



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION AND DESIGN REPORT
BLACK STURGEON RIVER BRIDGE REHABILITATION
KENORA, ONTARIO
LATITUDE: 49.9021°, LONGITUDE: -94.4897°
G.W.P. 6160-04-00, SITE NO. 41S-007**

GEOCRES Number: 52E-73

Report

to

HATCH

Date: January 15, 2020
File: 25996



TABLE OF CONTENTS

PART 1: FACTUAL INFORMATION

1.	INTRODUCTION	2
2.	SITE DESCRIPTION	2
3.	INVESTIGATION PROCEDURES	3
4.	LABORATORY TESTING	4
5.	DESCRIPTION OF SUBSURFACE CONDITIONS	4
5.1	Asphalt	5
5.2	Granular Fill	5
5.3	Sand and Silt to Sand Till.....	6
5.4	Cobbles and Boulders	6
5.5	Bedrock	7
5.6	Groundwater Conditions	7
6.	CORROSIVITY AND SULPHATE TEST RESULTS	8
7.	MISCELLANEOUS	9

PART 2: ENGINEERING DISCUSSIONS AND RECOMMENDATIONS

8.	GENERAL.....	11
9.	TEMPORARY ROADWAY PROTECTION.....	12
10.	ABUTMENT BACKFILL and LATERAL EARTH PRESSURES	14
11.	EMBANKMENT RESTORATION	16
12.	TEMPORARY EXCAVATIONS.....	16
13.	GROUNDWATER AND SURFACE WATER CONTROL.....	17
14.	CORROSION & SULPHATE ATTACK POTENTIAL	18
15.	CONSTRUCTION CONCERNS.....	18
16.	CLOSURE	19

APPENDICES

Appendix A	Record of Borehole Sheets
Appendix B	Geotechnical and Analytical Laboratory Test Results
Appendix C	Site Photographs
Appendix D	Photographic Records of Bedrock Cores
Appendix E	Borehole Locations and Soil Strata Drawing
Appendix F	List of OPSSs and OPSDs and Suggested Wording for NSSP



**FOUNDATION INVESTIGATION AND DESIGN REPORT
BLACK STURGEON RIVER BRIDGE REHABILITATION
KENORA, ONTARIO
LATITUDE: 49.902068°, LONGITUDE: -94.489702°
G.W.P. 6160-04-00, SITE NO. 41S-007**

GEOCRES Number: 52E-73

PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the proposed Black Sturgeon River Bridge Rehabilitation on Highway 658 in Kenora, Ontario.

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

Thurber was retained by the Ministry of Transportation (MTO), Northwest Region, to carry out this foundation investigation under the MTO Agreement Number 6017-E-0022, Assignment #14.

For preparation of this report, reference has been made to the following previous report:

- Foundation Investigation Report for Highway 658 (Formerly Highway #128) Moon Bridge over Black Sturgeon River, Site 415-7, W.P. 158-66, District #20 (Kenora), Geocres No. 52E00-008, dated June 27, 1967 (Reference 1).

2. SITE DESCRIPTION

The bridge site is located on Highway 658, approximately 11.5 km north of the Highway 17A in Kenora, Ontario. The existing structure is a six-span precast concrete bridge built in 1969. The bridge deck is approximately 111 m long and 10 m wide, which runs north-south above Black Sturgeon River. Based on the General Arrangement (GA) drawing provided by Hatch, the bridge is supported on a spread footing on the south abutment, pipe pile foundations at the piers, and H-pile foundations at the north abutment. The road surface elevation at the existing bridge deck



ranged from 322.1 m to 323.8 m (south to north), and the water level of Black Sturgeon River was at Elevation 317.35 m at the bridge on August 22, 2012.

The Ontario Structure Inspection Manual (OSIM) report on October 30, 2015 indicates that the existing bridge is in overall good condition. Some maintenance and repair/rehabilitation work were recommended, such as to repave the wearing surface and potholes, and to replace barrier wall and concrete sidewalks.

The lands surrounding the bridge site are heavily forested areas with several residential houses close to the site situated along Black Sturgeon River. Photographs of the bridge and surrounding area are presented in Appendix C.

Based on published geological information, the general site area lies within the physiographic region known as the Canadian Shield, characterized by Pre-Cambrian bedrock (gneissic and tonalite suite). Bedrock outcrops are visible along the highway near both ends of the bridge. The bedrock is locally overlain by undifferentiated sand to silt till.

3. INVESTIGATION PROCEDURES

The field investigation for the bridge rehabilitation project was carried out on May 29th and 30th, 2019 and consisted of drilling and sampling three (3) boreholes, labeled BH-1 to BH-3, to depths of approximately 5.5 m to 13.6 m (Elevation 318.2 m to 310.2 m). Borehole BH-1 was drilled at the south approach, while Boreholes BH-2 and BH-3 were drilled at the north approach. All boreholes were drilled through the existing road pavement.

The approximate locations of the boreholes from the investigation are shown on the Borehole Locations and Soil Strata Drawing included in Appendix E.

Utility clearances were obtained prior to the start of drilling. The ground surface elevations for the boreholes were estimated from the topographic drawings provided to Thurber by Hatch. The coordinate system MTM NAD 83 was used for the boreholes.

A rubber track-mounted CME-55 drill rig was used to advance the boreholes using hollow stem augers and NW casing. Soil samples were obtained in the boreholes at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). NQ coring methods were used to advance the boreholes past large obstructions such as cobbles and boulders and core the bedrock.

The drilling and sampling operations were supervised on a full-time basis by a member of



Thurber's technical staff. The supervisor logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing.

Upon completion of the drilling, all boreholes were backfilled in accordance with Ontario Regulation 903 (O.Reg.903). Completion details of the boreholes are summarized in Table 3.1.

Table 3.1 – Borehole Completion Details

Borehole Number	Borehole Depth / Base Elevation (m)	Completion Details
BH-01	5.5 / 316.5	Backfilled with bentonite holeplug to 0.3m, then concrete to 0.2 m, then cold patch to surface.
BH-02	13.6 / 310.2	Backfilled with bentonite holeplug to 0.3m, then concrete to 0.2 m, then cold patch to surface.
BH-03	5.7 / 318.2	Backfilled with bentonite holeplug to 0.3m, then concrete to 0.2 m, then cold patch to surface.

4. LABORATORY TESTING

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

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for corrosion associated with the structure, samples of the fills from Boreholes BH-01 and BH-02 were submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing of corrosivity parameters and sulphate content. The results of the analytical testing from the investigation are summarized in Section 6 and are presented in Appendix B.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix A. Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets and on the Borehole Locations and Soil Strata Drawing included in Appendix E. A general description of the



stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description and must be used for interpretation of the site conditions. It must be recognized and expected that soil conditions may vary between and beyond the borehole locations.

In general, the subsurface conditions encountered consisted of embankment fill, which contained some boulders and cobbles near the base of the fill, underlain by native sand and silty sand till, underlain by deposits of large granitic boulders. The overburden and boulder and cobble deposits were underlain by granitic gneiss bedrock. Descriptions of the individual strata are presented below.

5.1 Asphalt

Asphalt of 125 mm in thickness was encountered at the surface of the three boreholes drilled through the existing Highway 658 approach embankments.

5.2 Granular Fill

Granular fill consisting of sand to silty sand fill was encountered below the asphalt at all three boreholes. The fill also contained traces to some gravel, trace silt and some cobbles. The thickness of the fill ranged from 1.4 m to 6.0 m and extended to depths of between 1.5 m and 6.1 m (Elevation 320.5 m to 317.7 m). A boulder layer ranging in thickness from 0.5 to 0.6 m were encountered at the base of the fill in Boreholes BH-02 and BH-03.

SPT 'N' values in the granular fill ranged from 18 blows for 0.3 m of penetration to greater than 100 blows for less than 0.3 m of penetration, indicating compact to very dense conditions. The 100 blow values likely represent the presence of boulders and cobbles in the fill. The measured moisture content in the fill ranged from 2 percent to 12 percent.

The results of grain size analyses conducted on selected samples of fills are illustrated on Figures B1 and B2 in Appendix B. The results are summarized as follows:



Soil Particle	Sand Fill	Silty Sand Fill
Gravel	8 to 14	7
Sand	77 to 80	51
Silt	9 to 12	37
Clay		5

5.3 Sand and Silt to Sand Till

Deposits of native till, ranging from sand to silt and sand till were encountered below the fills in all of the boreholes. The native till contained traces to some gravel and clay, and cobble zones. The till ranged in thickness from 0.5 m to 1.5 m and extended to depths of 2.0 m to 7.6 m (Elevation 320.0 m to 316.2 m).

SPT 'N' values measured in the till ranged from 49 blows for 0.3 m penetration to greater than 50 blows for less than 0.3 m penetration, indicating dense to very dense conditions. The measured moisture content of the till ranged from 9 percent to 10 percent.

The results of grain size analyses conducted on a selected sample of the sand and silt till are illustrated on Figure B3 in Appendix B. The results are summarized as follows:

Soil Particle	Sand and Silt Till
Gravel	5
Sand	50
Silt	43
Clay	2

Glacial till inherently contains cobbles and boulders.

5.4 Cobbles and Boulders

Drill casing refusal was encountered on the top of a deposit of cobbles and boulders with sand and gravel at Borehole BH-2 at a depth of 7.6 m (Elevation 316.2 m). The cobbles and boulders were penetrated by coring below the casing depth at this borehole. The cobble and boulder layer was 3.0 m thick and extended to a depth of 10.6 m (Elevation 313.2 m). Boulder ranging in size from 0.2 to 0.5 m were recovered from this layer.



5.5 Bedrock

The overburden soils and the cobble and boulder deposits were underlain by grey granitic gneiss bedrock. All the boreholes were terminated in the bedrock at depths ranging from 5.5 m to 13.6 m (Elevations 318.2 m to 310.2 m). Table 5.1 below presents the bedrock depths and elevations encountered in the boreholes:

Table 5.1: Bedrock Depths and Elevations

Borehole	Depth to Bedrock (m)	Bedrock Elevation (m)
BH-01	2.0	320.0
BH-02	10.6	313.2
BH-03	4.9	319.0

Photographic records of the bedrock core samples are included in Appendix D.

The bedrock was granitic gneiss was described as grey and moderately to slightly weathered.

The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of the bedrock cores was typically 100 percent, with a TCR of 75 percent recorded in the upper portion of the bedrock in Borehole BH-01. The Rock Quality Designation (RQD) recorded in the bedrock cores typically ranged from 55 percent to 100 percent indicating fair to excellent rock quality, with the upper portion ranging from 29 percent to 31 percent indicating poor rock quality. The Fracture Index (FI) measured in the bedrock typically ranged from 0 to 5, with the upper weathered portion greater than 10.

Average Unconfined Compressive Strength (UCS) values estimated from point load test correlations on selected bedrock samples ranged from 100 MPa to 255 MPa, indicating strong to very strong rock.

5.6 Groundwater Conditions

Groundwater conditions were observed during drilling operations and groundwater levels were measured in the open boreholes upon completion of drilling. A summary of the water level measurements is provided in Table 5.2 below:

Table 5.2 - Groundwater Measurements

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
BH-01	May 30, 2019	0.6	321.4	Open Borehole
BH-02	May 29, 2019	Dry	-	Open Borehole
BH-03	May 29, 2019	Dry	-	Open Borehole

It was noted that the water levels were taken upon the completion of the removal of all the drill casing, where the boreholes caved to depths ranging from 1.2 to 2.7 m below existing grade. In addition, water was introduced in the boreholes during the casing advancement through the boulder and cobble deposits and to sample the bedrock. Therefore, the groundwater level encountered in the boreholes may not reflect the stabilized water level conditions that are anticipated during construction.

The groundwater level should be anticipated to reflect the river water level. The water level of Black Sturgeon River near the bridge was measured at Elevation 317.35 m in August 2012, as shown on the GA drawings provided by Hatch.

Groundwater levels are short-term observations and seasonal fluctuations of the groundwater levels are to be expected. In particular, the groundwater levels may be at a higher elevation during spring and after periods of significant or prolonged precipitation.

6. CORROSIVITY AND SULPHATE TEST RESULTS

Samples of the sand and silty sand fill were submitted for analytical testing of corrosivity parameters and sulphate. The results of the analytical tests are shown in Table 6.1. The laboratory certificates of analysis are presented in Appendix B.



Table 6.1 - Analytical Test Results

Parameter	Units (soil)	Test Results	
		BH-01 SS#1	BH-02 SS#4
		Sand Fill	Silty Sand Fill
Sulphide	%	<0.02	<0.02
Chloride	µg/g	220	380
Sulphate	µg/g	25	5.6
pH	no unit	8.76	7.15
Conductivity	µS/cm	760	1060
Resistivity (calculated)	ohms.cm	1320	943
Redox Potential	mV	244	332

7. MISCELLANEOUS

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

RPM Drilling of Thunder Bay, Ontario supplied and operated the drilling, sampling and in-situ testing equipment for the field investigation. The field investigation was supervised on a full-time basis by Mr. Jilesh Patel of Thurber. The overall supervision of the field program was conducted by Mr. Mark Farrant, P.Eng, of Thurber.

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

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



Thurber Engineering Ltd.



Rod de Castro, P.Eng.
Geotechnical Engineer



Mark Farrant, P.Eng.
Geotechnical Engineer



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



**FOUNDATION INVESTIGATION AND DESIGN REPORT
BLACK STURGEON RIVER BRIDGE REHABILITATION
KENORA, ONTARIO
LATITUDE: 49.902068°, LONGITUDE: -94.489702°
G.W.P. 6160-04-00, SITE NO. 41S-007**

GEOCRES Number: 52E-73

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

8. GENERAL

This report provides an interpretation of the geotechnical data in the factual report, and presents foundation design recommendations for the proposed Black Sturgeon River Bridge Rehabilitation on Highway 658 in Kenora, Ontario. The purpose of the investigation was to collect subsurface information and provide foundation recommendations for proposed rehabilitation of the bridge and design of temporary roadway protection system.

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 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 bridge site is located on Highway 658, approximately 11.5 km north of the Highway 17A in Kenora, Ontario. The existing structure is a six-span precast concrete bridge built in 1969. The bridge deck is approximately 111 m long and 10 m wide, which runs north-south above Black Sturgeon River. Based on the General Arrangement (GA) drawing provided by Hatch, the bridge is supported on a spread footing at the south abutment, pipe pile foundations at the piers and H-pile foundations at the north abutment. The road surface elevation at the existing bridge deck ranged from 322.1 m to 323.8 m (south to north), and the water level of Black Sturgeon River was at Elevation 317.35 m at the bridge on August 22, 2012.

The Ontario Structure Inspection Manual (OSIM) report on October 30, 2015 indicates that the existing bridge is in overall good condition. Some maintenance and repair/rehabilitation work were recommended, such as to repave the wearing surface and potholes, and to replace barrier



wall and concrete sidewalks.

The rehabilitation plans for the structure include rehabilitation of the deck and conversion of the existing abutments to semi-integral abutments. This retrofitting will necessitate excavation, placement of new approach slabs with asphalt surface and replacement of expansion joints. In addition, ballast walls will be removed and reconstructed and wingwalls will be partially removed and repaired.

9. TEMPORARY ROADWAY PROTECTION

It is understood that conversion of the abutments to a semi-integral design will require excavation to a depth in the order of 2.5 m within the approach embankments adjacent to the abutments. Depending on the actual depth of excavation, temporary roadway protection may be required to maintain a single lane of traffic at all times during abutment construction.

Temporary protection systems should be designed and constructed in accordance with OPSS.PROV 539 and designed for Performance Level 2 (maximum 25 mm horizontal deflection) provided that the existing adjacent roadway can tolerate this magnitude of deflection.

For a sheet pile option, since the bedrock is shallow and encountered at 2 m depth (Elevation 320.0) at the south abutment, the sheet pile penetration may not be enough to provide adequate lateral resistance. In addition the sheet piles may encounter refusal in cobbles and boulders above the bedrock.

Near the north abutment, the bedrock depths ranges from 10.6 m (Elevation 313.2) in BH-02 to 4.9 m (Elevation 319.0) in BH-03 indicating a bedrock surface sloping to the north. In addition boulders were noted at 3.8 to 5.5 m depths in BH-03 and BH-02. Furthermore, a 3 m thick boulder layer was noted at 7.6 m depth in BH-02. Depending on the depth of sheet piles required to meet lateral resistance, vibrating or driving sheet piles to an adequate depth may not be feasible in light of the presence of the cobbles and boulders in the overburden soils. Use of sheet pile shoring may therefore not be feasible at this site.

Use of a soldier pile and lagging system may be considered for the roadway protection at this site. Cobbles and boulders have been identified in the fill at both abutments, and driving of H-piles is expected to encounter refusal at varying depths in the cobbles and boulders in the granular fill. Predrilling, coring or other means may be required to achieve an adequate depth of embedment to develop the required lateral resistance for the protection system and to minimize vibrations caused by driving H-piles. At the south abutment, the soldier piles may need to be socketed by coring into the underlying very strong bedrock encountered at 2.0 m depth.

Design of the protection system must therefore consider the presence of the shallow bedrock at the sound abutment, as well as boulders and cobbles within the embankment fills. The shoring system may be stiffened by cross bracings, where applicable. Suggested text for an NSSP on obstructions is included in Appendix F.

The soil parameters in Table 9.1 may apply for design of the temporary roadway protection system with horizontal backfill.

Table 9.1 –Soil Parameters for Temporary Protection System Design

Soil Parameter	Sand / Silty Sand Fill (Existing Embankment Fill)	Silty Sand Till
ϕ (angle of internal friction)	30°	34°
γ (total unit weight)	20 kN/m ³	21 kN/m ³
γ' (submerged unit weight)	10 kN/m ³	11 kN/m ³
K_a (active earth pressure coefficient)	0.33	0.28
K_p (passive earth pressure coefficient)	3.0	3.5

Full hydrostatic pressure should be considered assuming a water level at least equal to the design river water level. Water-bearing sands (fill and native), especially at the north abutment, are susceptible to sloughing and basal instability due to unbalanced hydrostatic pressure.

The design of 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 retaining system, and these factors have to be considered when designing the shoring system.

The designer of the roadway protection system should check whether the depth of the soldier piles is sufficient to provide base fixity.

All protection systems should be designed by a Professional Engineer experienced in such designs, who will determine an appropriate support system.

In accordance with the CHBDC 2014, the selection of the seismic site class is based on the soil conditions encountered in the upper 30 m of the stratigraphy. In view of the presence of relatively shallow bedrock on site, the site can be classified as Site Class C in accordance with Table 4.1,



Clause 4.4.3.2 of the CHBDC. The peak ground acceleration, PGA, for a 2,475-year return period seismic event at this site is 0.038 g as per the National Building Code of Canada (NBCC).

In accordance with Clause 4.6.5 of the CHBDC 2014, retaining structures 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 9.2 may be used:

Table 9.2 – Earth Pressure Coefficients for Earthquake Loading

Condition	Earth Pressure Coefficient (K)		
	OPSS Granular A or Granular B Type II $\phi = 35^\circ$, $\gamma = 22.8 \text{ kN/m}^3$; $\gamma_{\text{submerged}} = 12.8 \text{ kN/m}^3$	OPSS Granular B Type I $\phi = 32^\circ$, $\gamma = 21.2 \text{ kN/m}^3$; $\gamma_{\text{submerged}} = 11.2 \text{ kN/m}^3$	Existing Fill $\phi = 30^\circ$; $\gamma = 20 \text{ kN/m}^3$; $\gamma_{\text{submerged}} = 10 \text{ kN/m}^3$
Active (K_{AE})*	0.29	0.32	0.35
Passive (K_{PE})	3.6	3.2	3.0
At Rest (K_{OE})**	0.48	0.52	0.55

* After Mononobe and Okabe, passive case assumes a horizontal surface in front of the wall.

** After Woods

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

10. ABUTMENT BACKFILL AND LATERAL EARTH PRESSURES

Backfill to the abutments after rehabilitation should consist of rock backfill or free-draining granular material conforming to OPS Granular A or B Type II specifications. Rock backfill must be restricted to a maximum dimension of 250 mm. The rock backfill and granular material should be placed to the extents shown in OPSD 3101.200 or 3121.150. Compaction should be carried out in accordance with OPSS.PROV 206 and OPSS.PROV 501.

Earth pressures acting on the structure may be assumed to be distributed triangularly and to be governed by the characteristics of the abutment backfill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC but generally are given by the expression:



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

Where:

- p_h = horizontal pressure on the wall at depth h (kPa)
- K = coefficient of lateral earth pressure (see Table 10.1)
- γ = unit weight of retained soil (see Table 10.1)
- h = depth below top of fill where pressure is computed (m)
- q = value of any surcharge (kPa)

In accordance with Clause 6.12.3 of the CHBDC 2014, a compaction surcharge should be added. The magnitude should be 12 kPa at the top of fill and decreasing to 0 kPa at a depth of 1.7 m for Granular B Type I, or 2.0 m for Granular A or Granular B Type II. Compaction equipment to be used adjacent to retaining structures should be restricted in accordance with OPSS.PROV 501.

Earth pressure coefficients for backfill to the abutment wall are dependent on the material used as backfill. Typical values are given in Table 10.1.

Table 10.1 – Coefficients of Lateral Earth Pressure (K)

Loading Condition	OPSS Granular A or Granular B Type II $\phi = 35^\circ$, $\gamma = 22.8$ kN/m ³		OPSS Granular B Type I or Type III $\phi = 32^\circ$, $\gamma = 21.2$ kN/m ³		Rock Backfill $\phi = 42^\circ$, $\gamma = 19$ kN/m ³	
	Horizontal Backfill	Sloping Backfill	Horizontal Backfill	Sloping Backfill	Horizontal Backfill	Sloping Backfill
Active K_A (Unrestrained Wall)	0.27	0.38*	0.31	0.46*	0.20	0.25
At-rest K_0 (Restrained Wall)	0.43	-	0.47	-	0.33	-
Passive K_P	3.7	-	3.3	-	5.0	-

* For wing walls, if required

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

If the support system allows yielding of the wall (unrestrained system), active horizontal earth pressure may be used in the design of the structure. If the support system does not allow yielding (restrained system), at-rest horizontal earth pressures should be used.



The factors in Table 10.1 are “ultimate” values and require certain movements for the respective conditions to be mobilized. The values to be used in design can be estimated from Figure C6.16 in the Commentary to the CHBDC 2014.

It is recommended that perforated sub-drains and/or weep holes be installed, where applicable, to provide positive drainage of the granular backfill behind the abutment walls.

11. EMBANKMENT RESTORATION

In general, the existing approach embankments comprise of sand, silty sand and cobbles and boulders. Embankment restoration after completion of the bridge rehabilitation should be carried out in accordance with OPSS.PROV 206. The embankment reconstruction material may consist of imported Granular A, Granular B Type II, or Granular B Type III material.

In general, any surface vegetation, topsoil, organic deposits, disturbed material or otherwise loose/soft soils should be stripped within the embankment reconstruction footprints. Inspection and approval of the foundation surfaces by qualified geotechnical personnel should be conducted.

Provided that the approach embankments are reconstructed at the same slope inclination as the existing embankment, but not steeper than 2H:1V, the restored embankment slope should remain stable.

It is anticipated that there will be no significant grade raise at this site for the bridge rehabilitation, and therefore settlement of the approach embankments may be limited in nature. However, if a grade raise is incorporated, then additional analysis of settlement should be carried out.

Disturbed or regraded earth slopes must be provided with erosion protection in accordance with OPSS.PROV 804.

12. TEMPORARY EXCAVATIONS

All excavations at the abutments for conversion to semi-integral design must be carried out in accordance with OPSS 902 and the requirements of the Occupational Health and Safety Act (OHSA). For the purposes of assessing temporary excavation slope requirements in compliance with the OHSA, the existing sand fill and native sand and silt till and sand till above the water level may be classified as Type 3 soil. The sand fill and till below the water level may be classified as Type 4 soils. The bedrock may be classified as Type 1.

The equipment required and method of excavation within the bedrock if required will be dependent upon the geometry of the excavation and relative depth of excavation into the bedrock. Although



the method of excavation should remain the responsibility of the contractor, and assuming that blasting will not be permitted at this site, equipment such as hoe ram, pneumatic hammer or equivalents should be considered. Progressively more difficult conditions should be anticipated with increasing depth of excavation.

The excavation and backfilling for foundations must be carried out in accordance with OPSS 902 and Special Provision No. SP 109S12. Excavations will be carried out through the existing embankment fills, which may contain perched water. It is anticipated that the excavation at the north abutment will be above the river level. It must be noted that obstructions such as cobbles and boulders were encountered in the boreholes and are anticipated to be encountered during construction.

The selection of the method of excavation is the responsibility of the contractor and must be based on his equipment, experience and interpretation of the site conditions. Excavations should be inspected regularly for evidence of instability if they have been left open for extended periods of time and following periods of heavy rain or thawing. If required, remedial actions must be taken to ensure the stability of the excavation and the safety of workers. Exposed soil slopes should be covered with plastic sheetings to protect against precipitation and surface runoff.

In accordance with OHSA, equipment, construction materials and stockpiles of excavated rock or soil must be kept at least 1 m from the upper edge of each wall of an excavation. The stability of a wall of an excavation must also be maintained if it may be affected by stockpiling soil, rock or construction materials. Accordingly, these materials should not be stockpiled near the edges of the excavations.

It is anticipated that that due to the presence of the shallow bedrock at the south abutment, an open excavation may be proposed. Provided that the excavation does not extend below the existing footing at the south abutment; the existing shallow foundation should not be impacted. Care must be taken for any hoe-ramming/pneumatic hammer activities in the vicinity of the existing footing to ensure that it is not damaged.

13. GROUNDWATER AND SURFACE WATER CONTROL

The groundwater level should be anticipated to reflect the river water level. The water level of Black Sturgeon River near the bridge was measured at Elevation 317.35 m in August 2012, as shown on drawings provided by MTO.

It is anticipated that excavations for the bridge rehabilitation will not extend below the river level. However, seepage or perched water from the granular fill is to be expected.



The Contractor should be prepared to pump from sumps to remove any remaining seepage water or surface water collecting in an excavation. Dewatering must remain operational and effective until the abutment is backfilled.

The design of the dewatering system that may be required is the responsibility of the Contractor and the Contract Documents must alert him to this responsibility and to design the system.

14. CORROSION & SULPHATE ATTACK POTENTIAL

The results of the corrosivity and sulphate analytical tests conducted on the fill indicate the following:

- The potential for sulphate attack on concrete foundations from the surrounding soil is considered to be negligible due to the low concentration of sulphate in the samples tested. The effect of road de-icing salt should also be considered when selecting the class of concrete.
- The potential for corrosion on metal structural elements is considered to be severe to very severe, based on the low resistivity of the samples tested.
- The effect of road de-icing salt should be considered when selecting corrosion protection measures.

15. CONSTRUCTION CONCERNS

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

- Cobbles or boulders are present in the granular embankment fill. Equipment capable of excavating the embankment fill and handling large boulders will be required for excavation. The boulder thickness will vary with location. Rock excavation, if required, will require pneumatic hammer and hoe ram or similar equipment since blasting will likely not be allowed. Care must be taken for any hoe-ramming/pneumatic hammer activities in the vicinity of the existing footing.
- Driving of soldier piles for installation of roadway protections systems may be difficult within the existing approach fill, and predrilling, coring or other means may be required to advance the piles to adequate depth. Use of sheet piles is not recommended.



- The bedrock surface is expected to vary along the length of the roadway protection system, and may be contacted at different elevations between and beyond the borehole locations. Variations in the bedrock surface should be anticipated during shoring installation.
- The bedrock is classified as very strong. Equipment that can penetrate hard rock will be required to construct soldier pile sockets.

Suggested wording for an NSSP alerting the Contractor to these concerns is provided in Appendix F.

16. CLOSURE

Engineering analysis and preparation of this report was carried out by Mr. Rod de Castro, P.Eng. and Mr. Mark Farrant, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.



Rod de Castro, P.Eng.
Geotechnical Engineer



Mark Farrant, P.Eng.
Geotechnical Engineer



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



Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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

 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS W _L < 50%	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. (W _L < 30%).
		CI	Inorganic clays of medium plasticity, silty clays. (30% < W _L < 50%).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS W _L > 50%	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

EXPLANATION OF ROCK LOGGING TERMS


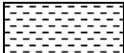



ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.

DISCONTINUITY SPACING

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

SYMBOLS

	CLAYSTONE
	SILTSTONE
	SANDSTONE
	COAL
	BEDROCK

STRENGTH CLASSIFICATION

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

TERMS

Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a % of total core run length.
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.

RECORD OF BOREHOLE No BH-01

1 OF 1

METRIC

GWP# 6160-04-00 LOCATION Black Sturgeon River Bridge MTM NAD83 N 5 530 419.4 E 197 766.9 ORIGINATED BY JP
 HWY 658 BOREHOLE TYPE Hollow Stem Augers/NQ Casing COMPILED BY BH
 DATUM Geodetic DATE 2019.05.30 - 2019.05.30 CHECKED BY MEF

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

ONTMT4S MTO-25996.GPJ 2017TEMPLATE(MTO).GDT 8/5/19

RECORD OF BOREHOLE No BH-02

1 OF 2

METRIC

GWP# 6160-04-00 LOCATION Black Sturgeon River Bridge MTM NAD83 N 5 530 531.1 E 197 822.6 ORIGINATED BY JP
 HWY 658 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY BH
 DATUM Geodetic DATE 2019.05.29 - 2019.05.29 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
323.8	GROUND SURFACE												
0.0	ASPHALT: (125mm)												
0.1	SAND , trace to some gravel, trace silt, some cobbles Dense to compact Brown to grey Moist to wet (FILL)			GS			323						14 77 9 (SI+CL)
			1	SS	50								
			2	SS	41		322						
			3	SS	23		321						
320.8							320						
3.0	SAND , silty, trace gravel Compact Grey Wet (FILL)		4	SS	24		319						
			5	SS	20		318						
318.3							317						
5.5	Boulder encountered from 5.5m to 6.1m						316						
317.7							315						
6.1	SAND AND SILT , trace gravel, trace clay Dense Grey Wet (TILL)		6	SS	49		314						
												5 50 43 2	
316.2													
7.6	COBBLES and BOULDERS , with sand and gravel Grey Wet			GS									
			1	RUN									
313.8													

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-03

1 OF 1

METRIC

GWP# 6160-04-00 LOCATION Black Sturgeon River Bridge MTM NAD83 N 5 530 536.4 E 197 825.5 ORIGINATED BY JP
 HWY 658 BOREHOLE TYPE Hollow Stem Augers/NQ Casing COMPILED BY BH
 DATUM Geodetic DATE 2019.05.29 - 2019.05.29 CHECKED BY MEF

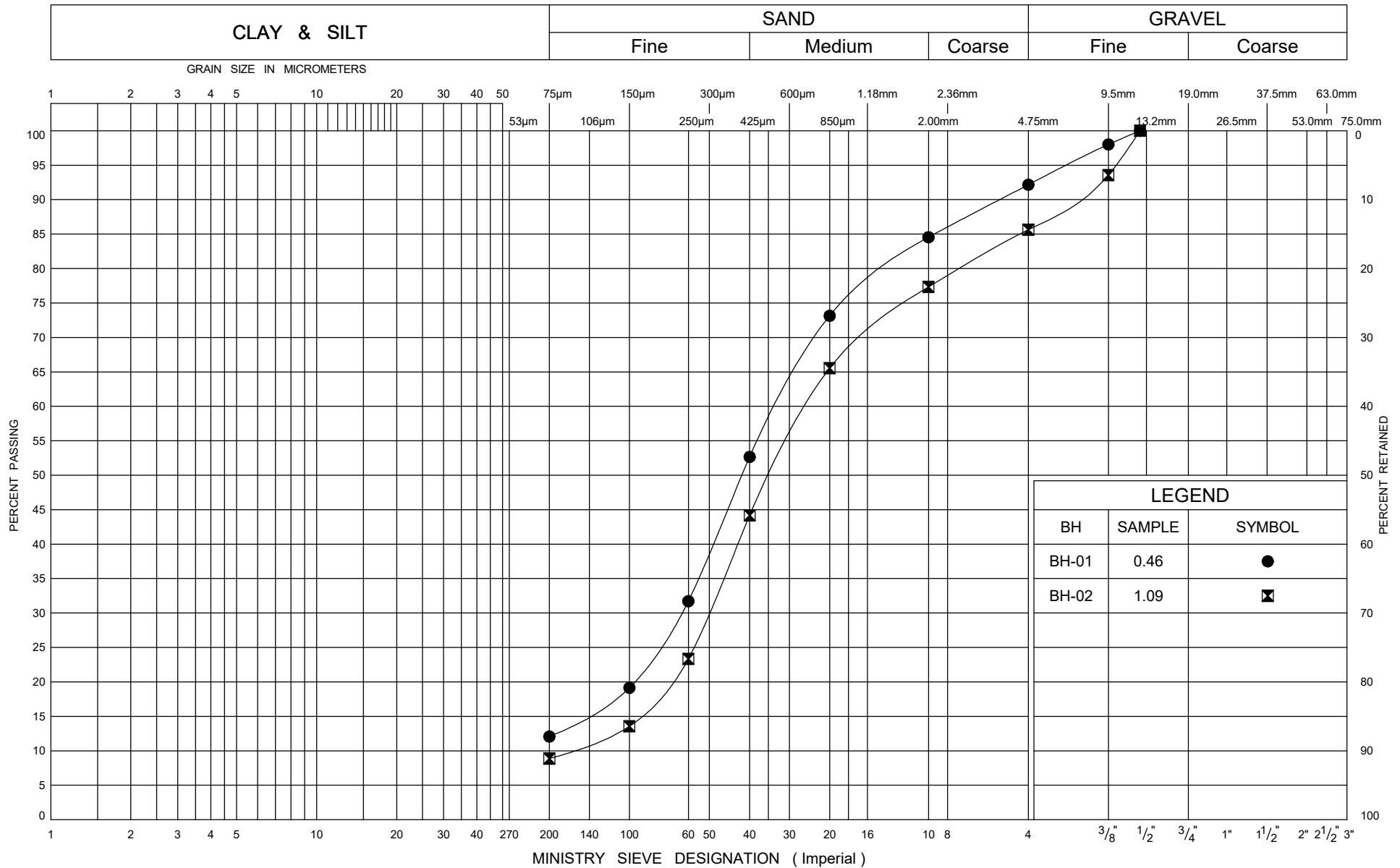
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	20 40 60 80 100	W P W W L	20 40 60					
323.9	GROUND SURFACE															
0.0	ASPHALT: (125mm)															
0.1	SAND, trace to some gravel, trace silt some cobbles Compact to Very Dense Brown to grey Moist to wet (FILL)			GS												
			1	SS	18											
			2	SS	50/ 0.100											
			3	SS	35											
320.9																
3.0	SAND, silty, trace gravel, trace clay Very Dense Grey Wet (FILL)		4	SS	100/ 0.025										7 51 37 5	
320.1																
3.8	Boulder encountered from 4.0m to 4.3m Light Grey															
319.6			1	Run											RUN #2 TCR=100% SCR=100% RQD=100% UCS=150MPa (Average)	
4.3	SAND, silty, some gravel, trace clay Grey Wet (TILL)															
319.0																
4.9	BEDROCK (GRANITIC GNEISS), grey, slightly weathered, very strong.		2	Run											RUN #3 TCR=100% SCR=100% RQD=100% UCS=231MPa (Average)	
318.2			3	Run												
5.7	END OF BOREHOLE AT 5.7m. BOREHOLE CAVED TO 2.4m AND DRY BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.3m, THEN CONCRETE TO 0.2m, THEN ASPHALT TO SURFACE															

ONTMT4S MTO-25996.GPJ 2017TEMPLATE(MTO).GDT 8/5/19



Appendix B

Geotechnical and Analytical Laboratory Test Results



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION

Sand Fill

FIG No B1

W P 6160-04-00

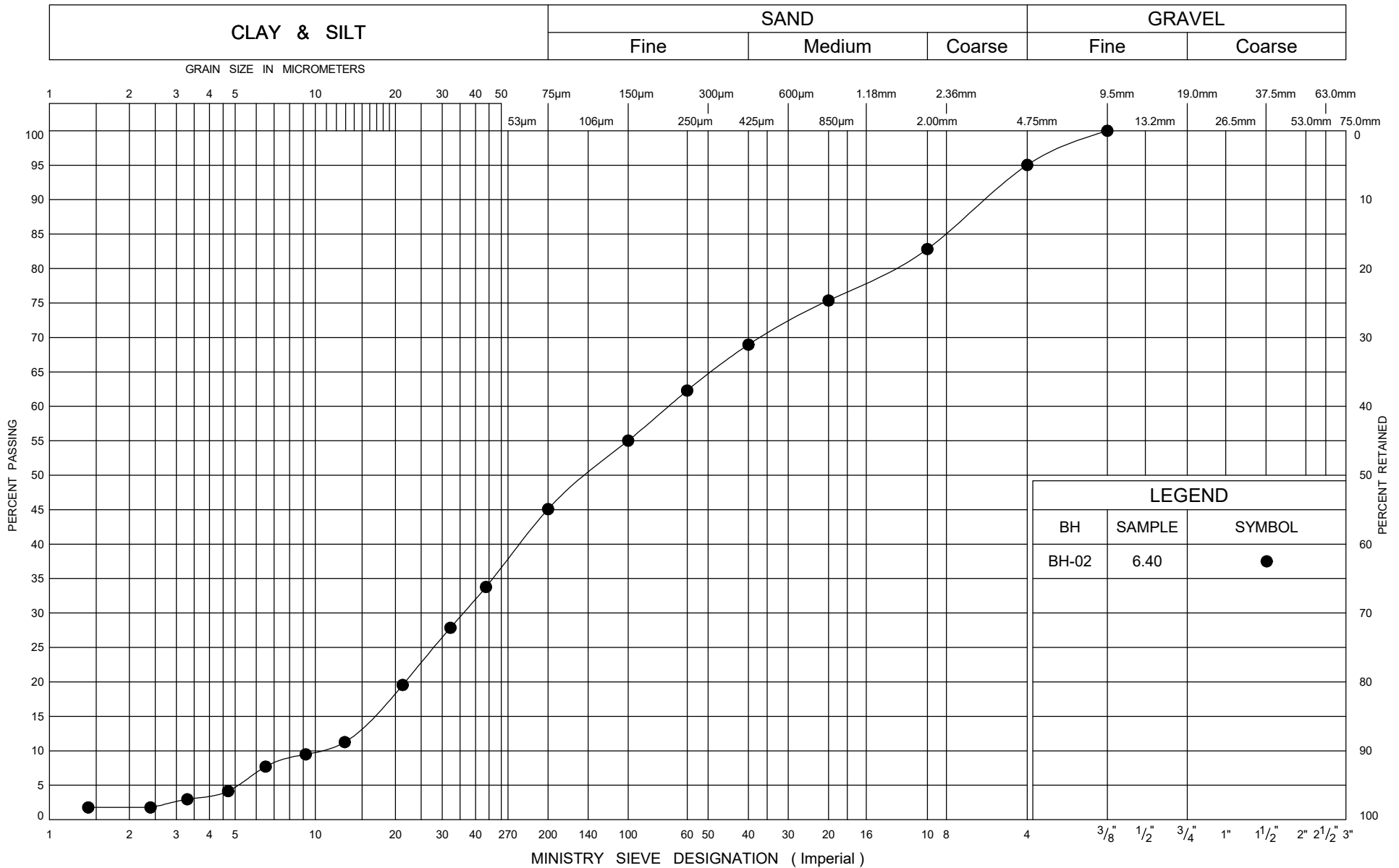
Black Sturgeon River Bridge



FIG No B2

W P 6160-04-00

Black Sturgeon River Bridge



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION

Sand and Silt Till

FIG No B3

W P 6160-04-00

Black Sturgeon River Bridge



FINAL REPORT

CA14362-JUN19 R1

25996

Prepared for

Thurber Engineering Ltd.

First Page

CLIENT DETAILS

Client Thurber Engineering Ltd.

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

Contact Mark Farrant

Telephone 905-829-8666 x 228

Facsimile

Email mfarrant@thurber.ca

Project 25996

Order Number

Samples Soil (2)

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 CA14362-JUN19

Received 06/07/2019

Approved 06/13/2019

Report Number CA14362-JUN19 R1

Date Reported 06/13/2019

COMMENTS

Temperature of Sample upon Receipt: 17 degrees C

Cooling Agent Present:No

Custody Seal Present:No

Chain of Custody Number:NA

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

Brad Moore Hon. B.Sc

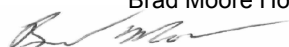




TABLE OF CONTENTS

First Page..... 1

Index..... 2

Results..... 3-4

QC Summary..... 5-6

Legend..... 7

Annexes..... 8



FINAL REPORT

CA14362-JUN19 R1

Client: Thurber Engineering Ltd.

Project: 25996

Project Manager: Mark Farrant

Samplers: NA

PACKAGE: - Corrosivity Index (SOIL)

Sample Number	5	6
Sample Name	BH-01, SS#1, 2.5'-3'10"	BH-02 SS#4, 10'-12'
Sample Matrix	Soil	Soil
Sample Date	30/05/2019	29/05/2019

Parameter	Units	RL		Result	Result
Corrosivity Index					
Corrosivity Index	none	1		14	11
Soil Redox Potential	mV	-		244	332
Sulphide	%	0.02		< 0.02	< 0.02
pH	pH Units	0.05		8.76	7.15
Resistivity (calculated)	ohms.cm	-9999		1320	943

PACKAGE: - General Chemistry (SOIL)

Sample Number	5	6
Sample Name	BH-01, SS#1, 2.5'-3'10"	BH-02 SS#4, 10'-12'
Sample Matrix	Soil	Soil
Sample Date	30/05/2019	29/05/2019

Parameter	Units	RL		Result	Result
General Chemistry					
Conductivity	uS/cm	2		760	1060

PACKAGE: - Metals and Inorganics (SOIL)

Sample Number	5	6
Sample Name	BH-01, SS#1, 2.5'-3'10"	BH-02 SS#4, 10'-12'
Sample Matrix	Soil	Soil
Sample Date	30/05/2019	29/05/2019

Parameter	Units	RL		Result	Result
Metals and Inorganics					
Moisture Content	%	0.1		9.0	12.7



FINAL REPORT

CA14362-JUN19 R1

Client: Thurber Engineering Ltd.
Project: 25996
Project Manager: Mark Farrant
Samplers: NA

PACKAGE: - Metals and Inorganics (SOIL)

Sample Number	5	6
Sample Name	BH-01, SS#1, 2.5'-3'10"	BH-02 SS#4, 10'-12'
Sample Matrix	Soil	Soil
Sample Date	30/05/2019	29/05/2019

Parameter	Units	RL		Result	Result
Metals and Inorganics (continued)					
Sulphate	µg/g	0.4		25	5.6

PACKAGE: - Other (ORP) (SOIL)

Sample Number	5	6
Sample Name	BH-01, SS#1, 2.5'-3'10"	BH-02 SS#4, 10'-12'
Sample Matrix	Soil	Soil
Sample Date	30/05/2019	29/05/2019

Parameter	Units	RL		Result	Result
Other (ORP)					
Chloride	µg/g	0.4		220	380



FINAL REPORT

CA14362-JUN19 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	DIO0194-JUN19	µg/g	0.4	<0.4	3	20	93	80	120	103	75	125
Sulphate	DIO0194-JUN19	µg/g	0.4	<0.4	7	20	94	80	120	98	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	ECS0018-JUN19	%	0.02	<0.02	ND	20	118	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	EWL0176-JUN19	uS/cm	2	2	0	10	100	90	110	NA		



FINAL REPORT

CA14362-JUN19 R1

QC SUMMARY

pH
Method: SM 4500 | Internal ref.: ME-CA-1ENVIEWL-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	EWL0176-JUN19	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

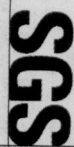
Samples analysed as received. Solid samples expressed on a dry weight basis. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

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. The Client's attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any other holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents.

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

-- End of Analytical Report --



SGS Environment,
Health and Safety

Request for Laboratory Services and CHAIN OF CUSTODY

No:

- Lakefield: 185 Concession St., Lakefield, ON K0L 2H0 Phone: 705-652-2000 Toll Free: 877-747-7658 Fax: 705-652-6365
- London: 657 Consortium Court, London, ON, N6E 2S8 Phone: 519-672-4500 Toll Free: 877-848-8060 Fax: 519-672-0361 Web: www.ca.sgs.com

Page ____ of ____

Received By: DAVID REID

Received Date: 060719 (mm/dd/yy)

Received Time: 03:43 am / pm (circle)

Laboratory Information Section
Received By (signature): [Signature]
Custody Seal Present: Y / N (circle)
Custody Seal Intact: Y / N

Cooling Agent Present: Y (circle) Type: 170

Temperature Upon Receipt (°C) 170

LAB LIMS # CA14362JUN19

REPORT INFORMATION

Company: Thunder Engineering Ltd.

Contact: Mark Farant

Address: 103-2010 Winston Park Dr.

City: Okaville ON L6H 5R7

Phone: 905-829-8666

Fax: 905-829-1166

Email: m.farant@thunderbcg

INVOICE INFORMATION

☒ (same as Report Information)

Company:

Contact:

Address:

Phone:

Fax:

Email:

PROJECT INFORMATION

Quotation #: 25996

Project #: 25996

TURNAROUND TIME (TAT) REQUIRED

☒ Regular TAT (5-7days) TATs are quoted in business days (exclude statutory holidays & weekends). Samples received after 3pm or on weekends : TAT begins the next business day

RUSH TAT (Additional Charges May Apply) ☐ 1 Day ☐ 2 Days ☐ 3-4 Days

PLEASE CONFIRM RUSH FEASIBILITY WITH SGS REPRESENTATIVE PRIOR TO SUBMISSION

Specify Due Date: Rush Confirmation ID:

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

ANALYSIS REQUESTED

COMMENTS:

Field Filtered (F)
Preserved (P)

REGULATIONS

Regulation 153 (2011):
☐ Table 1 ☐ Res/Park ☐ Soil Texture:
☐ Table 2 ☐ Ind/Com ☐ Coarse
☐ Table 3 ☐ Agri/Other ☐ Medium
☐ Table ☐ Fine

Other Regulations:

☐ Reg 347/558 (3 Day min TAT)

☐ PW/QO ☐ MMER

☐ CCME ☐ Other:

☐ MISA

Sewer By-Law:

☐ Sanitary

☐ Storm

Municipality:

RECORD OF SITE CONDITION (RSC) ☐ YES ☐ NO

SAMPLE IDENTIFICATION

DATE SAMPLED	TIME SAMPLED	# OF BOTTLES	MATRIX
1	BH-1 SS#1, 2.5'-3'10"	1	Soil
2	BH-2, SS#4, 10'-12'	1	Soil
3			
4			
5			
6			
7			
8			
9			
10			

Observations/Comments/Special Instructions

Sampled By (NAME):

Signature:

Date: 06/07/19 (mm/dd/yy)

Pink Copy - Client

Relinquished by (NAME):

Mark Farant

Signature:

Date: 06/07/19 (mm/dd/yy)

Yellow & White Copy - SGS



Appendix C

Site Photographs



**Photo 1: Highway 658 South Abutment over Black Sturgeon River Bridge,
looking north. Date Taken: May 30, 2019**



**Photo 2: Highway 658 North Abutment over Black Sturgeon River Bridge,
looking south. Date Taken: May 29, 2019**



Appendix D

Photographic Records of Bedrock Cores

PHOTOGRAPHS OF CORE SAMPLES
FOUNDATION INVESTIGATION AND DESIGN REPORT
BLACK STURGEON RIVER BRIDGE REHABILITATION
KENORA, ONTARIO
LATITUDE: 49.9021°, LONGITUDE: -94.4897°
G.W.P. 6160-04-00
GEOCRES Number:



BOREHOLE: BH-01
RUN NO. 1: 2.0 m to 2.4 m
RUN NO. 2: 2.4 m to 4.0 m
RUN NO. 3: 4.0 m to 5.5 m



BOREHOLE: BH-02
RUN NO. 1: 8.5 m to 10.3 m (Boulders and Cobbles)
RUN NO. 2: 10.6 m to 12.1 m
RUN NO. 3: 12.1 m to 13.6 m

PHOTOGRAPHS OF CORE SAMPLES

FOUNDATION INVESTIGATION AND DESIGN REPORT

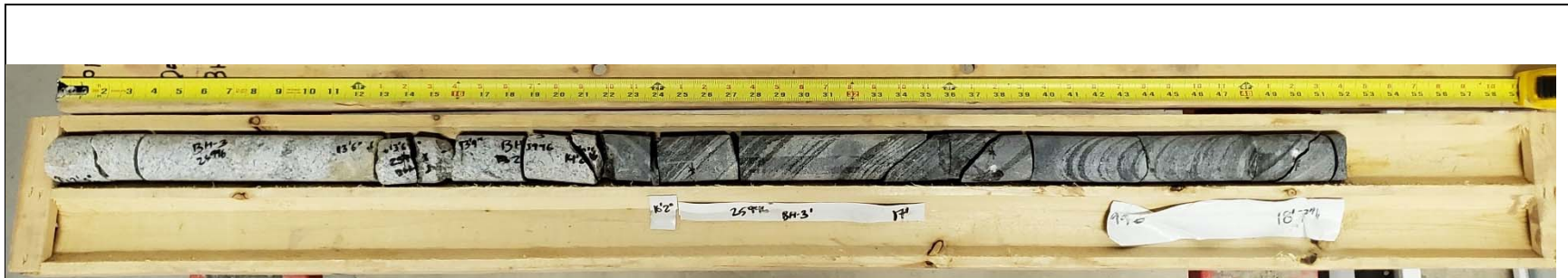
BLACK STURGEON RIVER BRIDGE REHABILITATION

KENORA, ONTARIO

LATITUDE: 49.9021°, LONGITUDE: -94.4897°

G.W.P. 6160-04-00

GEOCRES Number:



BOREHOLE: BH-03

RUN NO. 1: 3.8 m to 4.9 m (Boulder and Silty Sand – not pictured)

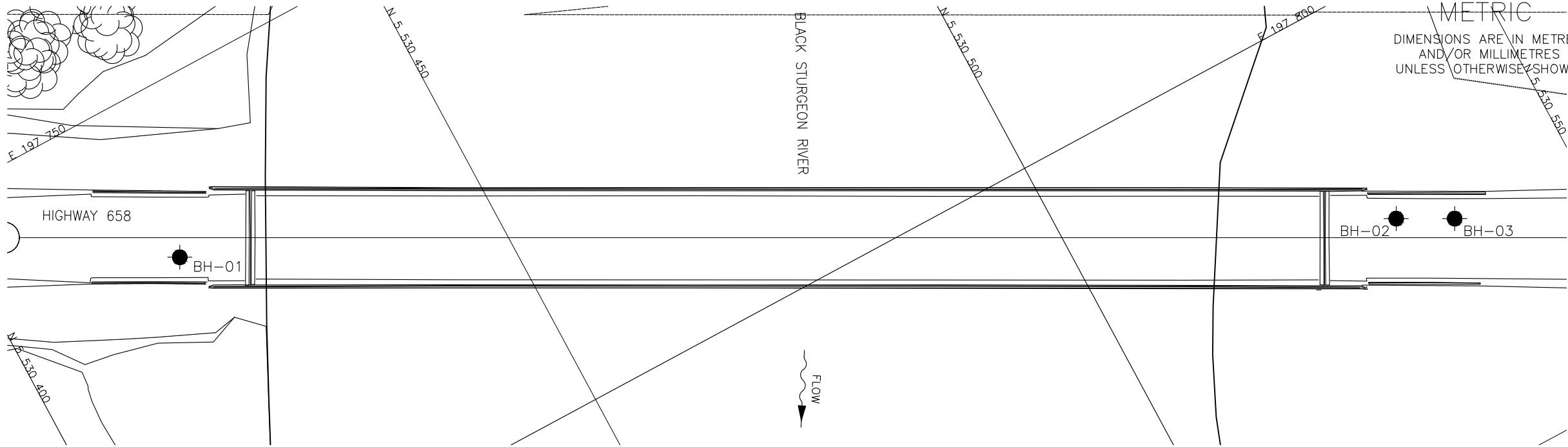
RUN NO. 2: 4.9 m to 5.2 m

RUN NO. 3: 5.2 m to 5.7 m



Appendix E

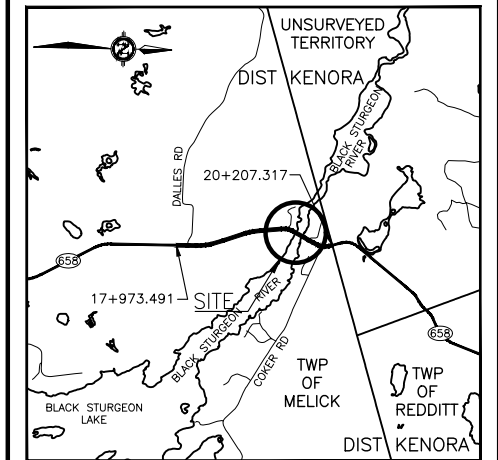
Borehole Locations and Soil Strata Drawing



CONT No
WP No 6160-04-00

HIGHWAY 658
BLACK STURGEON RIVER
BRIDGE REHABILITATION
BOREHOLE LOCATIONS

HATCH



KEYPLAN

LEGEND

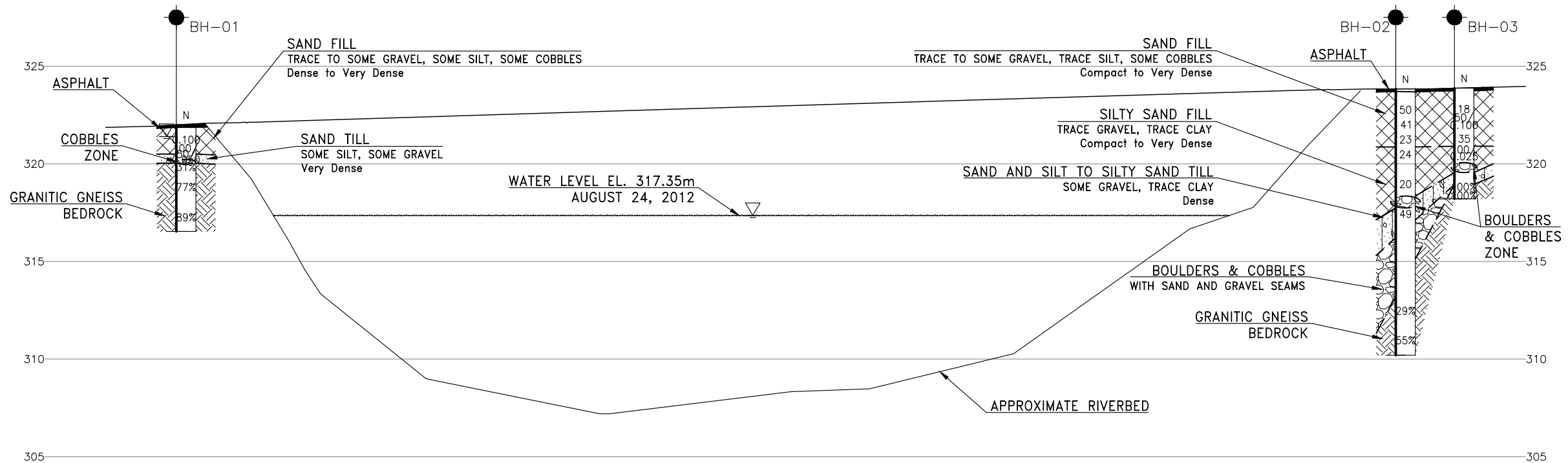
●	Borehole
⊕	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
⊕	Head Artesian Water
⊕	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
BH-01	322.0	5 530 419.4	197 766.9
BH-02	323.8	5 530 531.1	197 822.6
BH-03	323.9	5 530 536.4	197 825.5

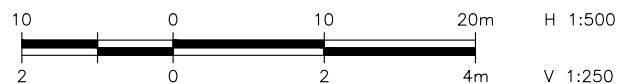
NOTES

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

GEOCRES No. 52E-73



PROFILE ALONG CL OF HIGHWAY 658



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	RDC	CHK MEF	CODE
DRAWN	BH	CHK PKC	SITE 41S-007
STRUCT	DATE	JAN 2020	DWG 1



Appendix F

List of OPSSs and OPSDs and Suggested Wording for NSSP



1. List of OPSS and OPSD Documents Relevant to this Project

- OPSS PROV 206 (Construction Specification for Grading)
- OPSS PROV 501 (Construction Specification for Compacting)
- 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)
- Special Provision No. SP 109S12 (Amendment to OPSS 902 – QVE, Backfilling Compaction, and Certificate of Conformance)
- OPSS PROV 1010 (Material Specification for Aggregates – Base, Subbase, Select Subgrade, and Backfill Material)
- OPSS 1860 (Material Specification for Geotextiles)
- OPSD 3090.100 (Foundation Frost Depths for Northern Ontario)
- OPSD 3101.150 (Walls Abutment, Backfill Minimum Granular Requirements)
- OPSD 3101.200 (Walls Abutment, Backfill Rock)
- OPSD 3102.100 (Wall Abutment Backfill Drain)



2. Suggested Text for NSSP on “Excavation and Installation of Roadway Protection”

The Contractor is advised of the following site conditions:

- Boulders are present within the existing approach embankment fill. Equipment capable of handling boulders will be required for excavation. The boulder layer thickness will vary with location.
- Driving of soldier piles for installation of roadway protection systems may be difficult within the existing approach fill, and predrilling coring, or other means may be required to advance the piles to adequate depth. Use of sheet piles is not recommended.
- The bedrock surface is expected to vary along the length of the roadway protection system, and may be contacted at different elevations between and beyond the borehole locations. Variations in the bedrock surface should be anticipated during shoring installation.
- The bedrock is classified as very strong. If excavation of bedrock is required, equipment that can excavate hard rock will be required. Equipment that can penetrate hard rock will be required to construct soldier pile sockets if required.