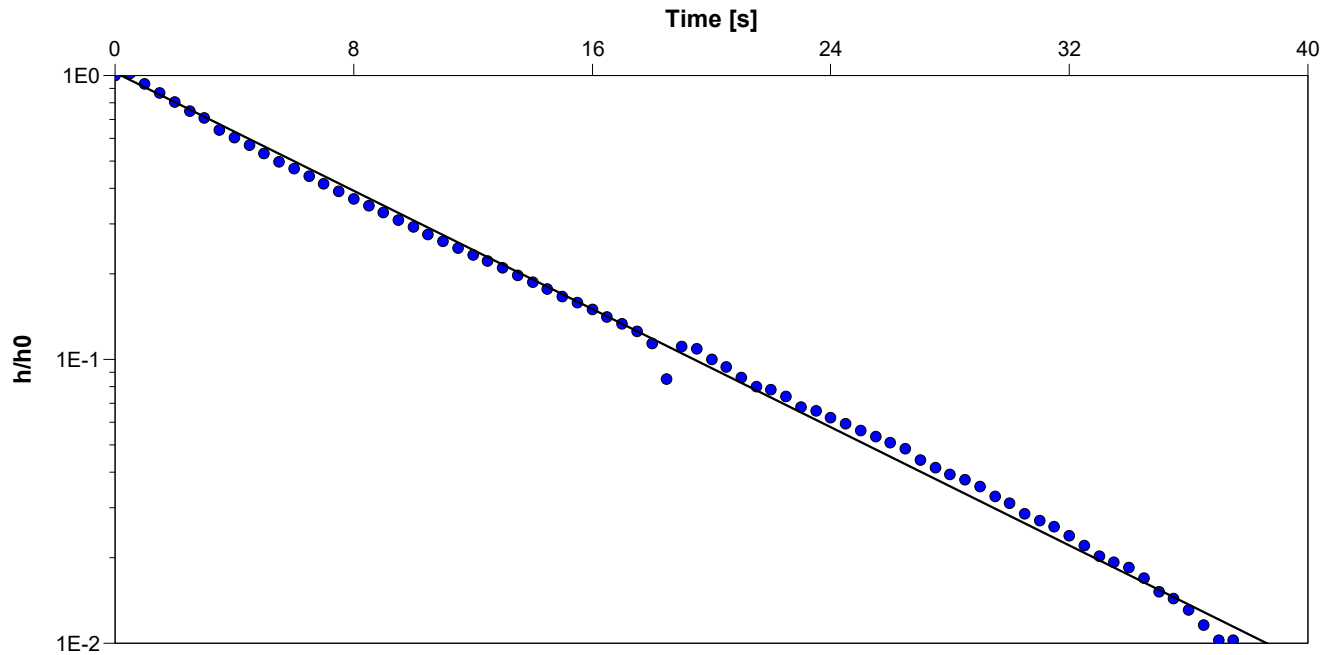
Analysis Performed by: PC

21-01 SWRT Analysis

Analysis Date: 2021-10-12

Aquifer Thickness:

Checked by: DH



Calculation using Hvorslev

Observation Well

Hydraulic  
Conductivity  
[m/s]

21-01

$6.1 \times 10^{-5}$



**THURBER** ENGINEERING LTD.

**Slug Test Analysis Report**

Project: Omer Lake Tributary Culvert

Number: 31344

Client: Hatch

Location: District of Thunder Bay

Slug Test: 21-02

Test Well: 21-02

Test Conducted by: RB

Test Date: 2021-04-25

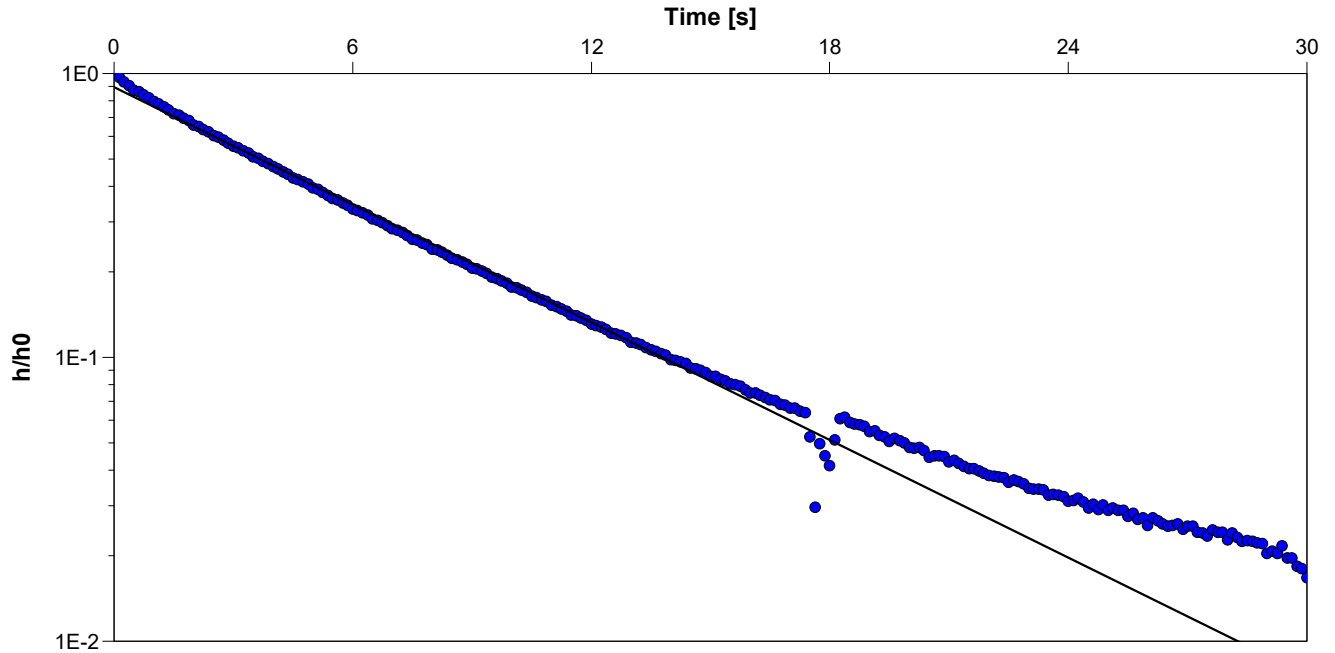
Analysis Performed by: PC

21-02 SWRT Analysis

Analysis Date: 2021-10-12

Aquifer Thickness:

Checked by: DH



Calculation using Hvorslev

Observation Well

Hydraulic  
Conductivity  
[m/s]

21-02

$4.7 \times 10^{-5}$



## FINAL REPORT

CA15887-APR21 R1

31344, Omer Lake Culvert

Prepared for

**Thurber Engineering Ltd.**



FINAL REPORT

CA15887-APR21 R1

First Page

CLIENT DETAILS		LABORATORY DETAILS	
Client	Thurber Engineering Ltd.	Project Specialist	Brad Moore Hon. B.Sc
Address	103, 2010 Winston Park Drive	Laboratory	SGS Canada Inc.
	Oakville, ON	Address	185 Concession St., Lakefield ON, K0L 2H0
	L6H 5R7, Canada		
Contact	Joshua Alexander	Telephone	705-652-2143
Telephone	613-606-7303	Facsimile	705-652-6365
Facsimile		Email	brad.moore@sgs.com
Email	jalexander@thurber.ca	SGS Reference	CA15887-APR21
Project	31344, Omer Lake Culvert	Received	04/28/2021
Order Number		Approved	05/05/2021
Samples	Soil (2)	Report Number	CA15887-APR21 R1
		Date Reported	05/05/2021

COMMENTS
Temperature of Sample upon Receipt: 7 degrees C
Cooling Agent Present: yes
Custody Seal Present: yes
Chain of Custody Number: 019461
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
<div>Brad Moore Hon. B.Sc</div> <div></div>



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# FINAL REPORT

CA15887-APR21 R1

**Client:** Thurber Engineering Ltd.

**Project:** 31344, Omer Lake Culvert

**Project Manager:** Joshua Alexander

**Samplers:** NA

## PACKAGE: - Corrosivity Index (SOIL)

<b>Sample Number</b>	5	6
<b>Sample Name</b>	BH21-01, SS6B	BH21-02, SS8
<b>Sample Matrix</b>	Soil	Soil
<b>Sample Date</b>	20/04/2021	22/04/2021

Parameter	Units	RL		Result	Result
<b>Corrosivity Index</b>					
Corrosivity Index	none	1		11	6
Soil Redox Potential	mV	-		210	199
Sulphide (Na <sub>2</sub> CO <sub>3</sub> )	%	0.04		< 0.04	< 0.04
pH	pH Units	0.05		7.52	8.74
Resistivity (calculated)	ohms.cm	-9999		236	2290

## PACKAGE: - General Chemistry (SOIL)

<b>Sample Number</b>	5	6
<b>Sample Name</b>	BH21-01, SS6B	BH21-02, SS8
<b>Sample Matrix</b>	Soil	Soil
<b>Sample Date</b>	20/04/2021	22/04/2021

Parameter	Units	RL		Result	Result
<b>General Chemistry</b>					
Conductivity	uS/cm	2		4230	436

## PACKAGE: - Metals and Inorganics (SOIL)

<b>Sample Number</b>	5	6
<b>Sample Name</b>	BH21-01, SS6B	BH21-02, SS8
<b>Sample Matrix</b>	Soil	Soil
<b>Sample Date</b>	20/04/2021	22/04/2021

Parameter	Units	RL		Result	Result
<b>Metals and Inorganics</b>					
Moisture Content	%	0.1		29.2	18.9
Sulphate	µg/g	0.4		51	5.2



FINAL REPORT

CA15887-APR21 R1

Client: Thurber Engineering Ltd.

Project: 31344, Omer Lake Culvert

Project Manager: Joshua Alexander

Samplers: NA

PACKAGE: - Other (ORP) (SOIL)

Sample Number	5	6
Sample Name	BH21-01, SS6B	BH21-02, SS8
Sample Matrix	Soil	Soil
Sample Date	20/04/2021	22/04/2021

Parameter	Units	RL		Result	Result
Other (ORP)					
Chloride	µg/g	0.4		4700	190



FINAL REPORT

CA15887-APR21 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	DIO0520-APR21	µg/g	0.4	<0.4	3	20	99	80	120	113	75	125
Sulphate	DIO0520-APR21	µg/g	0.4	<0.4	6	20	97	80	120	85	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)	ECS0001-MAY21	%	0.04	< 0.04	ND	20	105	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	EWL0541-APR21	uS/cm	2	< 2	3	20	101	90	110	NA		





FINAL REPORT

CA15887-APR21 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	EWL0541-APR21	pH Units	0.05	NA	0		100			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.

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## FINAL REPORT

CA15886-APR21 R

31344, Omer Lake Culvert

Prepared for

**Thurber Engineering Ltd.**



# FINAL REPORT

CA15886-APR21 R

## 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                31344, Omer Lake Culvert

Order Number

Samples               Solution (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        CA15886-APR21

Received              04/28/2021

Approved              05/05/2021

Report Number        CA15886-APR21 R

Date Reported         05/05/2021

### COMMENTS

Temperature of Sample upon Receipt: 7 degrees C

Cooling Agent Present:Yes

Custody Seal Present:Yes

### SIGNATORIES

Jill Campbell, B.Sc.,GISAS





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# FINAL REPORT

CA15886-APR21 R

**Client:** Thurber Engineering Ltd.

**Project:** 31344, Omer Lake Culvert

**Project Manager:** Joshua Alexander

**Samplers:** NA

## PACKAGE: - General Chemistry (WATER)

**Sample Number** 6  
**Sample Name** Omer Lake  
Trit@Hwy 11  
**Sample Matrix** Solution  
**Sample Date** 25/04/2021

Parameter	Units	RL	Result
<b>General Chemistry</b>			
Conductivity	uS/cm	2	210
Redox Potential	mV	-	243
Sulphide	µg/L	6	8

## PACKAGE: - Metals and Inorganics (WATER)

**Sample Number** 6  
**Sample Name** Omer Lake  
Trit@Hwy 11  
**Sample Matrix** Solution  
**Sample Date** 25/04/2021

Parameter	Units	RL	Result
<b>Metals and Inorganics</b>			
Sulphate	mg/L	0.04	2.1

## PACKAGE: - Other (ORP) (WATER)

**Sample Number** 6  
**Sample Name** Omer Lake  
Trit@Hwy 11  
**Sample Matrix** Solution  
**Sample Date** 25/04/2021

Parameter	Units	RL	Result
<b>Other (ORP)</b>			
pH	No unit	0.05	7.65
Chloride	mg/L	0.04	39





FINAL REPORT

CA15886-APR21 R

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	DIO0053-MAY21	mg/L	0.04	<0.04	ND	20	96	80	120	90	75	125
Chloride	DIO0524-APR21	mg/L	0.04	<0.04	0	20	101	80	120	101	75	125

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	EWL0547-APR21	uS/cm	2	< 2	1	20	97	90	110	NA		

pH  
Method: SM 4500 | 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
pH	EWL0547-APR21	No unit	0.05	NA	0		100			NA		



FINAL REPORT

CA15886-APR21 R

QC SUMMARY

Redox Potential  
Method: SM 2580 I

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
Redox Potential	EWL0502-APR21	mV	no	NA	1	20	104	80	120	NA		

Sulphide by SFA  
Method: SM 4500 I 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	SKA0022-MAY21	ug/L	6	<0.006	ND	20	102	80	120	NA	75	125



# FINAL REPORT

CA15886-APR21 R

## QC SUMMARY

---

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

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**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.

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-- End of Analytical Report --

Received By: <u>Colin Mazar</u> Received Date: <u>04/28/21</u> (mm/dd/yy) Received Time: <u>11:00</u> (hr:min)		Received By (signature): <u>[Signature]</u> Custody Seal Present: Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> Custody Seal Intact: Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>		Cooling Agent Present: Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> Temperature Upon Receipt (°C): <u>7.22</u> Type: <u>ice</u>		LAB LIMS #: <u>CA15805-</u> 87 April	
<b>REPORT INFORMATION</b> Company: <u>Thurber</u> Contact: <u>Sash Alexander</u> Address: <u>2010-123 Winston</u> <u>Park Dr. Unit 103</u> Phone: <u>613 606-7303</u> Fax: _____ Email: <u>jalexander@thurber.com</u>		<b>INVOICE INFORMATION</b> <input type="checkbox"/> (same as Report Information) Company: _____ Contact: _____ Address: _____ Phone: _____ Email: _____		Quotation #: <u>31344</u> Project #: <u>31344</u> P.O. #: _____ Site Location/ID: <u>Over Lake Culvert</u>		<b>TURNAROUND TIME (TAT) REQUIRED</b> <input checked="" type="checkbox"/> Regular TAT (5-7 days) <input type="checkbox"/> 1 Day <input type="checkbox"/> 2 Days <input type="checkbox"/> 3 Days <input type="checkbox"/> 4 Days RUSH TAT (Additional Charges May Apply): PLEASE CONFIRM RUSH FEASIBILITY WITH SGS REPRESENTATIVE PRIOR TO SUBMISSION	
<b>REGULATIONS</b> <input type="checkbox"/> O.Reg 153/04 <input type="checkbox"/> O.Reg 406/19 <input type="checkbox"/> Table 1 <input type="checkbox"/> Res/Park <input type="checkbox"/> Soil Texture: _____ <input type="checkbox"/> Table 2 <input type="checkbox"/> Ind/Com <input type="checkbox"/> Coarse <input type="checkbox"/> Table 3 <input type="checkbox"/> Agri/Other <input type="checkbox"/> Medium/Fine <input type="checkbox"/> Table _____ Soil Volume <input type="checkbox"/> <350m3 <input type="checkbox"/> >350m3		<b>Other Regulations:</b> <input type="checkbox"/> Reg 347/558 (3 Day min TAT) <input checked="" type="checkbox"/> Reg 347/558 (3 Day min TAT) <input type="checkbox"/> CCME <input type="checkbox"/> MISA <input type="checkbox"/> ODWS Not Reportable *See note		<b>Sewer By-Law:</b> <input type="checkbox"/> Sanitary <input type="checkbox"/> Storm <input type="checkbox"/> Municipality: _____		Specify Due Date: _____ *NOTE: DRINKING (POTABLE) WATER SAMPLES FOR HUMAN CONSUMPTION MUST BE SUBMITTED WITH SGS DRINKING WATER CHAIN OF CUSTODY	
<b>ANALYSIS REQUESTED</b>							
<b>RECORD OF SITE CONDITION (RSC)</b> <input type="checkbox"/> YES <input type="checkbox"/> NO		<b>DATE SAMPLED</b>		<b>TIME SAMPLED</b>		<b># OF BOTTLES</b>	
<b>SAMPLE IDENTIFICATION</b>		<b>DATE SAMPLED</b>		<b>TIME SAMPLED</b>		<b># OF BOTTLES</b>	
1 BH 21-01		04/25/21 13:00pm		13		water	
2 Over Lake Take Home		04/25/21 1:00pm		1		water	
3 BH 21-01, 55GB		04/25/21 2:00pm		1		Soil	
4 BH 21-01, 55B		04/25/21 4:00pm		1		Soil	
5							
6							
7							
8							
9							
10							
11							
12							
Observations/Comments/Special Instructions: <u>Please only test parameters within hold time</u>							
Sampled By (NAME): <u>Sash Alexander</u>		Signature: <u>[Signature]</u>		Date: <u>04/28/21</u> (mm/dd/yy)		Pink Copy - Client	
Relinquished by (NAME): <u>Sash Alexander</u>		Signature: <u>[Signature]</u>		Date: <u>04/28/21</u> (mm/dd/yy)		Yellow & White Copy - SGS	
Note: Submission of samples to SGS is acknowledgement that you have been provided direction 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 <a href="http://www.sgs.com/terms_and_conditions.htm">http://www.sgs.com/terms_and_conditions.htm</a> . (Printed copies are available upon request.) Attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein.							

COMMENTS:



## FINAL REPORT

CA15885-APR21 R1

31344, Omer Lake Culvert

Prepared for

**Thurber Engineering Ltd.**



FINAL REPORT

CA15885-APR21 R1

First Page

CLIENT DETAILS		LABORATORY DETAILS	
Client	Thurber Engineering Ltd.	Project Specialist	Jill Campbell, B.Sc.,GISAS
Address	103, 2010 Winston Park Drive, Oakville	Laboratory	SGS Canada Inc.
	Canada, L6H 5R7	Address	185 Concession St., Lakefield ON, K0L 2H0
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Email	jalexander@thurber.ca	SGS Reference	CA15885-APR21
Project	31344, Omer Lake Culvert	Received	04/28/2021
Order Number		Approved	05/04/2021
Samples	Ground Water (1)	Report Number	CA15885-APR21 R1
		Date Reported	05/04/2021

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:7 Cooling Agent Present:Yes Custody Seal Present:Yes  Chain of Custody Number:019461


SIGNATORIES
Jill Campbell, B.Sc.,GISAS 







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# FINAL REPORT

CA15885-APR21 R1

**Client:** Thurber Engineering Ltd.

**Project:** 31344, Omer Lake Culvert

**Project Manager:** Joshua Alexander

**Samplers:** NA

PACKAGE: **General Chemistry** (WATER)

**Sample Number** 7

**Sample Name** BH21-01

**Sample Matrix** Ground Water

**Sample Date** 25/04/2021

L1 = PWQQ\_L / WATER / - - Table 2 - General - July 1999 PIBS 3303E

Parameter	Units	RL	L1	Result
<b>General Chemistry</b>				
UV Transmittance	%T			72.9
Alkalinity	mg/L as CaCO <sub>3</sub>	2		116
Bicarbonate	mg/L as CaCO <sub>3</sub>	2		116
Carbonate	mg/L as CaCO <sub>3</sub>	2		< 2
OH	mg/L as CaCO <sub>3</sub>	2		< 2
Colour	TCU	3		11
Conductivity	uS/cm	2		638
Total Suspended Solids	mg/L	2		121
Organic Nitrogen	mg/L	0.05		0.43
Total Kjeldahl Nitrogen (N)	as N mg/L	0.05		1.58
Ammonia+Ammonium (N)	as N mg/L	0.04		1.15
Dissolved Organic Carbon	mg/L	1		7
Total Organic Carbon	mg/L	1		8
Sulphide	µg/L	6		< 6



# FINAL REPORT

CA15885-APR21 R1

**Client:** Thurber Engineering Ltd.

**Project:** 31344, Omer Lake Culvert

**Project Manager:** Joshua Alexander

**Samplers:** NA

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

**Sample Number** 7

**Sample Name** BH21-01

**Sample Matrix** Ground Water

**Sample Date** 25/04/2021

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

Parameter	Units	RL	L1	Result
<b>Metals and Inorganics</b>				
Fluoride	mg/L	0.06		0.12
Bromide	mg/L	0.05		0.05#<MDL
Nitrite (as N)	as N mg/L	0.003		0.003#<MDL
Nitrate (as N)	as N mg/L	0.006		0.102
Sulphate	mg/L	0.04		8.8
Mercury	µg/L	0.01	0.2	0.01
Hardness	mg/L as CaCO3	0.05		107
Aluminum	µg/L	1	15	1470
Arsenic	µg/L	0.2	5	3.1
Boron	µg/L	2	200	8
Barium	µg/L	0.02		20.4
Beryllium	µg/L	0.007	11	0.091
Bismuth	µg/L	0.01		0.01
Cobalt	µg/L	0.004	0.9	2.51
Calcium	mg/L	0.01		32.1
Cadmium	µg/L	0.003	0.1	0.044
Copper	µg/L	0.2	1	12.2
Chromium	µg/L	0.08	100	4.35
Iron	ug/L	7	300	3120
Potassium	mg/L	0.009		2.30
Magnesium	mg/L	0.001		6.46
Manganese	µg/L	0.01		95.5
Molybdenum	µg/L	0.04	40	3.61



FINAL REPORT

CA15885-APR21 R1

Client: Thurber Engineering Ltd.  
Project: 31344, Omer Lake Culvert  
Project Manager: Joshua Alexander  
Samplers: NA

PACKAGE: Metals and Inorganics (WATER)

Sample Number 7  
Sample Name BH21-01  
Sample Matrix Ground Water  
Sample Date 25/04/2021

L1 = PWQQ\_L / WATER / - - Table 2 - General - July 1999 PIBS 3303E

Parameter	Units	RL	L1	Result
Metals and Inorganics (continued)				
Nickel	µg/L	0.1	25	6.2
Sodium	mg/L	0.01		93.8
Phosphorus	mg/L	0.003	0.01	0.121
Lead	µg/L	0.01	11	1.83
Silicon	ug/L	20		4400
Silver	µg/L	0.05	0.1	< 0.05
Strontium	µg/L	0.02		71.5
Thallium	µg/L	0.005	0.3	0.038
Tin	µg/L	0.06		1.54
Titanium	ug/L	0.05		44.7
Antimony	µg/L	0.9	20	1.6
Selenium	µg/L	0.04	100	0.21
Uranium	µg/L	0.002	5	4.94
Vanadium	µg/L	0.01	6	4.58
Zinc	µg/L	2	20	13



FINAL REPORT

CA15885-APR21 R1

**Client:** Thurber Engineering Ltd.  
**Project:** 31344, Omer Lake Culvert  
**Project Manager:** Joshua Alexander  
**Samplers:** NA

PACKAGE: Other (ORP) (WATER)

**Sample Number** 7  
**Sample Name** BH21-01  
**Sample Matrix** Ground Water  
**Sample Date** 25/04/2021

L1 = PWQQ\_L / WATER / - - Table 2 - General - July 1999 PIBS 3303E

Parameter	Units	RL	L1	Result
Other (ORP)				
pH	No unit	5	0.1	8.21
Chloride	mg/L	0.04		130
Chromium VI	µg/L	0.2	1	< 0.2
Phenols				
4AAP-Phenolics	mg/L	0.002	0.001	< 0.002



EXCEEDANCE SUMMARY

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

BH21-01

Aluminum	SM 3030/EPA 200.8	µg/L	1470	15
Cobalt	SM 3030/EPA 200.8	µg/L	2.51	0.9
Copper	SM 3030/EPA 200.8	µg/L	12.2	1
Iron	SM 3030/EPA 200.8	ug/L	3120	300
Phosphorus	SM 3030/EPA 200.8	mg/L	0.121	0.01
pH	SM 4500	No unit	8.21	0.1
4AAP-Phenolics	SM 5530B-D	mg/L	< 0.002	0.001



FINAL REPORT

CA15885-APR21 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	EWL0547-APR21	mg/L as CaCO3	2	< 2	0	20	100	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)	SKA0276-APR21	mg/L	0.04	<0.04	4	10	101	90	110	101	75	125



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CA15885-APR21 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
Bromide	DIO0523-APR21	mg/L	0.05	<0.05	1	20	99	80	120	99	75	125
Nitrite (as N)	DIO0523-APR21	mg/L	0.003	<0.003	ND	20	95	80	120	98	75	125
Nitrate (as N)	DIO0523-APR21	mg/L	0.006	<0.006	0	20	102	80	120	92	75	125
Chloride	DIO0525-APR21	mg/L	0.04	<0.04	NV	20	100	80	120	NV	75	125
Sulphate	DIO0525-APR21	mg/L	0.04	<0.04	0	20	96	80	120	90	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	SKA0010-MAY21	mg/L	1	<1	1	10	103	90	110	102	75	125
Total Organic Carbon	SKA0010-MAY21	mg/L	1	<1	1	10	103	90	110	102	75	125





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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	EWL0547-APR21	mg/L as CaCO3	2	< 2	ND	10	NA	90	110	NA		
Bicarbonate	EWL0547-APR21	mg/L as CaCO3	2	< 2	0	10	NA	90	110	NA		
OH	EWL0547-APR21	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	EWL0518-APR21	TCU	3	< 3	ND	10	105	80	120	NA		



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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	EWL0547-APR21	uS/cm	2	< 2	1	20	97	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	EWL0520-APR21	mg/L	0.06	<0.06	ND	10	107	90	110	106	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	SKA0265-APR21	ug/L	0.2	<0.2	6	20	104	80	120	NV	75	125



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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	EHG0027-APR21	ug/L	0.01	<0.01	ND	20	108	80	120	115	70	130



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CA15885-APR21 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	EMS0161-APR21	ug/L	0.05	< 0.05	ND	20	99	90	110	105	70	130
Aluminum	EMS0161-APR21	ug/L	1	< 1	ND	20	106	90	110	130	70	130
Arsenic	EMS0161-APR21	ug/L	0.2	< 0.2	1	20	102	90	110	114	70	130
Barium	EMS0161-APR21	ug/L	0.02	< 0.02	3	20	99	90	110	101	70	130
Beryllium	EMS0161-APR21	ug/L	0.007	< 0.07	ND	20	110	90	110	111	70	130
Boron	EMS0161-APR21	ug/L	2	< 2	1	20	94	90	110	NV	70	130
Bismuth	EMS0161-APR21	ug/L	0.01	< 0.01	ND	20	93	90	110	97	70	130
Calcium	EMS0161-APR21	mg/L	0.01	< 0.02	4	20	95	90	110	91	70	130
Cadmium	EMS0161-APR21	ug/L	0.003	< 0.003	18	20	96	90	110	117	70	130
Cobalt	EMS0161-APR21	ug/L	0.004	< 0.004	18	20	101	90	110	109	70	130
Chromium	EMS0161-APR21	ug/L	0.08	< 0.08	ND	20	101	90	110	100	70	130
Copper	EMS0161-APR21	ug/L	0.2	< 0.2	2	20	99	90	110	95	70	130
Iron	EMS0161-APR21	ug/L	7	< 7	2	20	99	90	110	100	70	130
Potassium	EMS0161-APR21	mg/L	0.009	< 0.009	2	20	99	90	110	NV	70	130
Magnesium	EMS0161-APR21	mg/L	0.001	< 0.001	0	20	99	90	110	91	70	130
Manganese	EMS0161-APR21	ug/L	0.01	< 0.01	1	20	100	90	110	99	70	130
Molybdenum	EMS0161-APR21	ug/L	0.04	< 0.04	7	20	99	90	110	110	70	130
Sodium	EMS0161-APR21	mg/L	0.01	< 0.01	0	20	99	90	110	96	70	130
Nickel	EMS0161-APR21	ug/L	0.1	< 0.1	2	20	98	90	110	130	70	130
Lead	EMS0161-APR21	ug/L	0.01	< 0.01	ND	20	108	90	110	118	70	130



FINAL REPORT

CA15885-APR21 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
Phosphorus	EMS0161-APR21	mg/L	0.003	< 0.003	ND	20	98	90	110	NV	70	130
Antimony	EMS0161-APR21	ug/L	0.9	< 0.09	ND	20	100	90	110	125	70	130
Selenium	EMS0161-APR21	ug/L	0.04	< 0.04	ND	20	99	90	110	111	70	130
Silicon	EMS0161-APR21	ug/L	20	< 0.02	6	20	97	90	110	NV	70	130
Tin	EMS0161-APR21	ug/L	0.06	< 0.06	ND	20	95	90	110	NV	70	130
Strontium	EMS0161-APR21	ug/L	0.02	< 0.02	1	20	96	90	110	94	70	130
Titanium	EMS0161-APR21	ug/L	0.05	< 0.05	10	20	96	90	110	NV	70	130
Thallium	EMS0161-APR21	ug/L	0.005	< 0.005	ND	20	100	90	110	108	70	130
Uranium	EMS0161-APR21	ug/L	0.002	< 0.002	3	20	99	90	110	109	70	130
Vanadium	EMS0161-APR21	ug/L	0.01	< 0.01	ND	20	103	90	110	110	70	130
Zinc	EMS0161-APR21	ug/L	2	< 2	0	20	99	90	110	105	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	EWL0547-APR21	No unit	5	NA	0		100			NA		



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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	SKA0021-MAY21	mg/L	0.002	<0.002	ND	10	100	80	120	86	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	SKA0022-MAY21	ug/L	6	<0.006	ND	20	102	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	EWL0558-APR21	mg/L	2	< 2	1	10	99	90	110	NA		



FINAL REPORT

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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)	SKA0272-APR21	mg/L	0.05	<0.05	0	10	102	90	110	85	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 --



REPORT INFORMATION						INVOICE INFORMATION						LABORATORY INFORMATION SECTION - Lab use only																																															
Received By: <u>Cathy Mazarin</u>			Received Date: <u>04/28/21</u> (mm/dd/yy)			Custody Seal Present: Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>			Cooling Agent Present: Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>			Type: <u>ice</u>			LAB LIMS #: <u>CA15805-</u>																																												
Received Time: <u>11:00</u> (hr.: min)						Custody Seal Intact: Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>			Temperature Upon Receipt (°C) <u>7.77</u>						P.O. #: <u>874928</u>																																												
Company: <u>Thurber</u>						( ) same as Report Information						Quotation #: <u>31344</u>						Site Location/ID: <u>Over Lake Culvert</u>																																									
Contact: <u>Sash Alexander</u>						Company:						Project #:						TURNAROUND TIME (TAT) REQUIRED																																									
Address: <u>2010-133 Livingston Park Dr., unit 103</u>						Address:						Regular TAT (5-7 days) <input checked="" type="checkbox"/>						TAT's are quoted in business days (exclude statutory holidays & weekends). Samples received after 6pm or on weekends: TAT begins next business day																																									
Phone: <u>613 606-7303</u>						Phone:						RUSH TAT (Additional Charges May Apply): <input type="checkbox"/> 1 Day <input type="checkbox"/> 2 Days <input type="checkbox"/> 3 Days <input type="checkbox"/> 4 Days						PLEASE CONFIRM RUSH FEASIBILITY WITH SGS REPRESENTATIVE PRIOR TO SUBMISSION																																									
Fax:						Email: <u>jalexander@thurber.ca</u>						Specify Due Date:						*NOTE: DRINKING (POTABLE) WATER SAMPLES FOR HUMAN CONSUMPTION MUST BE SUBMITTED WITH SGS DRINKING WATER CHAIN OF CUSTODY																																									
REGULATIONS												ANALYSIS REQUESTED												COMMENTS:																																			
O.Reg 153/04 <input type="checkbox"/> O.Reg 406/19 <input type="checkbox"/> Table 1 <input type="checkbox"/> Res/Park Soil Texture: Table 2 <input type="checkbox"/> Ind/Com <input type="checkbox"/> Coarse Table 3 <input type="checkbox"/> Agri/Other <input type="checkbox"/> Medium/Fine Table <input type="checkbox"/> <input type="checkbox"/> >350m3 Soil Volume <input type="checkbox"/> <350m3 <input type="checkbox"/> >350m3						Other Regulations: <input type="checkbox"/> Reg 347/558 (3 Day min TAT) <input checked="" type="checkbox"/> PWOO <input type="checkbox"/> MMER <input type="checkbox"/> CCME <input type="checkbox"/> Other: <input type="checkbox"/> MISA <input type="checkbox"/> ODWS Not Reportable *See note						Sewer By-Law: <input type="checkbox"/> Sanitary <input type="checkbox"/> Storm Municipality:						M & I Metals & Inorganics (Cl, Na-water) Full Metals Suite (BFW-S&I only) Hg, CrVI ICP Metals only PAHs only SVOCs (all incl PAHs, ABNs, CPS) PCBs <input type="checkbox"/> Total <input type="checkbox"/> Aroclor F1-F4 + BTEX VOCs BTEX only Pesticides (Organochlorines or specify other)																		Other (please specify)						TCPL Specify TCPL tests <input type="checkbox"/> M&I <input type="checkbox"/> VOC <input type="checkbox"/> PCB <input type="checkbox"/> B(a)p <input type="checkbox"/> ABN <input type="checkbox"/> Light																	
RECORD OF SITE CONDITION (RSC) <input type="checkbox"/> YES <input type="checkbox"/> NO												DATE SAMPLED												TIME SAMPLED												# OF BOTTLES												MATRIX											
SAMPLE IDENTIFICATION												04/25/21 11:00am												13												water																							
1 BH 21-01												04/25/21 1:00pm												1												water																							
2 Over Lake Take @ Hwy 11												04/28/21 2:00pm												1												soil																							
3 BH 21-01, SSGB												04/28/21 4:00pm												1												soil																							
4 BH 21-02, SS8																																																											
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Please only test parameters within hold time																																																											
Sampled By (NAME): <u>Sash Alexander</u>												Signature: <u>[Signature]</u>												Date: <u>04/28/21</u> (mm/dd/yy)												Pink Copy - Client																							
Relinquished by (NAME): <u>Sash Alexander</u>												Signature: <u>[Signature]</u>												Date: <u>04/28/21</u> (mm/dd/yy)												Yellow & White Copy - SGS																							
Note: Submission of samples to SGS is acknowledgement that you have been provided direction 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. (Printed copies are available upon request.) Attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein.																																																											



## FINAL REPORT

CA15271-MAY21 R1

31344, Omer Lake Culvert

Prepared for

**Thurber Engineering Ltd.**



# FINAL REPORT

CA15271-MAY21 R1

## First Page

### CLIENT DETAILS

Client                   Thurber Engineering Ltd.

Address                103, 2010 Winston Park Drive, Oakville  
Canada, L6H 5R7  
Phone: 613-606-7303. Fax:

Contact                Joshua Alexander

Telephone             613-606-7303

Facsimile

Email                  jalexander@thurber.ca

Project                31344, Omer Lake Culvert

Order Number

Samples               Ground Water (1)

### LABORATORY DETAILS

Project Specialist     Brad Moore Hon. B.Sc

Laboratory            SGS Canada Inc.

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

Telephone             705-652-2143

Facsimile             705-652-6365

Email                  brad.moore@sgs.com

SGS Reference        CA15271-MAY21

Received              05/18/2021

Approved             05/27/2021

Report Number        CA15271-MAY21 R1

Date Reported         05/27/2021

### COMMENTS

### SIGNATORIES

Brad Moore Hon. B.Sc



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# FINAL REPORT

CA15271-MAY21 R1

**Client:** Thurber Engineering Ltd.

**Project:** 31344, Omer Lake Culvert

**Project Manager:** Joshua Alexander

**Samplers:** NA

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

**Sample Number** 7  
**Sample Name** BH21-01  
**Sample Matrix** Ground Water  
**Sample Date** 25/04/2021

L1 = PWQO\_L / 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		77.7
Aluminum (dissolved)	mg/L	0.001	0.015	0.031
Arsenic (dissolved)	mg/L	0.0002		0.0017
Boron (dissolved)	mg/L	0.002		0.009
Barium (dissolved)	mg/L	0.00002		0.00923
Beryllium (dissolved)	mg/L	0.00000 7		< 0.000007
Bismuth (dissolved)	mg/L	0.00001		< 0.00001
Cobalt (dissolved)	mg/L	0.00000 4		0.000091
Calcium (dissolved)	mg/L	0.01		23.4
Cadmium (dissolved)	mg/L	0.00000 3		0.000012
Copper (dissolved)	mg/L	0.0002		0.0034
Chromium (dissolved)	mg/L	0.00008		0.00026
Iron (dissolved)	mg/L	0.007		0.042
Potassium (dissolved)	mg/L	0.009		2.18
Magnesium (dissolved)	mg/L	0.001		4.66
Manganese (dissolved)	mg/L	0.00001		0.00049
Molybdenum (dissolved)	mg/L	0.00004		0.00453
Nickel (dissolved)	mg/L	0.0001		0.0010
Sodium (dissolved)	mg/L	0.01		94.7
Phosphorus (dissolved)	mg/L	0.003		0.016



# FINAL REPORT

CA15271-MAY21 R1

**Client:** Thurber Engineering Ltd.

**Project:** 31344, Omer Lake Culvert

**Project Manager:** Joshua Alexander

**Samplers:** NA

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

**Sample Number** 7

**Sample Name** BH21-01

**Sample Matrix** Ground Water

**Sample Date** 25/04/2021

L1 = PWQQ\_L / WATER / - - Table 2 - General - July 1999 PIBS 3303E

Parameter	Units	RL	L1	Result
<b>Metals and Inorganics (continued)</b>				
Lead (dissolved)	mg/L	0.00009		< 0.00009
Silicon (dissolved)	mg/L	0.02		2.89
Silver (dissolved)	mg/L	0.00005		< 0.00005
Strontium (dissolved)	mg/L	0.00002		0.0596
Thallium (dissolved)	mg/L	0.00000 5		0.000013
Tin (dissolved)	mg/L	0.00006		0.00071
Titanium (dissolved)	mg/L	0.00005		0.00049
Antimony (dissolved)	mg/L	0.0009		0.0022
Selenium (dissolved)	mg/L	0.00004		0.00015
Uranium (dissolved)	mg/L	0.00000 2		0.00410
Vanadium (dissolved)	mg/L	0.00001		0.00090
Zinc (dissolved)	mg/L	0.002		< 0.002



EXCEEDANCE SUMMARY

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

BH21-01

Aluminum (dissolved)	SM 3030/EPA 200.8	mg/L	0.031	0.015
----------------------	-------------------	------	-------	-------



FINAL REPORT

CA15271-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
Sodium (dissolved)	EMS0103-MAY21	mg/L	0.01	<0.01	2	20	107	90	110	99	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





FINAL REPORT

CA15271-MAY21 R1

QC SUMMARY

Metals in aqueous samples - ICP-MS (continued)  
Method: SM 3030/EPA 200.8 | Internal ref.: ME-CA-ENVISPE-LAK-AN-003

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
Phosphorus (dissolved)	EMS0103-MAY21	mg/L	0.003	<0.003	6	20	99	90	110	NV	70	130
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



# FINAL REPORT

CA15271-MAY21 R1

## 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.

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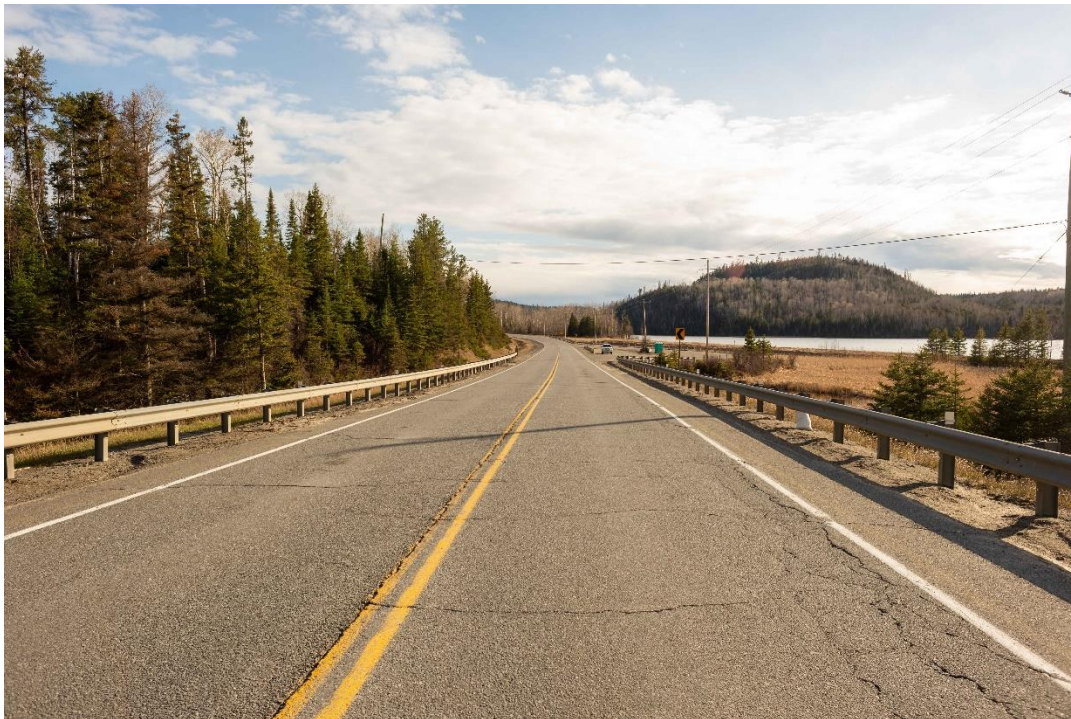


## **Appendix C**

### **Site Photographs**



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



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





**Figure 3: Looking south towards culvert inlet (May 2021)**



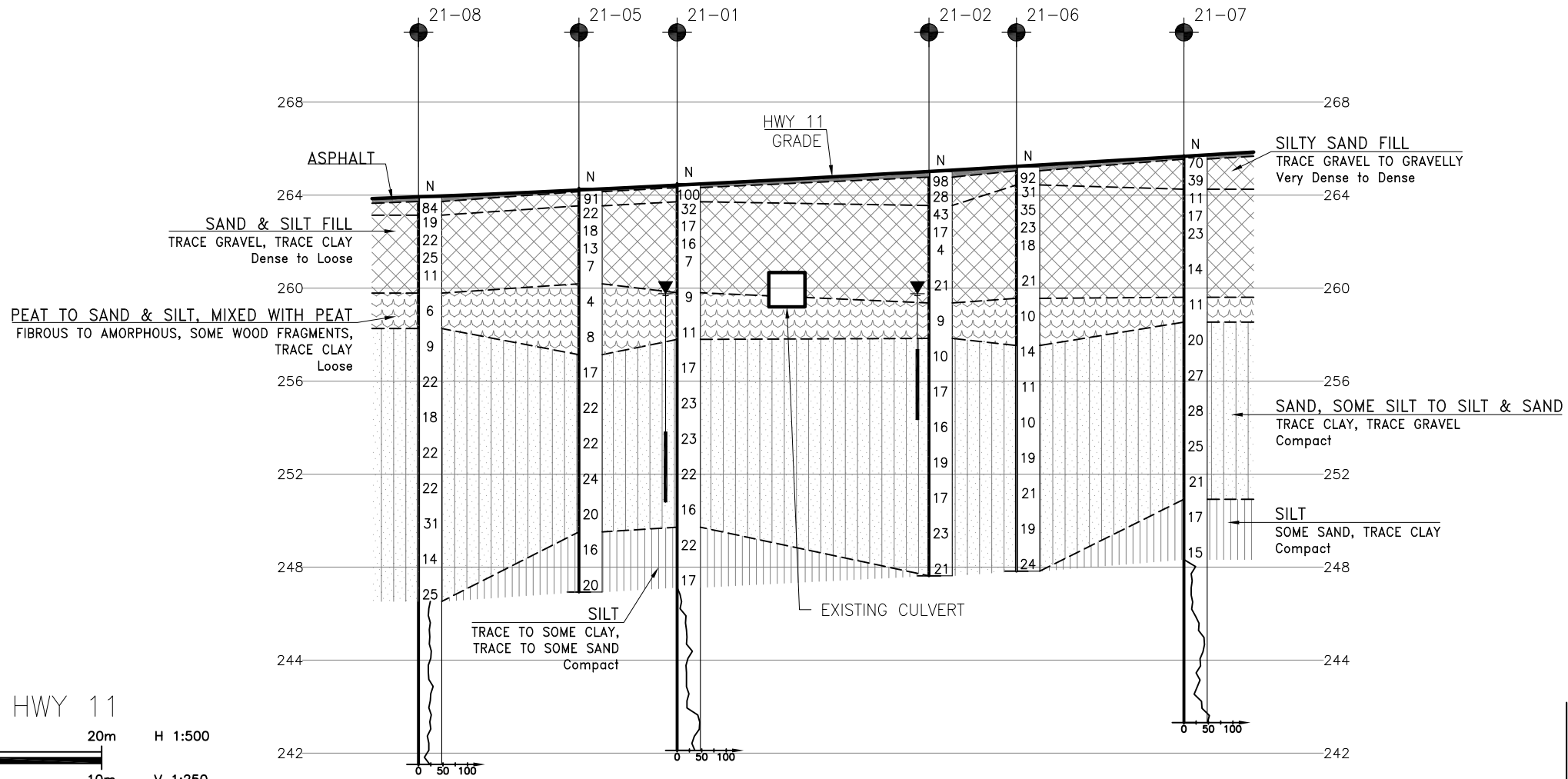
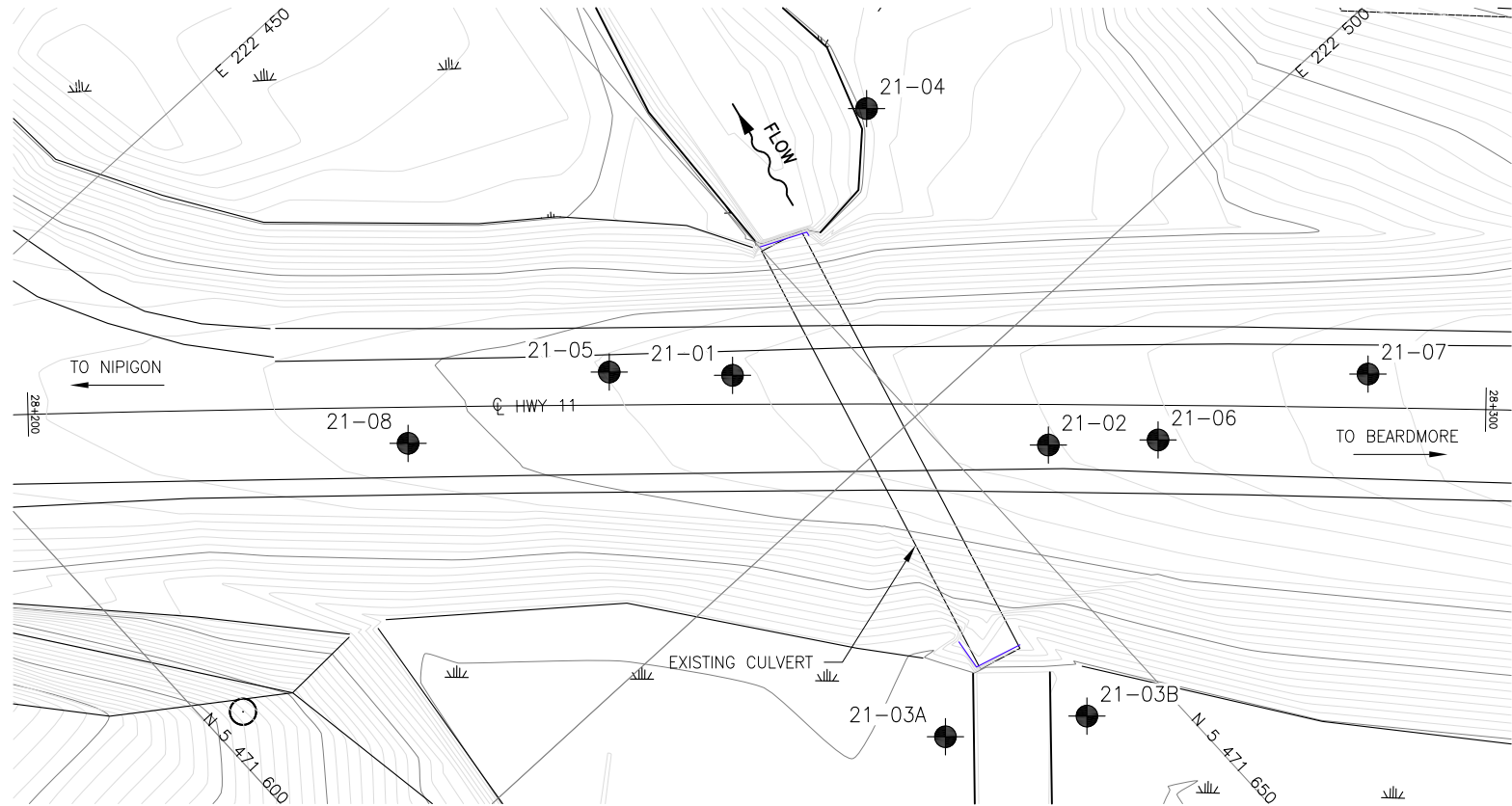
**Figure 4: Looking north towards culvert outlet (May 2021)**



## **Appendix D**

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





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



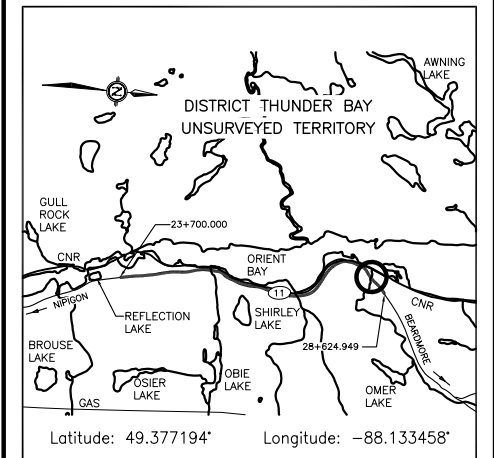
CONT No  
WP No 6118-17-01

OMER LAKE CULVERT  
ON HIGHWAY 11  
REPLACEMENT  
BOREHOLE LOCATIONS AND SOIL STRATA

HATCH



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
21-01	264.5	5 471 642.7	222 489.4
21-02	265.0	5 471 655.5	222 507.6
21-03A	259.9	5 471 636.7	222 517.6
21-03B	259.8	5 471 644.9	222 523.1
21-04	260.2	5 471 661.8	222 482.1
21-05	264.3	5 471 636.6	222 483.6
21-06	265.2	5 471 661.2	222 512.4
21-07	265.7	5 471 674.9	222 518.8
21-08	263.9	5 471 623.1	222 477.9

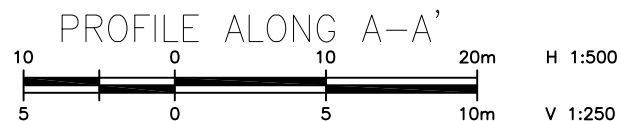
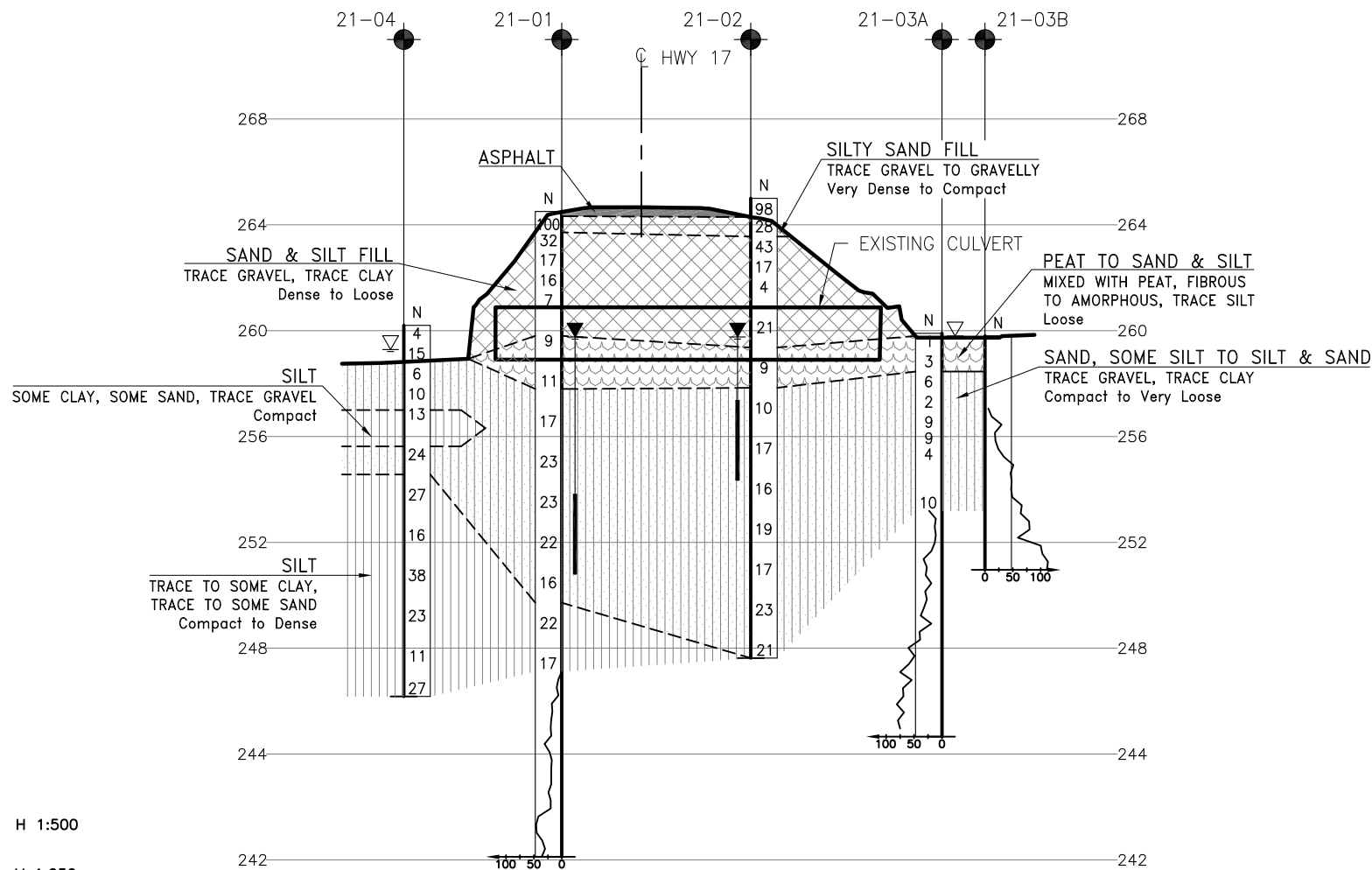
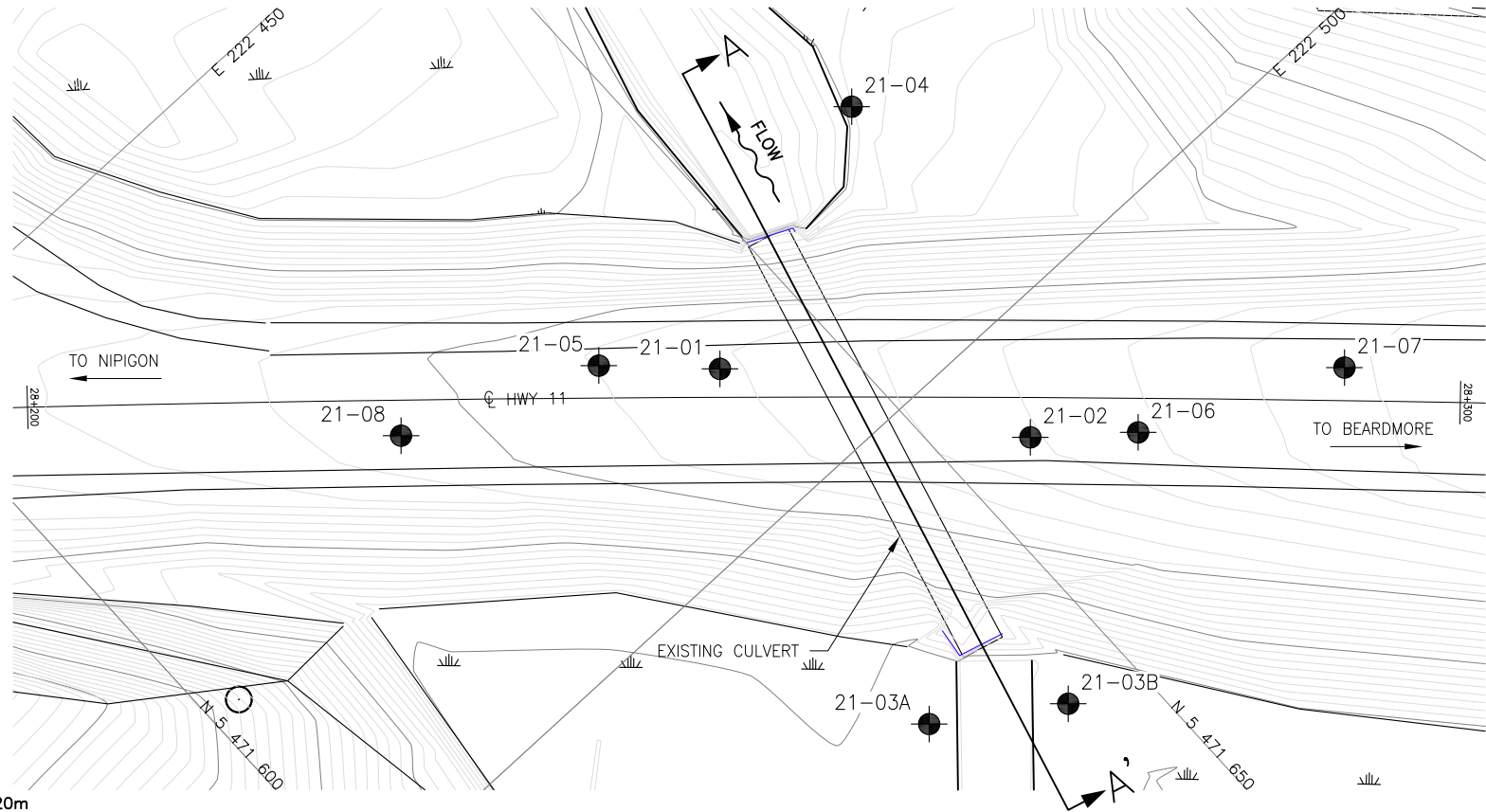
-NOTES-

- 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-051

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	JA	CHK MEF	CODE
DRAWN	AN	CHK JA	SITE 48C-0181/CO
LOAD	DATE	JAN 2023	DWG 1





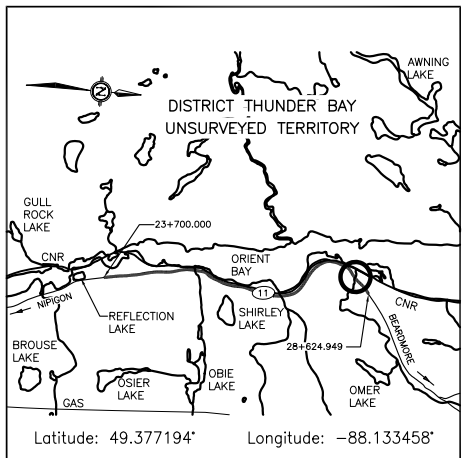
METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN



CONT No  
WP No 6118-17-01

OMER LAKE CULVERT  
ON HIGHWAY 11  
REPLACEMENT  
BOREHOLE LOCATIONS AND SOIL STRATA

**HATCH**



KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
21-01	264.5	5 471 642.7	222 489.4
21-02	265.0	5 471 655.5	222 507.6
21-03A	259.9	5 471 636.7	222 517.6
21-03B	259.8	5 471 644.9	222 523.1
21-04	260.2	5 471 661.8	222 482.1
21-05	264.3	5 471 636.6	222 483.6
21-06	265.2	5 471 661.2	222 512.4
21-07	265.7	5 471 674.9	222 518.8
21-08	263.9	5 471 623.1	222 477.9

-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-051

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	JA	CHK MEF	CODE
DRAWN	AN	CHK JA	SITE 48C-0181/CO
			LOAD
			DATE JAN 2023
			DWG 2



## **Appendix E**

### **Foundation Comparison**



## **GEOTECHNICAL COMPARISON OF ALTERNATIVE FOUNDATION TYPES**

<b>Corrugated Steel Pipe (CSP), Structural Steel CSP (SPCSP), or Twin SPCSPs</b>	<b>Concrete Box Culvert</b>	<b>Concrete Open Footing Culvert</b>	<b>Structural Steel CSP Arch Supported on Sheet Piles</b>
<u>Advantages:</u> i. Conventional construction.  ii. Segmented pipes can accommodate some potential differential settlement along culvert axis  iii. Steel pipes may be more cost effective than concrete box or open footing culverts.	<u>Advantages:</u> i. Relatively rapid installation and less disturbance to subgrade soils if pre-cast segments are used.  ii. Segmental option can accommodate some potential differential settlement along culvert axis.  iii. Able to be constructed in the wet.	<u>Advantages:</u> i. Conventional construction.  ii. Possibly less disturbance of creek channel / less environmental issues such as those involving spawning fish species.	<u>Advantages:</u> i. Does not require excavation for placement of culvert bedding.  ii. Reduces the need to excavate peat from below the groundwater level.  iii. Able to be constructed in the wet.
<u>Disadvantages:</u> i. Steel pipes may have shorter design life than concrete culverts.  ii. Higher corrosion potential compared to concrete culverts.  iii. Multiple pipes maybe needed to meet hydraulic requirements.  iv. Not recommended to be placed in the wet.  v. Additional field investigation and stability assessments are recommended in peat removal	<u>Disadvantages:</u> i. More expensive than a Concrete pipe or CSP culvert.  ii. Additional field investigation and stability assessments are recommended in peat removal areas near the embankment toes.	<u>Disadvantages:</u> i. Greater potential for differential settlement.  ii. Deeper excavation and potentially longer dewatering requirements in cohesionless soils.  iii. Additional field investigation and stability assessments are recommended in peat removal areas near the embankment toes.	<u>Disadvantages:</u> i. Potentially more expensive than a Concrete pipe or CSP culvert.  ii. Higher corrosion potential compared to concrete culverts and where sheet piles are in contact with peat.  iii. Additional foundation investigation recommended to confirm the soil conditions along the sheet pile alignments.  iv. Additional field investigation and stability assessments are recommended in peat removal



Corrugated Steel Pipe (CSP), Structural Steel CSP (SPCSP), or Twin SPCSPs	Concrete Box Culvert	Concrete Open Footing Culvert	Structural Steel CSP Arch Supported on Sheet Piles
areas near the embankment toes.			areas near the embankment toes.  v. Risk of encountering obstructions when driving piles.
FEASIBLE	RECOMMENDED	NOT RECOMMENDED	RECOMMENDED



## **Appendix F**

### **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.PROV 421	Construction Specification for Pipe Culvert Installation in Open Cut
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
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
OPSS.PROV 903	Construction Specification for Deep Foundations
SP 109S12	QVE, Backfilling Compaction, and Certificate of Conformance
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 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



## **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 Installation of Steel Sheet Piles**

Obstructions such as wood, boulders or rock fill may be present within the existing embankment fill. These obstructions may impede the driving of sheet piles and at some locations the sheet piles may not be able to penetrate these materials to reach the design depth of installation. The Contractor shall be prepared to remove, drill through and/or penetrate these obstructions and extend the piles to the design depth.

- **Suggested Text for NSSP on Temporary Modular Bridge**

The Contractor is responsible for the detailed design of the Temporary Modular Bridge (TMB) including, but not limited to, slope stability of the temporary excavation slope in front of the TMB abutment footings, determination of bearing capacity for the abutment footings and safe footing set back distance from the open excavation, as well as the performance of the temporary footings throughout construction. As a minimum, modular bridge footings shall be set back a minimum two (2) metres from the top of the temporary excavation. The temporary excavation slope shall be no steeper than two (2) horizontal to one (1) vertical with full dewatering to 500 mm below the final base of the temporary excavation for the duration of time when the temporary modular bridge is in use. The contractor is responsible for retaining



a RAQS approved Licensed Geotechnical Engineer with a medium-complexity rating (RAQs Category – Geotechnical Structures and Embankment – Medium Complexity) to confirm all aspects of the modular bridge slope stability and foundation design. All final reports and drawings must be sealed and signed by a Professional Engineer, who shall also be a RAQS Designated Contact.



## **DEWATERING STRUCTURE EXCAVATIONS - Item No.**

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Special Provision No. FOUN0003

March 8, 2018

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### **Amendment to OPSS 902, November 2010**

OPSS 902, November 2010, Construction Specification for Excavating and Backfilling - Structures is amended as follows:

#### **902.02 REFERENCES**

Section 902.02 of OPSS 902 is amended by the addition of the following:

#### **Ontario Provincial Standard Specifications, Construction**

OPSS 517      Dewatering  
OPSS 805      Temporary Erosion and Sediment Control Measures

#### **902.03 DEFINITIONS**

Section 903.03 of OPSS 902 is amended by the addition of the following:

**Automatic Transfer Switch** means as defined in OPSS 517.

**Cofferdam** means as defined in OPSS 539.

**Cut-Off Wall** means as defined in OPSS 517.

**Design Storm Return Period** means as defined in OPSS 517.

**Dewatering System** means as defined in OPSS 517.

**Groundwater Control System** means as defined in OPSS 517.

**Plug** means as defined in OPSS 517.

**Sediment** means as defined in OPSS 517.

**Sediment Control Measure** means as defined in OPSS 517.

**Temporary Flow Passage System** means as defined in OPSS 517.

**Unwatering** means as defined in OPSS 517.

**Vegetated Discharge Area** means as defined in OPSS 517.

**Waterbody** means as defined in OPSS 517.

**Watercourse** means as defined in OPSS 517.

## **902.04 DESIGN AND SUBMISSION REQUIREMENTS**

### **902.04.01 Design Requirements**

#### **902.04.01.01 Dewatering**

Clause 902.04.01.01 of OPSS 902 is deleted in its entirety and replaced with the following:

A dewatering system shall be designed to control water and the flow of water into the excavation, prevent disturbance of the foundation, permit the placing of concrete in the dry, and complete the excavating and backfilling for structures work.

When the system includes temporary flow passage system, the system shall be designed, as a minimum, for a [\* Designer Fill-In, See Notes to Designer] year design storm return period, and groundwater discharge. A longer return period shall be used when determined appropriate for the work.

The dewatering system shall be according to the design requirements specified in OPSS 517.

### **902.04.02 Submission Requirements**

Subsection 902.04.02 of OPSS 902 is deleted in its entirety and replaced with the following:

#### **902.04.02.01 Working Drawings**

Working Drawings for the dewatering system shall be according to OPSS 517.

#### **902.04.02.02 Preconstruction Survey**

When a groundwater control system by wells or a well point system will be used, a condition survey of property and structures that may be affected by the work shall be carried out. The condition survey shall include the location and condition of adjacent properties, buildings, underground structures, water wells, Utilities, and structures, within a distance of [\*\* Designer Fill-In, See Notes to Designer] metres from the groundwater control system. In addition, all water wells used as a supply of drinking water and located within this distance shall be tested for compliance with Ontario Drinking Water Quality Standards.

Water wells within the preconstruction survey distance can be located using the website <https://www.ontario.ca/environment-and-energy/map-well-records> or its successor site.

Copies of the condition survey and water quality test results shall be submitted to the Contract Administrator prior to the operation of the groundwater control system.

#### **902.04.02.03 Milestone Inspections**

Clause 902.04.02.03 of OPSS 902 is deleted in its entirety.

## **902.07 CONSTRUCTION**

Subsection 902.07.04 of OPSS 902 is deleted in its entirety and replaced with the following:

#### **902.07.04                      Dewatering Structure Excavation**

##### **902.07.04.01                      General**

The dewatering systems shall be constructed and operated according to the Working Drawings.

Activation and deactivation of a temporary flow passage system, if applicable, shall be according to OPSS 517.

The dewatering system shall be continuously operational to control buoyancy forces until such forces can be resisted by backfill and structure self-weight, to keep excavations stable, to avoid erosion impacts from the release of accumulated water, and to keep the work area in the condition required to complete the associated work as specified in the Contract Documents.

When a temporary flow passage system is to remain operational through a seasonal shutdown period, the Contractor shall be responsible for any maintenance or repair costs due to the system during the seasonal shutdown period.

Temporary erosion and sediment control measures, including controlling the discharge of water, shall be according to OPSS 805. Measures not specified in OPSS 805 shall be according to the Working Drawings. Temporary erosion and sediment control measures and cover material to protect exposed soils, as required by the Working Drawings, shall be installed as soon as is practical.

Stranded fish shall be managed as specified in the Contract Documents.

Unwatering shall be carried out as necessary.

Water suspected of being contaminated as indicated by visual or olfactory observations shall be reported to the Contract Administrator.

Dewatering and temporary flow passage systems shall be discontinued in a manner that does not disturb any structure, pipeline, or flow channel. Operation of the dewatering system shall be shut down according to the procedures specified in the Working Drawings, where applicable.

##### **902.07.04.02                      Discharge of Water**

The discharge of water shall be according to OPSS 517.

##### **902.07.04.03                      Monitoring**

Monitoring shall be according to OPSS 517.

##### **902.07.04.04                      System Amendments**

Amendments to stop any displacement, damage, soil loss or erosion due to the operation of the dewatering system shall be according to OPSS 517.

##### **902.07.04.05                      Removal**

Removal of dewatering system and temporary flow passage system components shall be according to OPSS 517.

NOTES TO DESIGNER:

Designer Fill-Ins

- \* Fill in the design storm return period according to MTO Drainage Design Standard TW-1.
- \*\* Fill in the preconstruction survey distance as recommended by the foundation engineer.

WARRANT: Include with this standard tender item **only** on the recommendation of a foundation engineer.

CUSTODIAN: Tony Sangiuliano, MERO - Foundation Group.








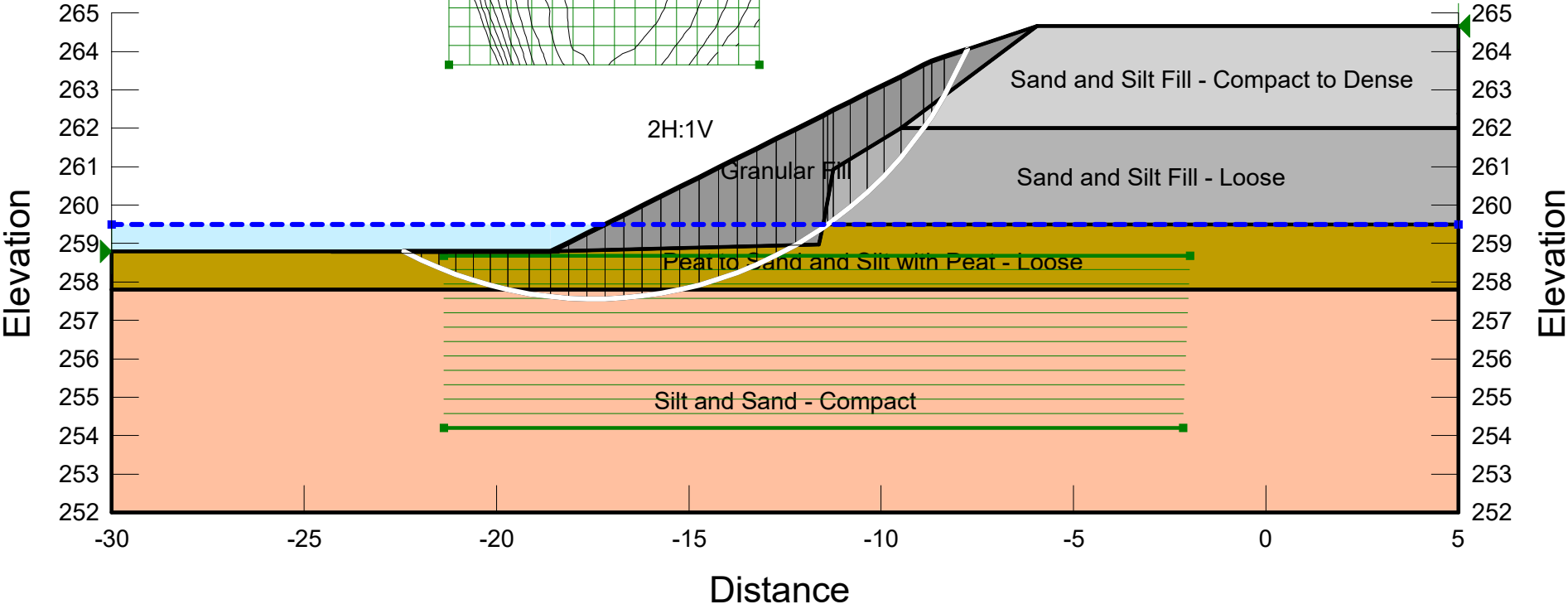
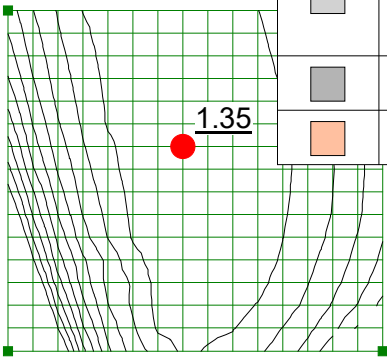
## **Appendix G**

### **Slope Stability Analysis Figures**

**FIGURE 1**  
**SIDE SLOPE**  
**EMBANKMENT WIDENING - NO PEAT REMOVAL**

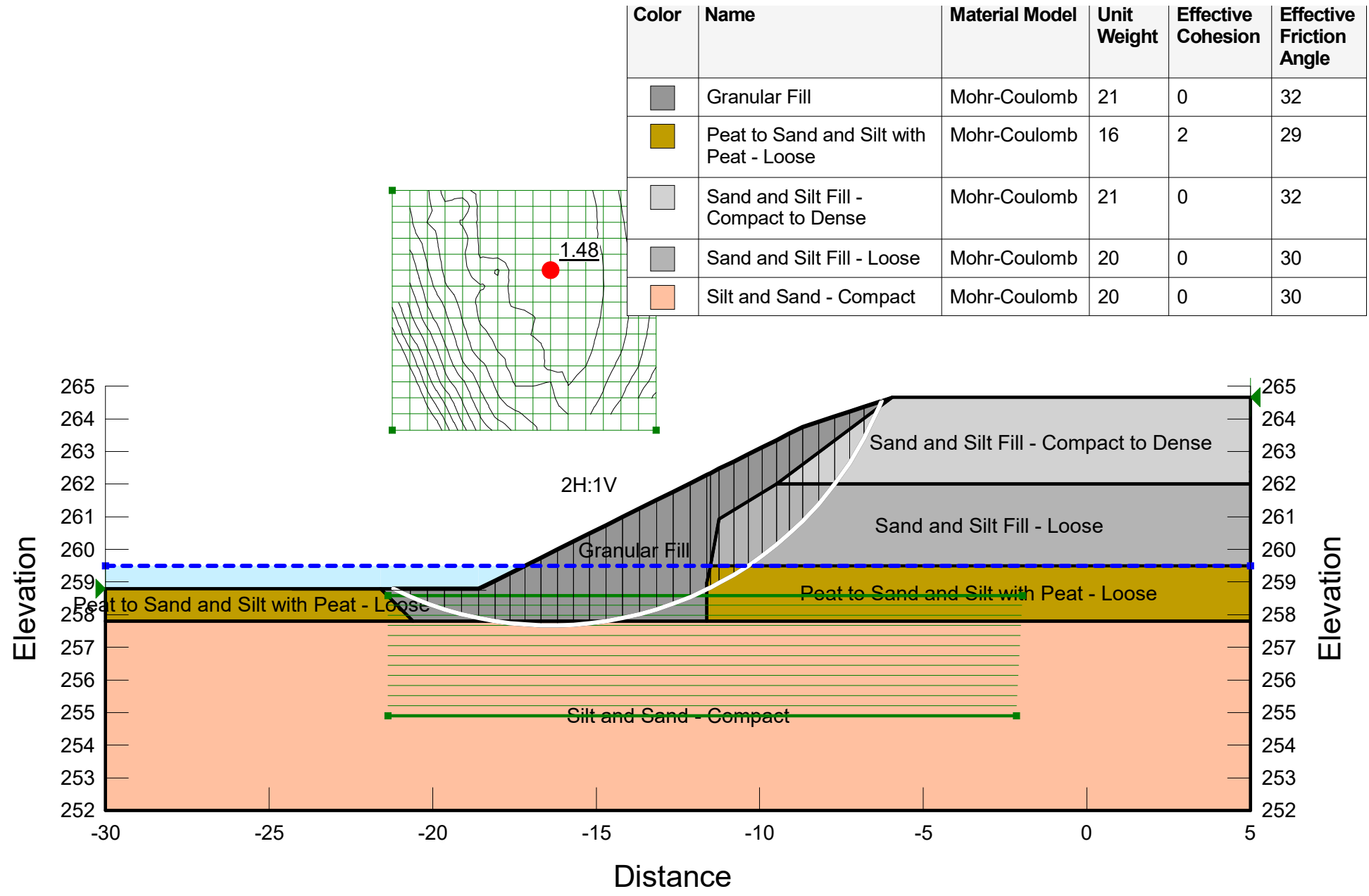
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	Sand and Silt Fill - Compact to Dense	Mohr-Coulomb	21	0	32
	Sand and Silt Fill - Loose	Mohr-Coulomb	20	0	30
	Silt and Sand - Compact	Mohr-Coulomb	20	0	30



**FIGURE 2**  
**SIDE SLOPE**  
**EMBANKMENT WIDENING - WITH PEAT REMOVAL**

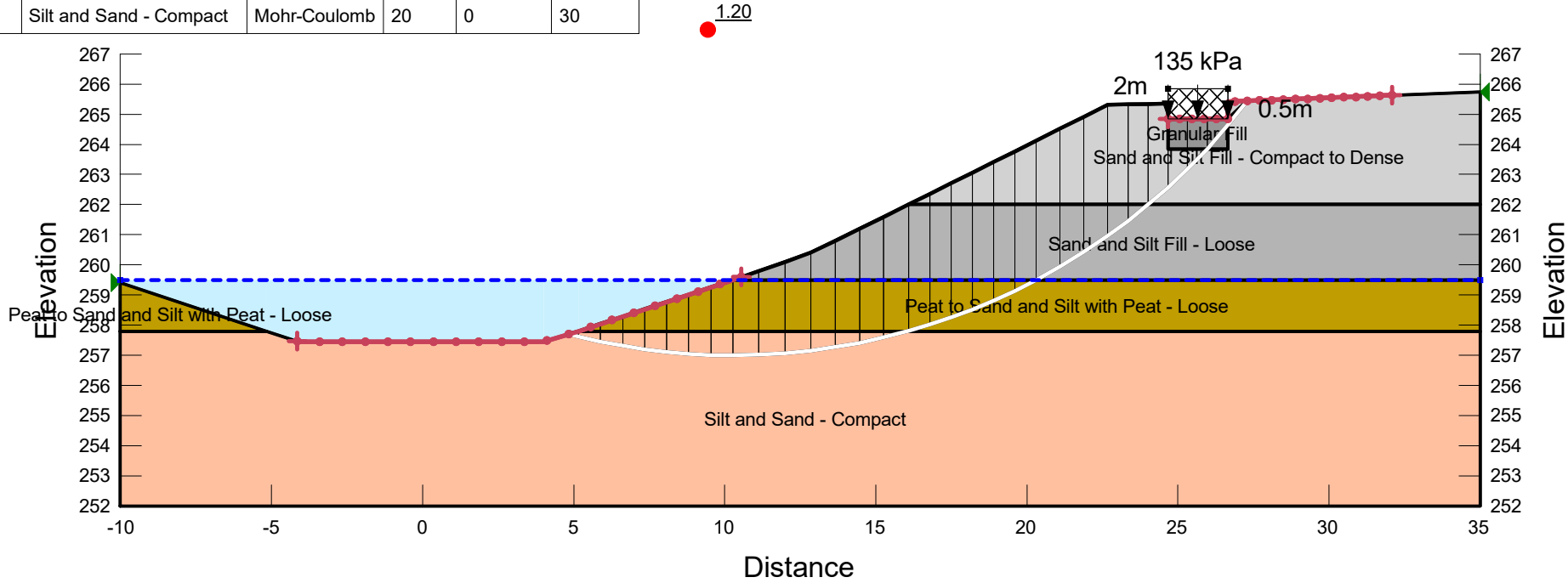
**OMER LAKE CULVERT**



**FIGURE 3**  
**FORWARD SLOPE**  
**2m WIDE FOOTING - BASE AT 0.5m DEPTH**

**OMER LAKE CULVERT**

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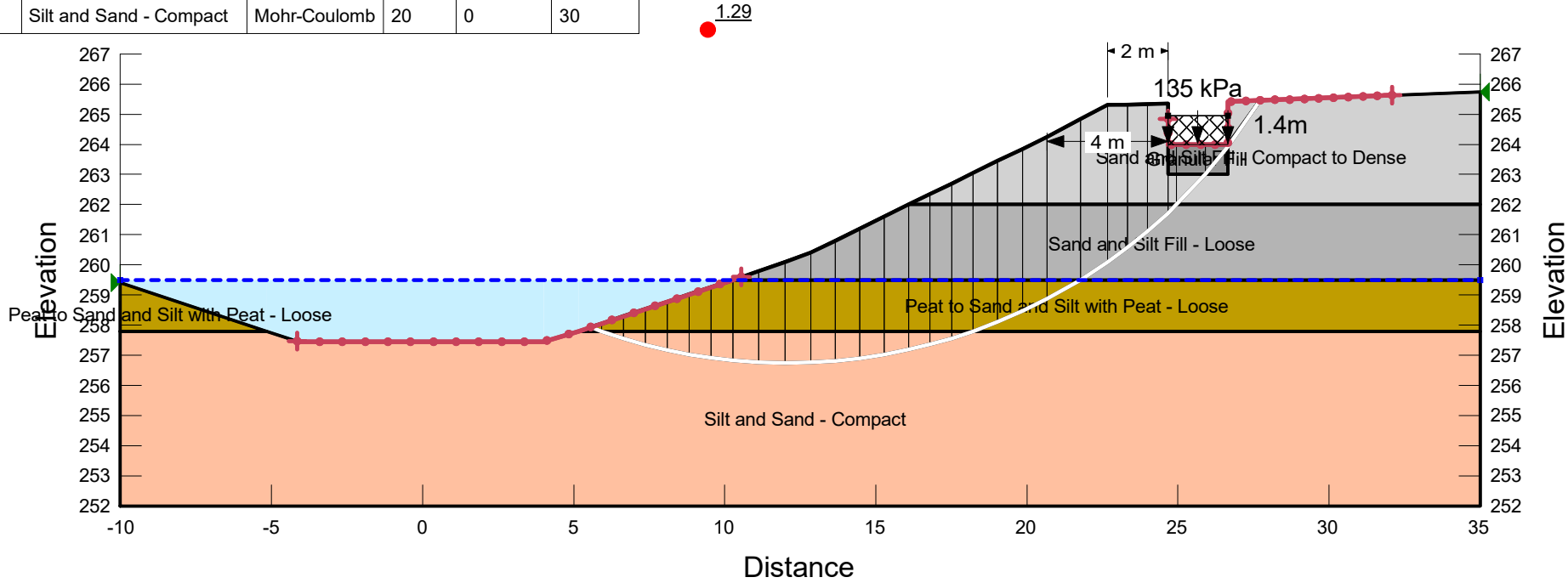




**FIGURE 4**  
**FORWARD SLOPE**  
**2m WIDE FOOTING - BASE AT 1.4m DEPTH**

**OMER LAKE CULVERT**

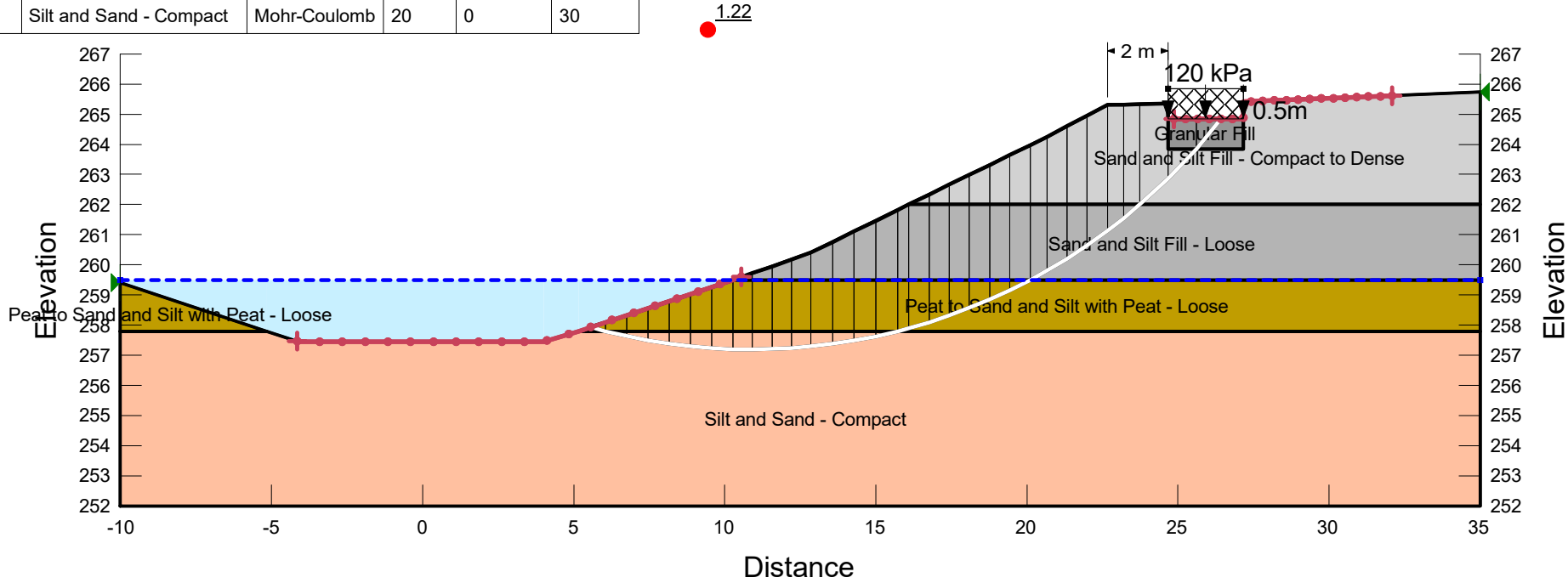
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<div></div>	Sand and Silt Fill - Compact to Dense	Mohr-Coulomb	21	0	32
<div></div>	Sand and Silt Fill - Loose	Mohr-Coulomb	20	0	30
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**FIGURE 5**  
**FORWARD SLOPE**  
**2.5m WIDE FOOTING - BASE AT 0.5m DEPTH**

**OMER LAKE CULVERT**

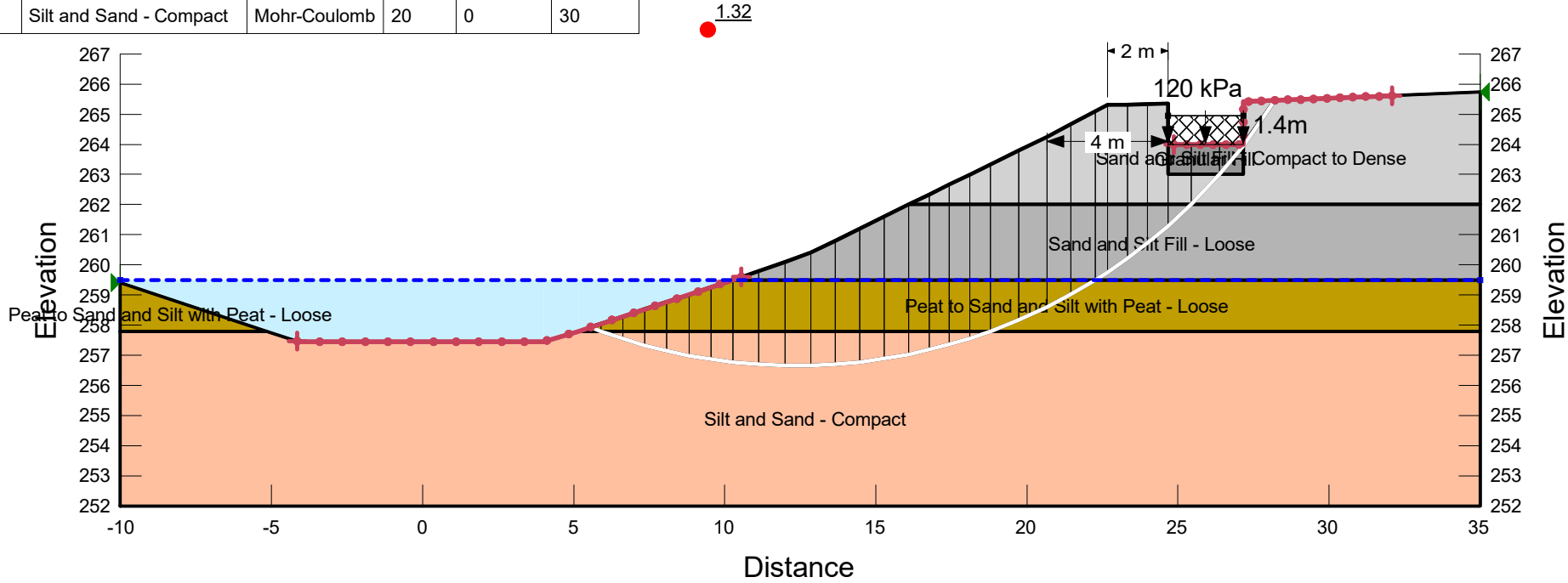
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**FIGURE 6**  
**FORWARD SLOPE**  
**2.5m WIDE FOOTING - BASE AT 1.4m DEPTH**

**OMER LAKE CULVERT**

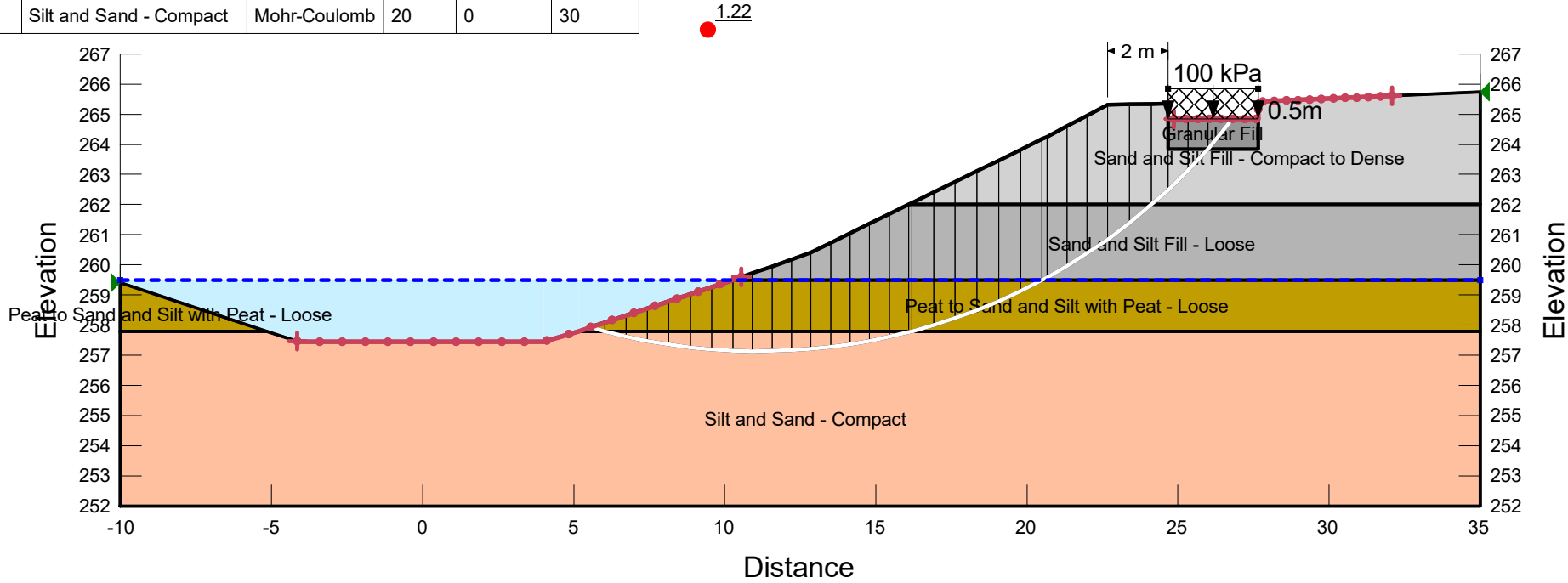
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<div></div>	Silt and Sand - Compact	Mohr-Coulomb	20	0	30



**FIGURE 7**  
**FORWARD SLOPE**  
**3m WIDE FOOTING - BASE AT 0.5m DEPTH**

**OMER LAKE CULVERT**

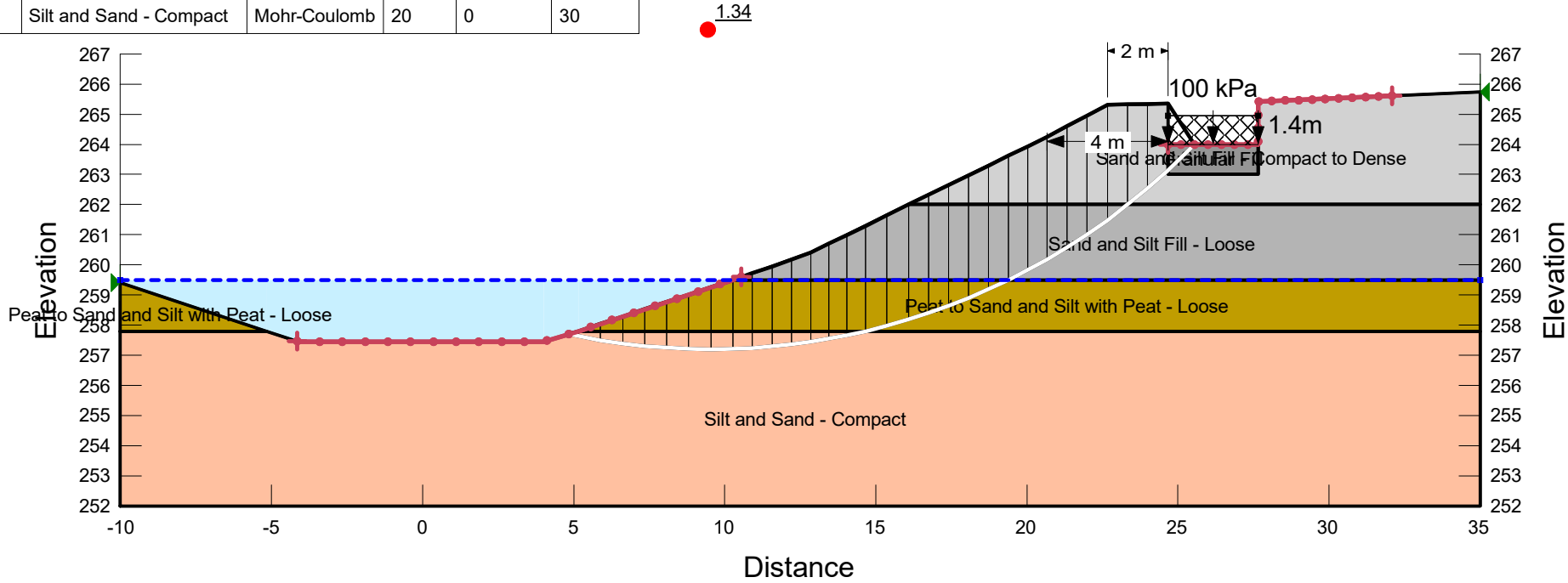
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**FIGURE 8**  
**FORWARD SLOPE**  
**3m WIDE FOOTING - BASE AT 1.4m DEPTH**

**OMER LAKE CULVERT**

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## **Appendix H**

### **Preliminary Draft General Arrangement Drawings**

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DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES UNLESS  
OTHERWISE SHOWN

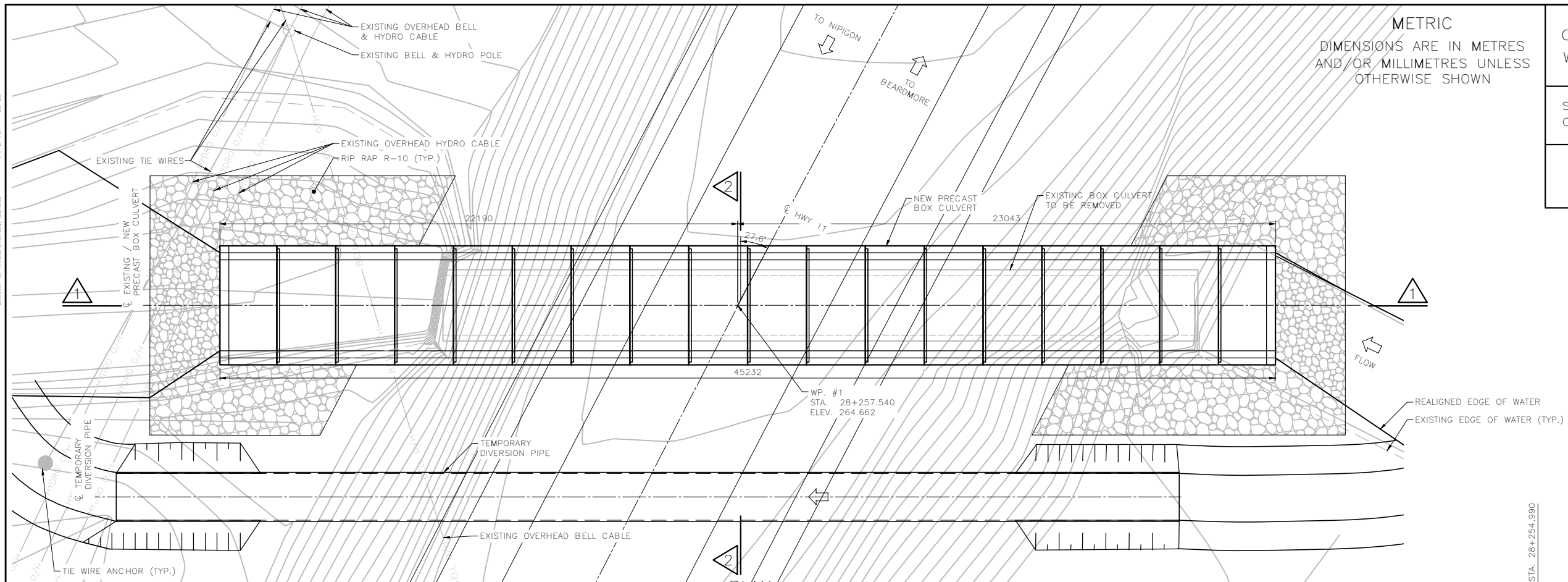
CONT No. 2021-XXXX  
WP No. XXXX-XX-XX

OMER LAKE CULVERT  
STRUCTURAL REPLACEMENT  
OPTION 2 – PRECAST BOX  
GENERAL ARRANGEMENT

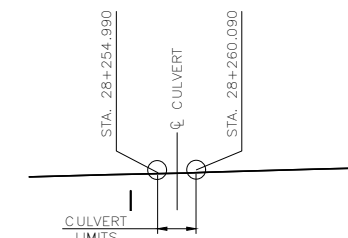


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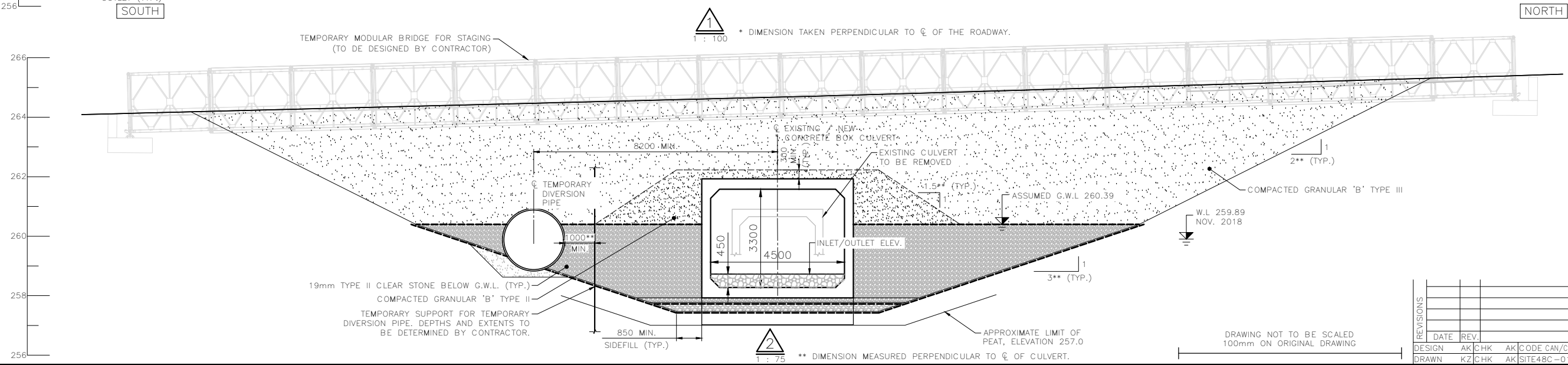
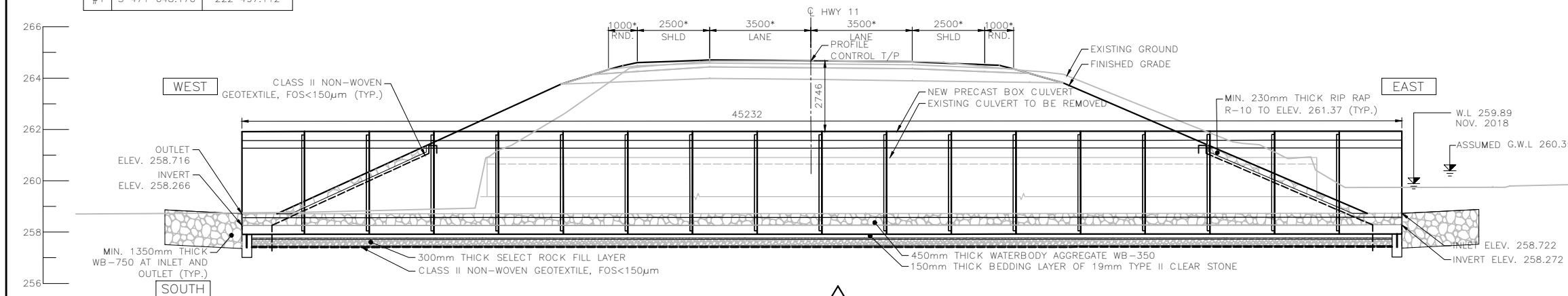
## HATCH



WP	NORTHING	EASTING
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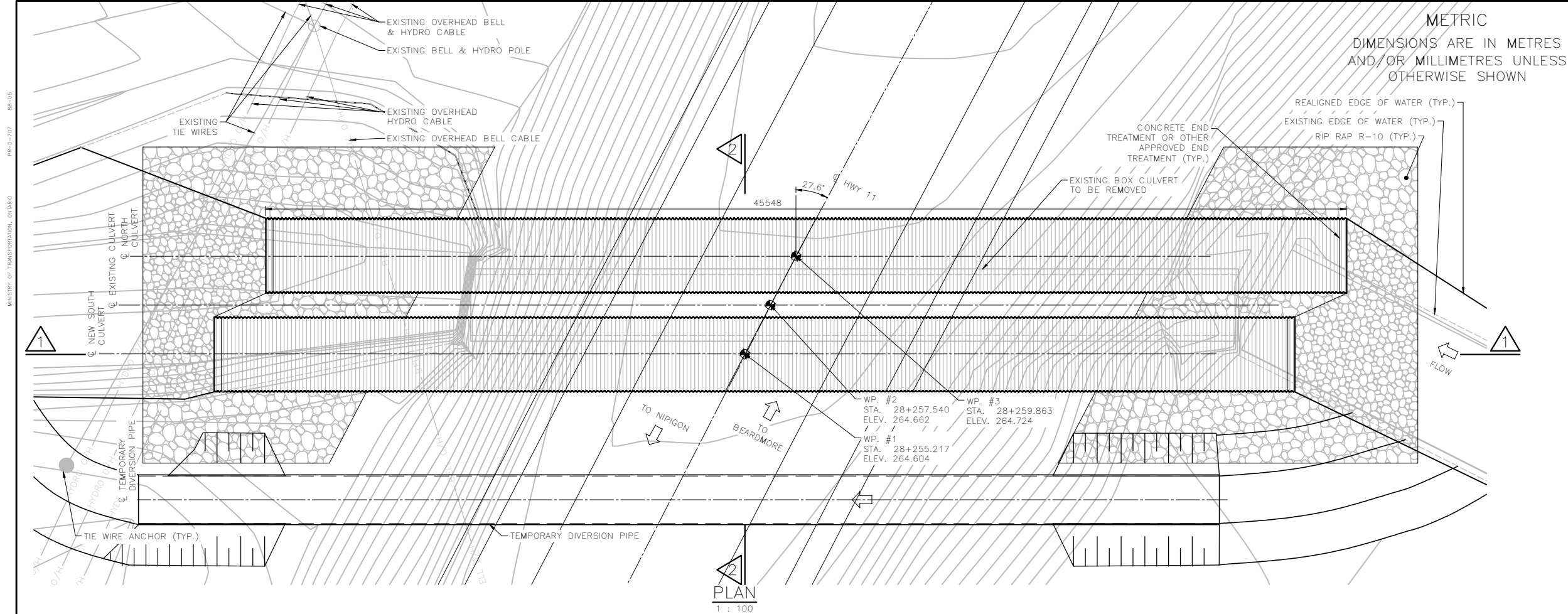


ROAD PROFILE  
N.T.S.



DRAWING NOT TO BE SCALED  
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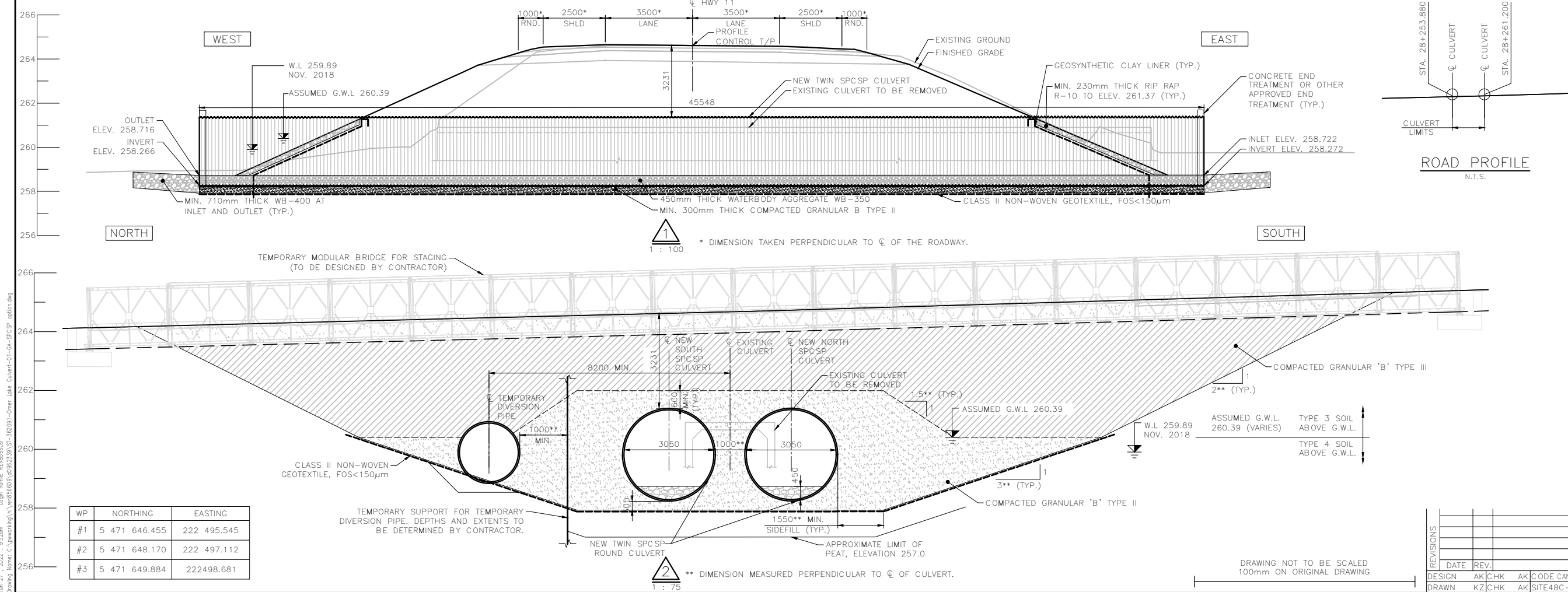


CONT No. 2021-XXXX  
WP No. XXXX-XX-XX

OMER LAKE CULVERT  
STRUCTURAL REPLACEMENT  
OPTION 1 - TWIN SPCSP  
GENERAL ARRANGEMENT

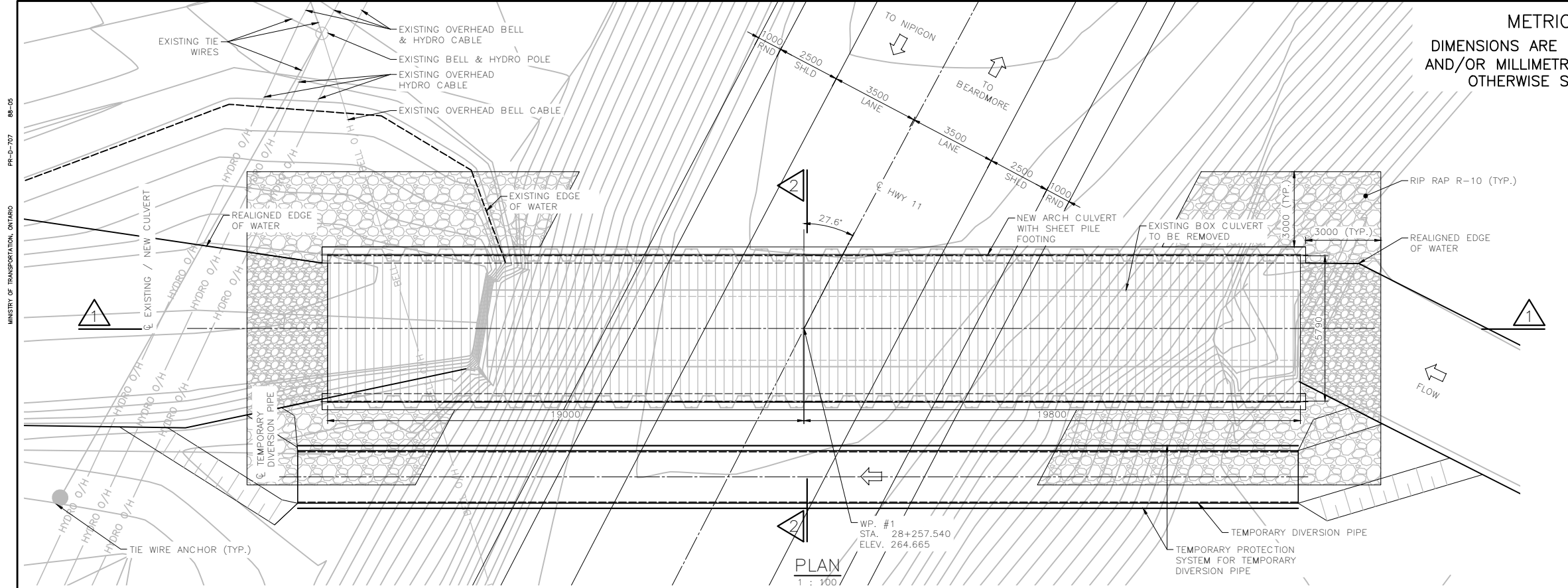
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# HATCH



PR-D-707 88-03  
MINISTRY OF TRANSPORTATION, ONTARIO  
Jun 27, 2022, 8:52am Login Name: RHN66608  
Drawing Name: C:\working\h\enr55603\086233\ST-35203-Omer Lake Culvert-01-CA-SPCSP option.dwg





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

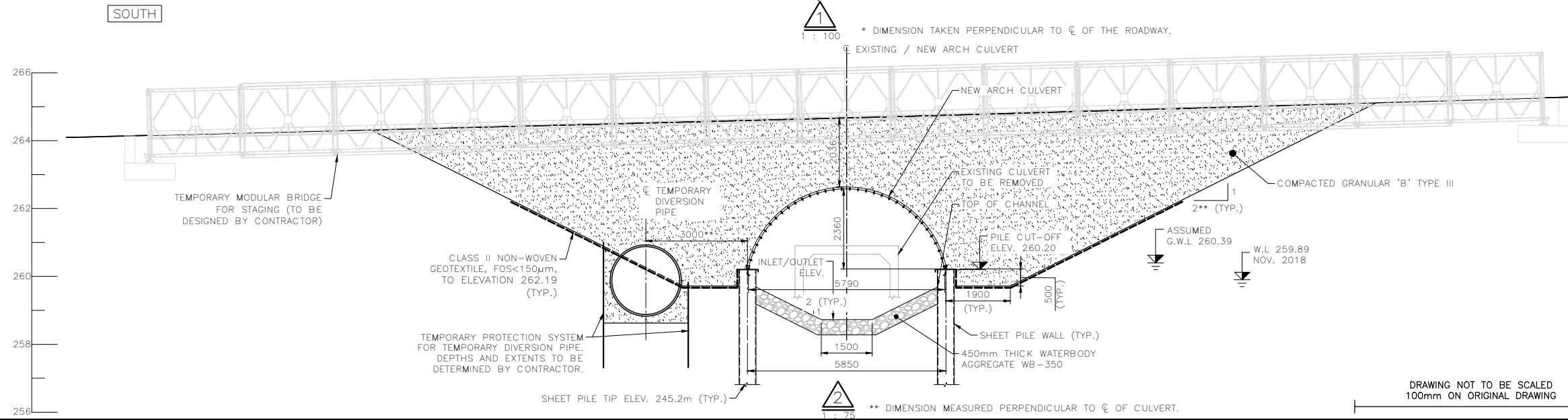
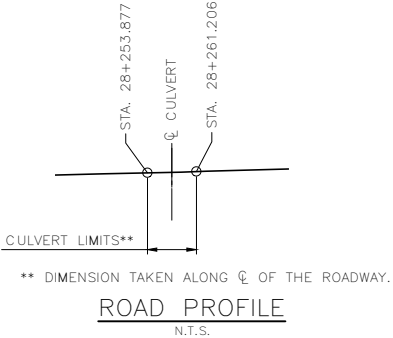
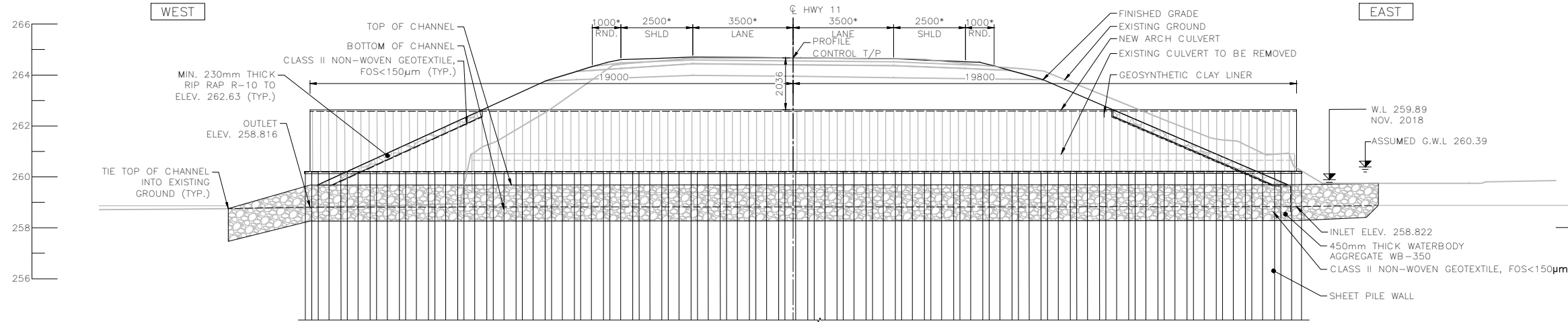
CONT No. 2021-XXXX  
WP No. XXXX-XX-XX

OMER LAKE CULVERT  
STRUCTURAL REPLACEMENT  
OPTION-SPCSP WITH SHEET PILE  
GENERAL ARRANGEMENT

SHEET

HATCH

WP	NORTHING	EASTING
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DATE	REV.	DESCRIPTION
DESIGN	AK/CHK	AK/CODE CAN/CSA S6-19/LOAD CL-625-0M/DATE SEPT. 2021
DRAWN	CR/CHK	AK/SITE 48C-0181/C0/DWG

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PR-D-707 88-05  
Aug 24, 2022 - 10:18am  
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