



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION REPORT
BLACK STURGEON LAKES BAILEY BRIDGE REPLACEMENT
DETAILED DESIGN
HIGHWAY 671, HAYCOCK TOWNSHIP
DISTRICT OF KENORA, ONTARIO
LATITUDE: 49.821862°, LONGITUDE: -94.240724°
GWP 6124-17-00, SITE No. 41S-0242/B0**

GEOCRES Number: 52E-74

Report

to

Hatch

Date: March 25, 2022
File: 32670



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1. INTRODUCTION

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for detailed design of the proposed replacement of the Black Sturgeon Lakes Bridge on Highway 671, located in Haycock Township, District of Kenora, Ontario.

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

Thurber was retained by Hatch to carry out this foundation investigation under the Ministry of Transportation (MTO) Northwest Region Agreement Number 6019-E-0009, Assignment #34.

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

- Foundation Investigation and Design Report, Black Sturgeon Lakes Bailey Bridge Replacement, Highway 671, Haycock Township, Site 41S-242, Ministry of Transportation, Ontario, prepared by Thurber Engineering Limited, dated December 18, 2017, GEOCRES Number: 52E-66. (Reference 1).

The records of borehole sheets from the previous investigation are included in this report in Appendix B.



2. SITE DESCRIPTION

The site is located on Highway 671, approximately 9.0 km north of Highway 17A, in Haycock Township, District of Kenora, Ontario. The existing bridge allows Drewry Lake to flow into Little Black Sturgeon River in a southeast to northwest direction under Highway 671. Highway 671 generally runs in a northeast to southwest direction at the bridge site.

The Ontario Structure Inspection Manual (Inspection Form) prepared by MTO on June 5, 2019 indicates that the existing structure is a single span steel bailey panel bridge built in 1999. The inspection report indicates that the bridge deck is 40 m long and 6 m wide. The bridge deck is supported on shallow timber foundations. The ground surface elevation at the existing bridge deck is approximately Elevation 334.9 m. The water level of Little Black Sturgeon River beneath the bridge was measured at Elevation 331.86 m on July 21, 2017.

The lands surrounding the bridge site predominantly consist of heavily forested areas with occasional lakes, swamps, rivers, and creeks. Local topography is hummocky and knobby and is generally of moderate relief. Photographs of the bridge and surrounding area are presented in Appendix D. Large diameter rock protection is present along the riverbanks and surrounding the north and south abutments.

Based on published geological information, the bridge lies within an area consisting of sandy till subsurface soils overlying a knobby bedrock profile. Based on local geological maps, the bedrock in the area is identified as tonalite to granodiorite.

3. INVESTIGATION PROCEDURES

The current site investigation and field testing program for this project was carried out between September 21 and 22, 2021 and consisted of drilling and sampling four (4) boreholes, labeled 21-01 to 21-04, to depths ranging from approximately 10.8 m to 15.4 m (Elevation 323.4 to 318.0 m). The boreholes were drilled beside the east side of the existing highway, near the approximate locations of the temporary detour bridge abutments and detour approach embankments. An additional seven (7) pavement boreholes and five (5) topsoil probes were advanced and labelled PVT21-01 to PVT21-07 and TPS21-01 to TPS21-05, respectively. The pavement boreholes and topsoil probes were located along the proposed detour embankment alignment and were advanced to depths ranging between 2.1 and 3.6 m.

The pavement borehole and topsoil probe logs are included in Appendix B for reference. A separate Pavement Design Memorandum is provided to discuss the results of the pavement



investigation.

The previous foundation investigation by Thurber included two (2) boreholes, labeled BSL-01 and BSL-02, which were drilled from the existing road grade on the gravel shoulder near the proposed abutments for the permanent bridge. Boreholes BSL-01 and BSL-02 were drilled to depths of approximately 15.4 m and 15.3 m (Elevation 319.3 and 319.4 m), respectively.

The approximate locations of the boreholes from the current and previous investigations are shown on the Borehole Locations and Soil Strata Drawings included in Appendix A. The Record of Borehole Sheets for all foundation and pavement boreholes are included in Appendix B.

Utility clearances were obtained prior to the start of drilling. The ground surface elevations for the boreholes were estimated from the cross sections and topographic drawings provided to Thurber by Hatch. The coordinate system MTM NAD 83, Zone 16 was used for the boreholes.

A track-mounted drill rig was used to advance the boreholes using hollow stem augers, wash boring 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). Dynamic Cone Penetration Tests (DCPTs) were conducted at Boreholes BSL-01 and BSL-02 from the ground surface and extended to cone refusal of 100 blows / 0.3 m penetration. Due to wet ground conditions on the north side of the river, an excavator was utilized to build granular fill working pads for the drill rig at the locations of Boreholes 21-03 and 21-04.

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.

Groundwater conditions were observed in the open boreholes upon completion of drilling and piezometers were installed in Boreholes 21-02 and BSL-02. The boreholes were backfilled in general accordance with Ontario Regulation 903 as amended. The piezometers were decommissioned on September 22, 2021 and October 3, 2017 in general accordance with Ontario Regulation 903 as amended.

Completion details of the boreholes are summarized in Table 3.1.

Table 3.1 – Borehole Completion Details

Borehole Number	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
21-01	10.9 / 323.4	-	Borehole backfilled with bentonite holeplug from 10.9 m to surface.
21-02	15.4 / 318.0	15.2 / 318.2	Borehole was backfilled with filter sand from 15.2 m to 11.6 m, bentonite holeplug from 11.6 m to surface.
21-03	15.4 / 318.7	-	Borehole backfilled with bentonite holeplug from 15.4 m to surface.
21-04	10.8 / 322.7	-	Borehole backfilled with bentonite holeplug from 10.8 m to surface.
BSL-01	15.4 / 319.3	-	Borehole backfilled with bentonite holeplug and cuttings to surface.
BSL-02	15.3 / 319.4	15.2 / 319.5	Sand from 15.3 m to 11.6 m, then bentonite holeplug and cuttings to surface.

4. LABORATORY TESTING

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

Sample of the native silty clay, existing embankment fill and surface water from the river upstream of the existing bridge were tested during the previous investigation for sulphate attack and corrosivity parameters. The samples were tested by SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario. The results of the analytical testing are summarized in Section 6 and are presented in Appendix C.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix B. Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets and on the Borehole Locations and Soil Strata Drawings for the detour alignment (current investigation) and the Highway 671 alignment (previous investigation) included in Appendix A.



A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description and 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 consist of gravelly sand embankment fill along the Highway 671 alignment, native deposits of silty clay and silty sand to sand, overlying silty sand to sandy silt till. Descriptions of the individual strata are presented below.

5.1 Topsoil

Topsoil was encountered with a thickness of 75 mm at Borehole 21-02, which was drilled offroad along the east side of the detour alignment. While not encountered in Boreholes 21-03 and 21-04, due to the construction of granular pads for drill rig site access, it is important to note that topsoil or other organics should also be expected along the detour alignment on the north side of the river. Furthermore, sand and gravel fill should be expected at the locations of Boreholes 21-03 and 21-04 along the detour alignment, due to the granular pads built for site access (see Photo 8 in Appendix D).

5.2 Sand Fill

Sand fill, containing some silt and gravel, was encountered at the ground surface in Borehole 21-01. The borehole was drilled through the surficial fill of a local boat launch. The sand fill extended to a depth of approximately 0.7 m (Elevation 333.6 m)

A SPT 'N' value in the sand fill was recorded as 29 blows for 0.3 m penetration, indicating a compact relative density. The measured moisture content in the fill was 2 percent.

5.3 Embankment Fill

Gravelly sand embankment fill, containing trace to some silt and clay and occasional cobbles and boulders, was encountered at the ground surface in Boreholes BSL-01 and BSL-02 on Highway 671. The embankment fill extended to a depth of approximately 2.3 m (Elevation 332.4 m) in Borehole BSL-01 and to approximately 1.5 m (Elevation 333.2 m) in Borehole BSL-02.

SPT 'N' values in the gravelly sand fill ranged from 13 to 55 blows for 0.3 m penetration, indicating a compact to very dense relative density. One higher blow count was encountered, which is likely



indicative of the presence of cobbles and boulders. The measured moisture content in the fill ranged from 7 to 20 percent.

The results of grain size analyses conducted on samples of the gravelly sand fill are provided on the Record of Borehole sheets in Appendix B, and illustrated in Figure C1 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage
Gravel	32 to 36
Sand	52 to 60
Silt & Clay	8 to 12

5.4 Silty Clay

Silty clay, containing some sand to becoming sandy, and trace gravel, roots and rootlets, was encountered below the topsoil in Borehole 21-02 and below the embankment fill in Boreholes BSL-01 and BSL-02. In Borehole BSL-02 the silty clay was not noted to contain organic content or rootlets. The silty clay layer was approximately 1.5 m to 2.1 m thick and extended to depths of approximately 2.2 m and 4.1 m (Elevation 331.7 to 330.6 m).

SPT 'N' values measured in the silty clay ranged from 6 to 15 blows for 0.3 m penetration, indicating a firm to very stiff consistency. The measured moisture content in the silty clay ranged from 22 to 76 percent. The higher moisture content values recorded in Boreholes BSL-01 and 21-02 may be indicative of the organic content.

The results of a grain size analyses and Atterberg limits conducted on samples of the silty clay are provided on the Record of Borehole sheets in Appendix B and illustrated in Figures C2 and C8 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage
Gravel	0
Sand	25 to 31
Silt	42 to 49
Clay	20 to 33



Soil Property	Percentage
Liquid Limit	39 to 49
Plastic Limit	17 to 18

The results of the Atterberg Limit test indicate that the silty clay typically has an intermediate plasticity with a group symbol of CI.

5.5 Silty Sand to Sand

A deposit of silty sand to sand, containing some silt, trace gravel and cobbles, was encountered at the surface of Borehole 21-04. The silty sand to sand deposit was approximately 3.9 m thick and extended to a depth of 3.9 m (Elevation 329.6 m).

SPT 'N' values measured in the silty sand to sand ranged from 25 to more than 100 blows for 0.3 m penetration, indicating a compact to very dense consistency. The measured moisture content in the silty sand to sand ranged from 13 to 19 percent.

The results of a grain size analysis conducted on a sample of the silty sand to sand is provided on the Record of Borehole sheets in Appendix B, and illustrated in Figure C3 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage
Gravel	0
Sand	88
Silt	12
Clay	0

5.6 Silty Sandy Gravel

A deposit of silty sandy gravel, containing occasional cobbles, was encountered below the silty sand to sand at a depth of 3.9 m in Borehole 21-04. The silty sandy gravel deposit was approximately 1.5 m thick and extended to a depth of 5.4 m (Elevation 328.1 m).

A SPT 'N' value measured in the silty sandy gravel was 100 blows for 0.075 m penetration, indicating a very dense consistency. The measured moisture content in the silty sandy gravel was 12 percent.



The results of a grain size analysis conducted on a sample of the silty sandy gravel is provided on the Record of Borehole sheets in Appendix B, and illustrated in Figure C4 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage
Gravel	43
Sand	33
Silt & Clay	24

5.7 Silty Sand to Sandy Silt Till

A thick deposit of till, ranging in composition from silty sand to sandy silt till, and containing trace gravel to gravelly, trace clay, and occasional cobbles and boulders, was encountered at the ground surface in Borehole 21-03, beneath the silty clay layer in Boreholes BSL-01, BSL-02 and 21-02, beneath the sand fill in Borehole 21-01 and beneath the silty sandy gravel in Borehole 21-04. All boreholes were terminated within the till deposit at depths of 10.8 to 15.4 m (Elevation 323.4 to 318.0 m). A 450 mm diameter boulder was encountered in Borehole 21-01 at a depth of 7.6 m (Elevation 326.7 m). Glacial tills inherently contain cobbles and boulders.

SPT 'N' values measured in the till typically were greater than 100 blows for 0.3 m penetration, indicating a very dense relative density, and the possible presence of cobbles and boulders in the till. In the upper part of the deposit, some lower SPT N' values of 25 to 65 blows per 0.3 m penetration were noted, indicating a compact to dense density. The DCPTs conducted from the ground surface at Boreholes BSL-01 and BSL-02 encountered refusal on 100 blows per 0.3 m penetration at depths of 4.2 and 3.8 m (Elevation 330.5 m and 330.9 m) within the till. The measured moisture contents in the till ranged from 3 to 22 percent.

The results of grain size analyses conducted on samples of the silty sand to sandy silt till are provided on the Record of Borehole sheets in Appendix B and illustrated on Figures C5 to C7 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage
Gravel	0 to 27
Sand	24 to 73
Silt	14 to 72
Clay	1 to 5
Silt and Clay	13 to 14

5.8 Groundwater Conditions

Groundwater conditions were observed during drilling operations and groundwater levels were measured in the open boreholes upon completion of drilling. Temporary piezometers were installed in Boreholes BSL-02 and 21-02. A summary of the water level readings is summarized in provided in Table 5.1 below.

Table 5.1: Groundwater Measurements

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
21-01	September 21, 2021	1.8	332.5	Open Borehole
21-02	September 21, 2021	1.7	331.7	In piezometer
	September 22, 2021	1.7	331.7	
21-03	September 22, 2021	0.0	334.1	Open Borehole
21-04	September 22, 2021	0.0	333.5	Open Borehole
BSL-01	October 1, 2021	2.1	332.6	Open Borehole
BSL-02	October 1, 2021	2.0	332.7	In piezometer
	October 2, 2021	2.7	332.0	
	October 3, 2021	2.7	332.0	

The groundwater level should be assumed to reflect the local river water level. The river water level was measured at Elevation 331.9 m on July 21, 2017, as shown on drawings provided by MTO.

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

A sample of the embankment fill, a sample of the native silty clay, and a sample of the surface water from the river were submitted for analytical testing of corrosivity parameters and sulphate during the previous investigation. The results of the analytical tests are shown in Table 6.1. The laboratory certificates of analysis are presented in Appendix C.



Table 6.1 - Analytical Test Results

Parameter	Units (Soil)	Units (Water)	Test Results		
			BSL-01 SS 3 Depth 1.8 m	BSL-01 SS 4 Depth 2.6 m	Black Sturgeon Lake
			(Gravelly Sand Fill)	(Silty Clay)	(River Water)
Sulphide	%	mg/L	<0.02	<0.02	<0.006
Chloride	µg/g	mg/L	2.1	77	4.1
Sulphate	µg/g	mg/L	7.0	10	1.2
pH	No unit	No unit	8.05	7.68	6.79
Electrical Conductivity	µS/cm	µS/cm	44	223	50
Resistivity	Ohms.cm	Ohms.cm	22700	4480	20000
Redox Potential	mV	mV	310	227	303

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 Hatch and MTO.

RPM Drilling Ltd. of Thunder Bay, Ontario and Eastern Ontario Diamond Drilling of Hawkesbury, Ontario and supplied and operated the drilling, sampling and in-situ testing equipment for the field investigations. The field investigations were both supervised on a full time basis by Mr. Amir Fereidouni of Thurber. Overall supervision of the field programs were provided by Mr. Joshua Alexander, EIT and 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. Joshua Alexander, EIT and Mr. Mark Farrant, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.



Thurber Engineering Ltd.

Joshua Alexander
Geotechnical EIT



Mark Farrant, P.Eng.
Associate, Senior Geotechnical Engineer

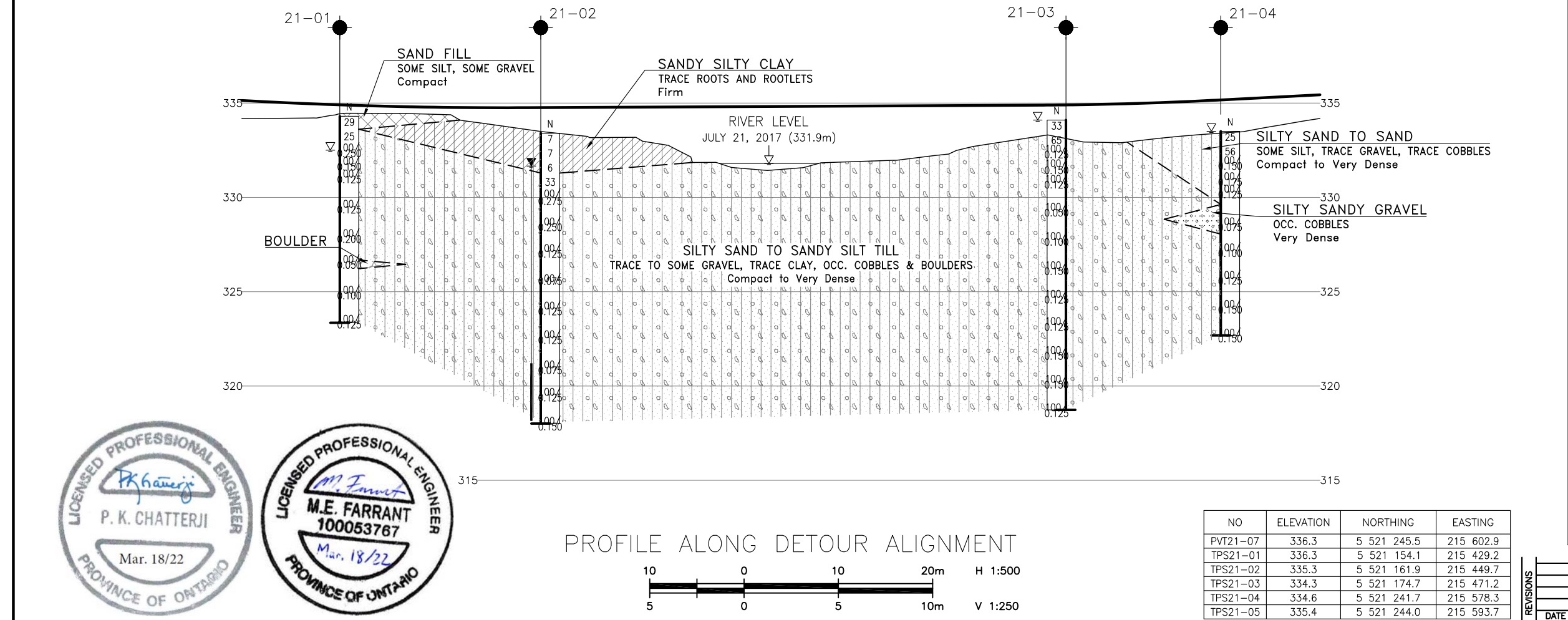
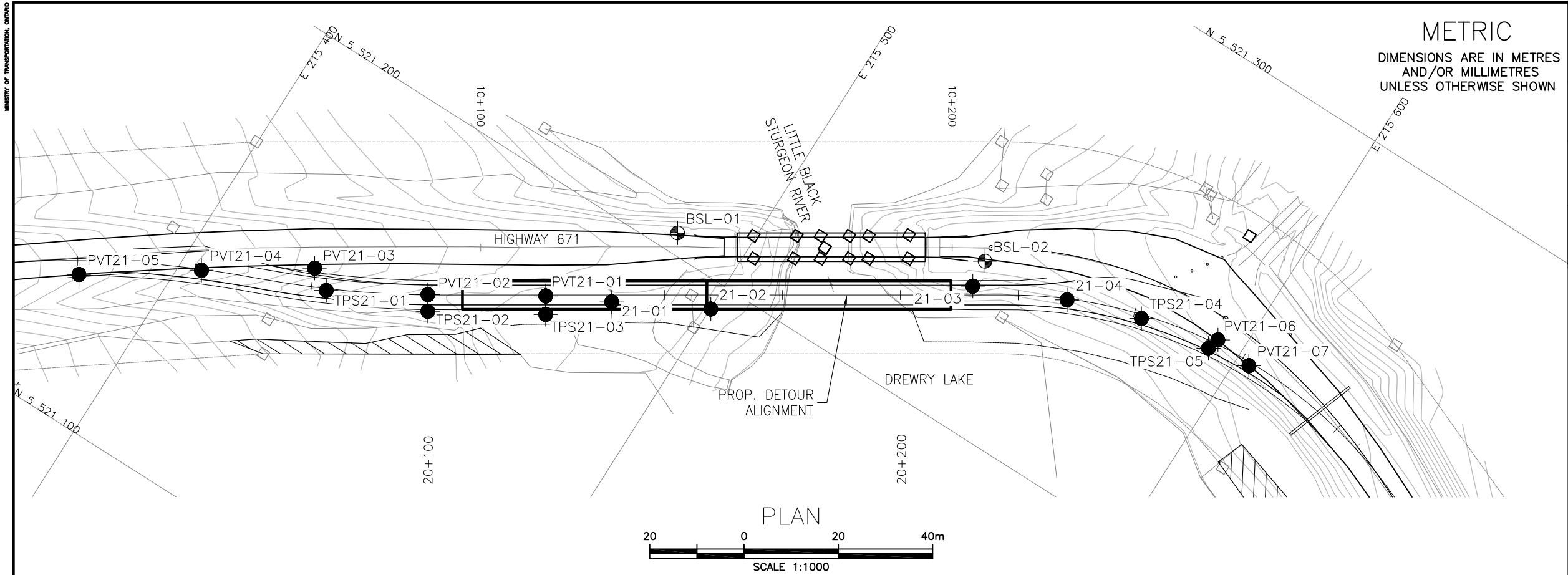


P.K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact

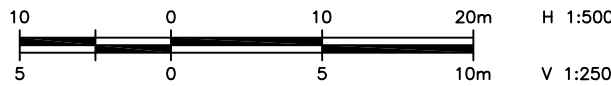


Appendix A

Borehole Locations and Soil Strata Drawings (Current and Previous Investigations)



PROFILE ALONG DETOUR ALIGNMENT



NO	ELEVATION	NORTHING	EASTING
PVT21-07	336.3	5 521 245.5	215 602.9
TPS21-01	336.3	5 521 154.1	215 429.2
TPS21-02	335.3	5 521 161.9	215 449.7
TPS21-03	334.3	5 521 174.7	215 471.2
TPS21-04	334.6	5 521 241.7	215 578.3
TPS21-05	335.4	5 521 244.0	215 593.7

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

W.O. No 6124-17-00

HIGHWAY 671
BLACK STURGEON LAKES
BAILEY BRIDGE
BOREHOLE LOCATIONS AND SOIL STRATA

Ontario Ministry of Transportation
Northwestern Region

THURBER ENGINEERING LTD.

Latitude: 49.8218° Longitude: -94.2403°

KEYPLAN

●

Borehole (Current Investigation)

●

Borehole (Previous Investigation)

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	334.3	5 521 184.4	215 481.6
21-02	333.4	5 521 194.4	215 500.2
21-03	334.1	5 521 228.3	215 544.5
21-04	333.5	5 521 236.6	215 562.9
BSL-01	334.7	5 521 204.3	215 485.6
BSL-02	334.7	5 521 234.2	215 543.8
PVT21-01	334.3	5 521 178.0	215 469.1
PVT21-02	335.2	5 521 164.9	215 447.8
PVT21-03	337.3	5 521 156.7	215 424.6
PVT21-04	338.4	5 521 143.5	215 404.5
PVT21-05	339.9	5 521 128.8	215 383.1
PVT21-06	336.2	5 521 246.6	215 594.5

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

3) Coordinate system is MTM NAD 83, Zone 16.

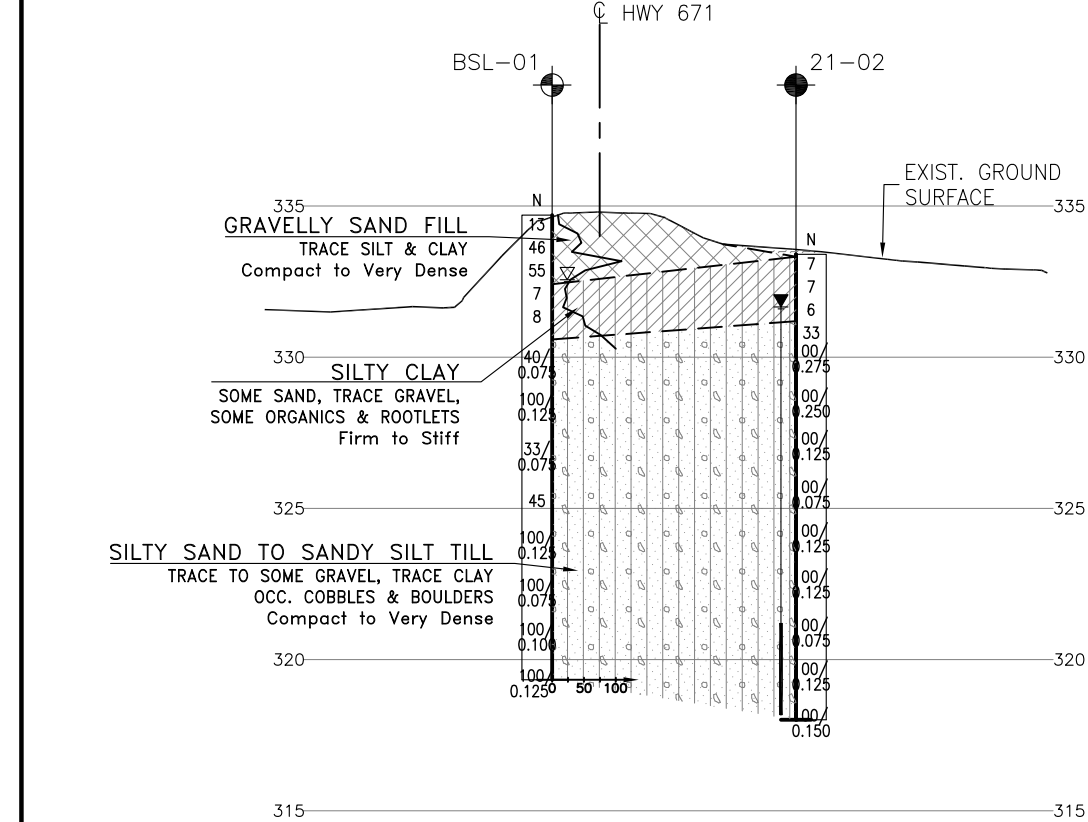
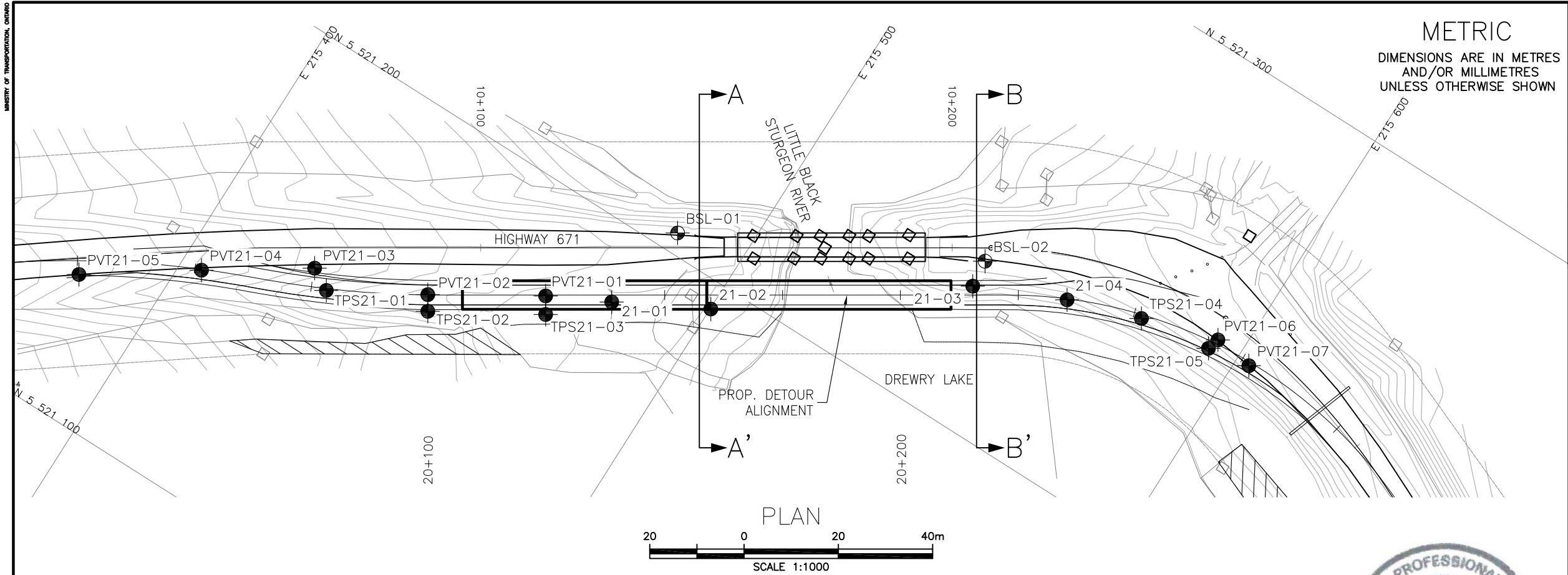
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REVISIONS

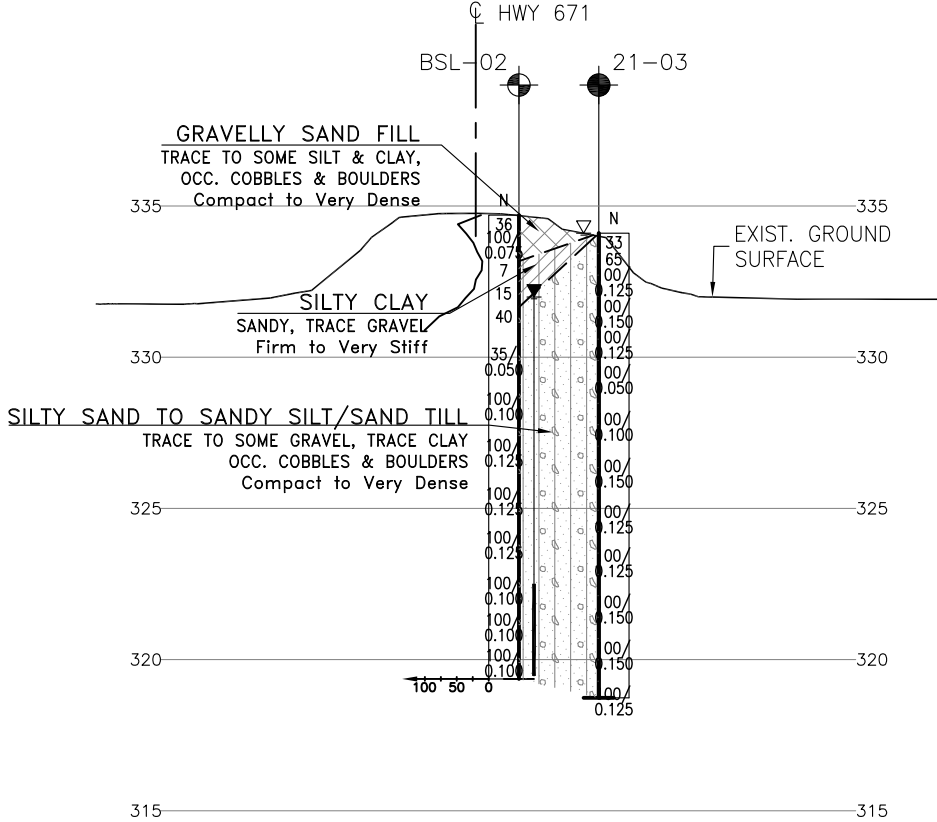
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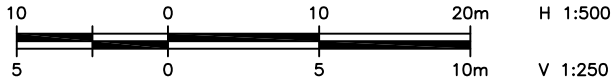
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SECTION ALONG A-A'



SECTION ALONG B-B'



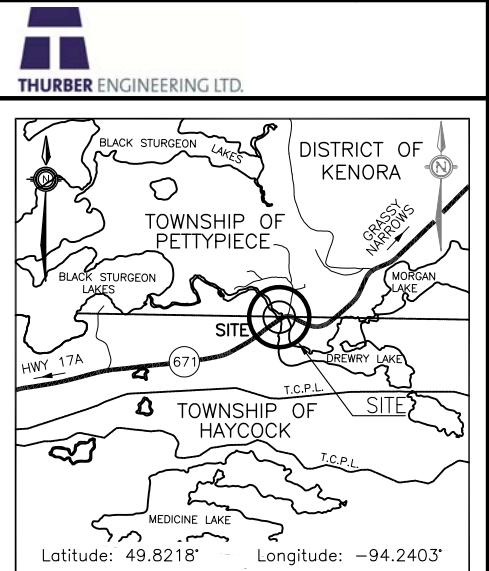
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HIGHWAY 671
BLACK STURGEON LAKES
BAILEY BRIDGE
BOREHOLE LOCATIONS AND SOIL STRATA

Ontario Ministry of Transportation
Northwestern Region

SHEET



KEYPLAN

Borehole (Current Investigation)

Borehole (Previous Investigation)

N

Blows /0.3m (Std Pen Test, 475J/blow)

CONE

Blows /0.3m (60° Cone, 475J/blow)

PH

Pressure, Hydraulic

W

Water Level

W

Head Artesian Water

P

Piezometer

90%

Rock Quality Designation (RQD)

A/R

Auger Refusal

NO	ELEVATION	NORTHING	EASTING
21-01	334.3	5 521 184.4	215 481.6
21-02	333.4	5 521 194.4	215 500.2
21-03	334.1	5 521 228.3	215 544.5
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PVT21-02	335.2	5 521 164.9	215 447.8
PVT21-03	337.3	5 521 156.7	215 424.6
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GEOCRES No. 52E-74

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TPS21-05	335.4	5 521 244.0	215 593.7

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	JA	CHK MEF	CODE
DRAWN	BH	CHK JA	SITE
			LOAD
			STRUCT
			DWG 2
			DATE MAR 2022

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PLOTDATE: 3/19/2022 5:18 PM



Appendix B

Record of Borehole Sheets (Current and Previous Investigations)

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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

 Water Level

C_{pen} Shear Strength Determination by Pocket Penetrometer

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

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			

METRIC

GWP#	6124-17-00	LOCATION	Black Sturgeon Lakes Bailey Bridge, MTM NAD83-16; N 5 521 184.4 E 215 481.6			ORIGINATED BY	AF		
DIST	Kenora	HWY	671	BOREHOLE TYPE	Hollow Stem Augers/NW Casing			COMPILED BY	AN
DATUM	Geodetic	DATE	2021.09.21 - 2021.09.21	LATITUDE	49.821538	LONGITUDE	-94.241349	CHECKED BY	JA

[illegible]

+³, ×³: Numbers refer to Sensitivity

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RECORD OF BOREHOLE No 21-01

2 OF 2

METRIC

GWP# 6124-17-00 LOCATION Black Sturgeon Lakes Bailey Bridge, MTM NAD83-16; N 5 521 184.4 E 215 481.6 ORIGINATED BY AF
DIST Kenora HWY 671 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY AN
DATUM Geodetic DATE 2021.09.21 - 2021.09.21 LATITUDE 49.821538 LONGITUDE -94.241349 CHECKED BY JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	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									
	Continued From Previous Page																
323.4			10	SS	100/												
10.9	END OF BOREHOLE AT 10.9m. WATER LEVEL AT 1.8m IN OPEN BOREHOLE. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.				0.125												

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 21-02

1 OF 2

METRIC

GWP# 6124-17-00 LOCATION Black Sturgeon Lakes Bailey Bridge, MTM NAD83-16; N 5 521 194.4 E 215 500.2 ORIGINATED BY AF
DIST Kenora HWY 671 BOREHOLE TYPE NW Casing COMPILED BY AN
DATUM Geodetic DATE 2021.09.21 - 2021.09.21 LATITUDE 49.821631 LONGITUDE -94.241094 CHECKED BY JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								
							20	40	60	80	100	20	40	60		
333.4	GROUND SURFACE															
0.0	TOPSOIL: (75mm)															
0.1	Silty CLAY , some sand, trace roots and rootlets Firm Brown Moist to Wet		1	SS	7											
			2	SS	7											0 25 42 33
			3	SS	6											
331.2																
2.2	Silty SAND to Sandy SILT , trace to some gravel, trace clay Dense to Very Dense Grey Wet (TILL)		4	SS	33											
			5	SS	100/ 0.275											
			6	SS	100/ 0.250											4 43 48 5
			7	SS	100/ 0.125											
			8	SS	100/ 0.075											0 24 72 4
			9	SS	100/ 0.125											

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

20
15
10
(%) STRAIN AT FAILURE

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 21-03

1 OF 2

METRIC

GWP# 6124-17-00 LOCATION Black Sturgeon Lakes Bailey Bridge, MTM NAD83-16; N 5 521 228.3 E 215 544.5 ORIGINATED BY AF
DIST Kenora HWY 671 BOREHOLE TYPE NW Casing COMPILED BY AN
DATUM Geodetic DATE 2021.09.22 - 2021.09.22 LATITUDE 49.821942 LONGITUDE -94.240486 CHECKED BY JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							
334.1	GROUND SURFACE														
0.0	Silty SAND, trace clay, trace gravel Dense to Very Dense Grey Wet (TILL)		1	SS	33		334								
			2	SS	65		333								2 71 26 1
			3	SS	100/ 0.125		332								
	Occasional cobbles, gravelly		4	SS	100/ 0.150		331								
			5	SS	100/ 0.125		330								
			6	SS	100/ 0.050		329								
			7	SS	100/ 0.100		328								
			8	SS	100/ 0.150		327								1 73 25 1
			9	SS	100/ 0.125		326								
							325								

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 21-03

2 OF 2

METRIC

GWP# 6124-17-00 LOCATION Black Sturgeon Lakes Bailey Bridge, MTM NAD83-16; N 5 521 228.3 E 215 544.5 ORIGINATED BY AF
DIST Kenora HWY 671 BOREHOLE TYPE NW Casing COMPILED BY AN
DATUM Geodetic DATE 2021.09.22 - 2021.09.22 LATITUDE 49.821942 LONGITUDE -94.240486 CHECKED BY JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								
	Continued From Previous Page															
	Possible cobble layer 10.7 to 15.4m depth		10	SS	100/	0.125										
	becoming some gravel		11	SS	100/	0.150										
			12	SS	100/	0.150										
			13	SS	100/	0.125										
318.7 15.4	END OF BOREHOLE AT 15.4m. WATER LEVEL AT GROUND SURFACE IN OPEN BOREHOLE. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.															

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

RECORD OF BOREHOLE No 21-04

1 OF 2

METRIC

GWP# 6124-17-00 LOCATION Black Sturgeon Lakes Bailey Bridge, MTM NAD83-16; N 5 521 236.6 E 215 562.9 ORIGINATED BY AF
DIST Kenora HWY 671 BOREHOLE TYPE NW Casing COMPILED BY AN
DATUM Geodetic DATE 2021.09.22 - 2021.09.22 LATITUDE 49.822019 LONGITUDE -94.240232 CHECKED BY JA

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			20	40	60	80	100		
333.5	GROUND SURFACE													
0.0	Silty SAND to SAND , some silt, trace gravel, trace cobbles Compact to Very Dense Grey Wet		1	SS	25		333							
			2	SS	56		332							
			3	SS	100/ 0.150		331							
			4	SS	100/ 0.175		330							
			5	SS	100/ 0.125		329							
329.6	Silty Sandy GRAVEL , occasional cobbles Very Dense Grey Wet		6	SS	100/ 0.075		328							
3.9			7	SS	100/ 0.100		327							
			8	SS	100/ 0.125		326							
328.1	Silty SAND to SAND , some silt, gravelly, occasional cobbles Very Dense Grey Wet (TILL)		9	SS	100/ 0.150		325							
5.4							324							

Continued Next Page

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

RECORD OF BOREHOLE No 21-04

2 OF 2

METRIC

GWP# 6124-17-00 LOCATION Black Sturgeon Lakes Bailey Bridge, MTM NAD83-16; N 5 521 236.6 E 215 562.9 ORIGINATED BY AF
DIST Kenora HWY 671 BOREHOLE TYPE NW Casing COMPILED BY AN
DATUM Geodetic DATE 2021.09.22 - 2021.09.22 LATITUDE 49.822019 LONGITUDE -94.240232 CHECKED BY JA

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)				
							20	40	60	80	100	W _p	W	W _L			
	Continued From Previous Page																
322.7			10	SS	100/		323					○				23 64 13	
10.8	END OF BOREHOLE AT 10.8m. WATER LEVEL AT GROUND SURFACE IN OPEN BOREHOLE. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.				0.150											(SI+CL)	

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BSL-01

1 OF 2

METRIC

W.P. _____ LOCATION Black Sturgeon Lakes Bailey Bridge N 5 521 204.3 E 215 485.6 ORIGINATED BY AHF
 HWY 671 BOREHOLE TYPE NW Casing/Dynamic Cone Penetration Test COMPILED BY MP
 DATUM Geodetic DATE 2017.10.01 - 2017.10.03 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	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						
							20 40 60 80 100	20 40 60						
334.7	GROUND SURFACE													
0.0	Gravelly SAND , trace silt and clay Compact to Very Dense Brown Moist (FILL) occasional cobbles		1	SS	13									
			2	SS	46									
			3	SS	55									
332.4														
2.3	Silty CLAY , some organics, some sand, trace gravel, rootlets Firm to Stiff Grey Wet		4	SS	7									
			5	SS	8									
330.6														
4.1	Silty SAND to SAND and SILT , trace to some gravel, trace clay, occasional cobbles and boulders Dense to Very Dense Grey Wet (TILL)		6	SS	40/ 0.075									
			7	SS	100/ 0.125									
			8	SS	33/ 0.075									
			9	SS	45									

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No BSL-02

1 OF 2

METRIC

W.P. _____ LOCATION Black Sturgeon Lakes Bailey Bridge N 5 521 234.2 E 215 543.8 ORIGINATED BY AHF
 HWY 671 BOREHOLE TYPE NW Casing/Dynamic Cone Penetration Test COMPILED BY MP
 DATUM Geodetic DATE 2017.09.30 - 2017.10.01 CHECKED BY MEF

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa							
334.7	GROUND SURFACE						20 40 60 80 100	○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	WATER CONTENT (%)				GR SA SI CL		
0.0	Gravelly SAND , trace to some silt and clay, occasional cobbles and boulders Dense to Very Dense Brown Moist (FILL)		1	SS	36		334						36 52 12 (SI+CL)		
			2	SS	100/ 0.075										
333.2															
1.5	Silty CLAY , sandy, trace gravel Firm to Very Stiff Brown Wet (CI)		3	SS	7		333								
			4	SS	15		332							0 31 49 20	
331.7															
3.0	SAND , some silt, trace to some gravel, trace clay, occasional cobbles and boulders Dense to Very Dense Brown Wet (TILL)		5	SS	40		331							24 59 14 3	
			6	SS	35/ 0.050		330								
			7	SS	100/ 0.100	329									

Continued Next Page

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

RECORD OF BOREHOLE No BSL-02

2 OF 2

METRIC

W.P. _____ LOCATION Black Sturgeon Lakes Bailey Bridge N 5 521 234.2 E 215 543.8 ORIGINATED BY AHF
 HWY 671 BOREHOLE TYPE NW Casing/Dynamic Cone Penetration Test COMPILED BY MP
 DATUM Geodetic DATE 2017.09.30 - 2017.10.01 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 20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%) 20 40 60 W _p W W _L				
10.0	Continued From Previous Page Silty SAND , trace to some gravel, trace clay, occasional cobbles and boulders Very Dense Grey Wet (TILL)		10	SS	100/ 0.125	324										8 68 22 2	
			11	SS	100/ 0.100	323											
			12	SS	100/ 0.100	321											
			13	SS	100/ 0.100	320											
319.4																	
15.3	END OF BOREHOLE AT 15.3m. Standpipe installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2017.10.01 2.0 332.7 2017.10.02 2.7 332.0 2017.10.03 2.7 332.0				0.100												



REPLACEMENT OF BLACK STURGEON LAKES BRIDGE
ASSIGNMENT No. 6019-E-0009 (SITE No. 41S-0242/B0)
HIGHWAY 671, 9 KM NORTH OF HIGHWAY 17A
TOWNSHIP OF HAYCOCK, ONTARIO

Detour Alignment

PVT21-05 Station 20+025 .5m RT CL

0- 750 Br Sa Some Gr Some Si Moist
w @ 0.4m = 10%
750- 2.3 Br/Gry Cl W Si Tr Sa Moist
w @ 1.5m = 36%
Percent Passing 4.75 mm = 100%
75 µm = 98%
5 µm = 79%
Frost Susceptibility = LSFH
Soil Erodibility = 0.16
2.3- 3 Gry Si Tr Sa Moist
w @ 2.6m = 14%
Zone 16 N 5521128.8 E 215383.1 Elev 339.9 m

PVT21-04 Station 20+051 0m CL

0- 750 Br Sa Some Si Tr Gr Tr Cl Moist
w @ 0.4m = 7%
750- 1.5 Gry Cl W Si Tr Sa Wet
w @ 1.1m = 36%
1.5- 2.1 Gry Cl W Si Tr Sa (Firm) Moist
Nvalue=7 blows / 300mm
w @ 1.8m = 23%
2.1- 3 Gry Si Tr Sa Moist
w @ 2.6m = 17%
Zone 16 N 5521143.5 E 215404.5 Elev 338.4 m

PVT 21-03 Station 20+075 5m LT CL

0- 725 Br Sa Some Gr Some Si Moist
w @ 0.4m = 7%
Percent Passing 4.75 mm = 84%
75 µm = 15%
Slightly Finer Than Granular B Type I
725- 1.5 Br/Gry Cl W Si Tr Sa Wet
w @ 1.1m = 33%
1.5- 3 Gry Si Tr Sa Moist
w @ 2.3m = 16%
Zone 16 N 5521156.7 E 215424.6 Elev 337.3 m

PVT21-02 Station 20+100

0- 725 Gry Cl W Sa W Si

.5m LT CL

Wet

w @ 0.4m = 37%
Percent Passing 4.75 mm = 100%
75 µm = 76%
5 µm = 56%
Frost Susceptibility = LSFH
Soil Erodibility = 0.19
W_L = 60%
W_p = 21%
P_I = 39%
MTC Soil Classification = CH

725- 1.5 Gry Si Some Sa Tr Cl

Moist

w @ 1.1m = 16%

1.5- 2.1 Gry Si(y) Sa Tr Gr

Moist

w @ 1.8m = 9%

Zone 16 N 5521164.9 E 215447.8 Elev 335.2 m

PVT21-01 Station 20+125

3m RT CL

0- 50 Tps

50- 225 Br Sa Some Si Tr Gr

Moist

w @ 0.1m = 7%

225- 2 Gry Si Some Sa

Moist

w @ 1.1m = 16%

2- 3 Gry Si(y) Sa Tr Gr

Moist

w @ 2.5m = 10%

Percent Passing 4.75 mm = 93%

75 µm = 34%

5 µm = 3%

Frost Susceptibility = LSFH

Soil Erodibility = 0.24

Zone 16 N 5521178 E 215469.1 Elev 334.3 m



REPLACEMENT OF BLACK STURGEON LAKES BRIDGE
ASSIGNMENT No. 6019-E-0009 (SITE No. 41S-0242/B0)
HIGHWAY 671, 9 KM NORTH OF HIGHWAY 17A
TOWNSHIP OF HAYCOCK, ONTARIO

21-01 Station 20+139		1.5m RT CL	21-02 Station 20+160		3m RT CL
0- 700	Br Sa Some Gr Some Si (Compact)	Moist	0- 75	Tps	
	Nvalue=29 blows / 300mm		75- 600	Br Si(y) Cl Some Sa Tr Org (Firm)	Moist
		w @ 0.4m = 2%		Nvalue=7 blows / 300mm	
		Split spoon depth from 0-600mm			w @ 0.3m = 23%
700- 1.4	Br/Gry Si and Sa Tr Cl (Compact)	Moist			Split spoon depth from 0-600mm
	Nvalue=25 blows / 300mm		600- 1.4	Br Cl(y) Si W Sa (Firm)	Moist
		w @ 1m = 10%		Nvalue=7 blows / 300mm	
		Split spoon depth from 700-1350mm			w @ 1m = 22%
1.4- 1.8	Br/Gry Si and Sa Tr Cl (V. Dense)	Moist			Percent Passing 4.75 mm = 100%
	Nvalue=100 blows / 250mm				75 µm = 75%
		w @ 1.6m = 12%			5 µm = 37%
		Percent Passing 4.75 mm = 100%			Frost Susceptibility = LSFH
		75 µm = 52%			Soil Erodibility = 0.29
		5 µm = 7%			W _L = 39%
		Frost Susceptibility = MSFH			W _p = 17%
		Soil Erodibility = 0.33			P _I = 22%
		Split spoon depth from 1500-1750mm			MTC Soil Classification = CI
1.8- 2.4	Br/Gry Si and Sa Tr Cl (V. Dense)	Moist	1.4- 2.1	Br Cl(y) Si W Sa Tr Co Fib Org Matl (Firm)	Moist
	Nvalue=100 blows / 150mm			Nvalue=6 blows / 300mm	
		Split spoon depth from 2250-2400mm			w @ 1.7m = 76%
2.4- 3.1	Br/Gry Si and Sa Tr Cl (V. Dense)	Moist			Split spoon depth from 1500-2100mm
	Nvalue=100 blows / 125mm		2.1- 2.9	Gry Si and Sa Tr Cl Tr Gr (Dense)	Moist
		w @ 2.8m = 13%		Nvalue=33 blows / 300mm	
		Split spoon depth from 3000-3125mm			w @ 2.5m = 12%
3.1- 4.6	Br/Gry Si and Sa Occ Cob (V. Dense)	Moist			Split spoon depth from 2250-2850mm
	Nvalue=100 blows / 125mm		2.9- 3.3	Gry Si and Sa Tr Cl Tr Gr (V. Dense)	Moist
		w @ 3.9m = 11%		Nvalue=100 blows / 275mm	
		Split spoon depth from 4500-4625mm			w @ 3.1m = 16%
		Zone 16 N 5521184.4 E 215481.6 Elev 334.3 m	3.3- 4.8	Gry Si and Sa Tr Cl Tr Gr (V. Dense)	Moist
				Nvalue=100 blows / 250mm	
					w @ 4m = 14%
					Percent Passing 4.75 mm = 96%
					75 µm = 53%
					5 µm = 10%
					Frost Susceptibility = MSFH
					Soil Erodibility = 0.3
					Split spoon depth from 4500-4750mm
					Zone 16 N 5521194.4 E 215500.2 Elev 333.4 m



REPLACEMENT OF BLACK STURGEON LAKES BRIDGE
ASSIGNMENT No. 6019-E-0009 (SITE No. 41S-0242/B0)
HIGHWAY 671, 9 KM NORTH OF HIGHWAY 17A
TOWNSHIP OF HAYCOCK, ONTARIO

21-03 Station 20+215		1.9m LT CL	21-04 Station 20+235		0m CL
0- 600	Gry Si(y) Sa Tr Gr Tr Cl	Moist	0- 600	Gry Si(y) Sa Tr Gr Tr Cob	Moist
	(Compact)			(Compact)	
	Nvalue=33 blows / 300mm			Nvalue=25 blows / 300mm	
		w @ 0.3m = 9%			w @ 0.3m = 19%
		Split spoon depth from 0-600mm			Split spoon depth from 0-600mm
600- 1.4	Gry Sa W Si (V. Dense)	Moist	600- 1.4	Gry Si(y) Sa Tr Gr Tr Cob (V. Dense)	Moist
	Nvalue=65 blows / 300mm			Nvalue=56 blows / 300mm	
		w @ 1m = 8%			w @ 1m = 15%
		Percent Passing 4.75 mm = 98%			Split spoon depth from 750-1350mm
		75 µm = 27%			
		5 µm = 3%	1.4- 1.7	Gry Si(y) Sa Tr Gr Tr Cob (V. Dense)	Moist
		Frost Susceptibility = LSFH		Nvalue=100 blows / 150mm	
		Soil Erodibility = 0.17			Split spoon depth from 1500-1650mm
		Split spoon depth from 750-1350mm	1.7- 2.4	Gry Sa Some Si (V. Dense)	Moist
1.4- 1.6	Gry Sa W Si (V. Dense)	Moist		Nvalue=100 blows / 175mm	
	Nvalue=100 blows / 125mm				w @ 2m = 13%
		Split spoon depth from 1500-1625mm			Split spoon depth from 2250-2425mm
1.6- 2.4	Gry Sa W Si Occ Cob (V. Dense)	Moist	2.4- 3.9	Gry Sa Some Si (V. Dense)	Moist
	Nvalue=100 blows / 150mm			Nvalue=100 blows / 125mm	
		w @ 2m = 8%			w @ 3.2m = 15%
		Split spoon depth from 2250-2350mm			Percent Passing 4.75 mm = 100%
2.4- 3.1	Gry Sa W Si Occ Cob (V. Dense)	Moist			75 µm = 12%
	Nvalue=100 blows / 125mm				5 µm = 0%
		w @ 2.7m = 12%			Frost Susceptibility = LSFH
		Split spoon depth from 3000-3125mm			Soil Erodibility = 0.05
3.1- 4.6	Gry Sa W Si Occ Cob (V. Dense)	Moist	3.9- 5.4	Gry Sa(y) Gr W Si (V. Dense)	Moist
	Nvalue=100 blows / 50mm			Nvalue=100 blows / 75mm	
		Split spoon depth from 4500-4550mm			w @ 4.7m = 12%
		Zone 16 N 5521228.3 E 215544.5 Elev 334.1 m			Percent Passing 4.75 mm = 57%
					75 µm = 24%
					Split spoon depth from 4500-4575mm
					Zone 16 N 5521236.6 E 215562.9 Elev 333.5 m
			PVT 21-06 Station 20+269		
			1m LT CL		
			0- 600	Br Sa Some Si Tr Gr Tr Cl	Moist
					w @ 0.3m = 5%
					Percent Passing 4.75 mm = 93%
					75 µm = 18%
					5 µm = 5%
					Frost Susceptibility = LSFH
					Soil Erodibility = 0.05
			600- 2.1	Br Sa Some Si Tr Gr Tr Cl	Moist
			2.1- 3.6	Br Cl W Si Tr Sa	Wet
					w @ 2.9m = 30%
					Zone 16 N 5521246.6 E 215594.5 Elev 336.2 m



REPLACEMENT OF BLACK STURGEON LAKES BRIDGE
ASSIGNMENT No. 6019-E-0009 (SITE No. 41S-0242/B0)
HIGHWAY 671, 9 KM NORTH OF HIGHWAY 17A
TOWNSHIP OF HAYCOCK, ONTARIO

PVT 21-07 Station 20+275 1m RT CL
0- 600 Br Sa Some Gr Some Si Moist
Percent Passing 4.75 mm = 81%
75 µm = 10%
Acceptable Granular B Type I
600- 1.1 Br Sa Some Gr Some Si Moist
1.1- 1.5 Br Cl W Si W Sa Moist
1.5- 2.1 Br Cl W Si W Sa (Firm) Moist
Nvalue=6 blows / 300mm
2.1- 2.7 Br Cl W Si W Sa Moist
2.7- 3.6 Br Si(y) Sa Tr Cl (Compact) Moist
Nvalue=10 blows / 300mm
Zone 16 N 5521245.5 E 215602.9 Elev 336.3 m

Detour Alignment - Topsoil Probes

TPS 21-01 Station 20+078 .5m RT CL
0- 125 Tps
Zone 16 N 5521154.1 E 215429.2 Elev 336.3 m

TPS 21-02 Station 20+100 3.5m RT CL
0- 75 Tps
Zone 16 N 5521161.9 E 215449.7 Elev 335.3 m

TPS 21-03 Station 20+125 4m RT CL
0- 50 Tps
Zone 16 N 5521174.7 E 215471.2 Elev 334.3 m

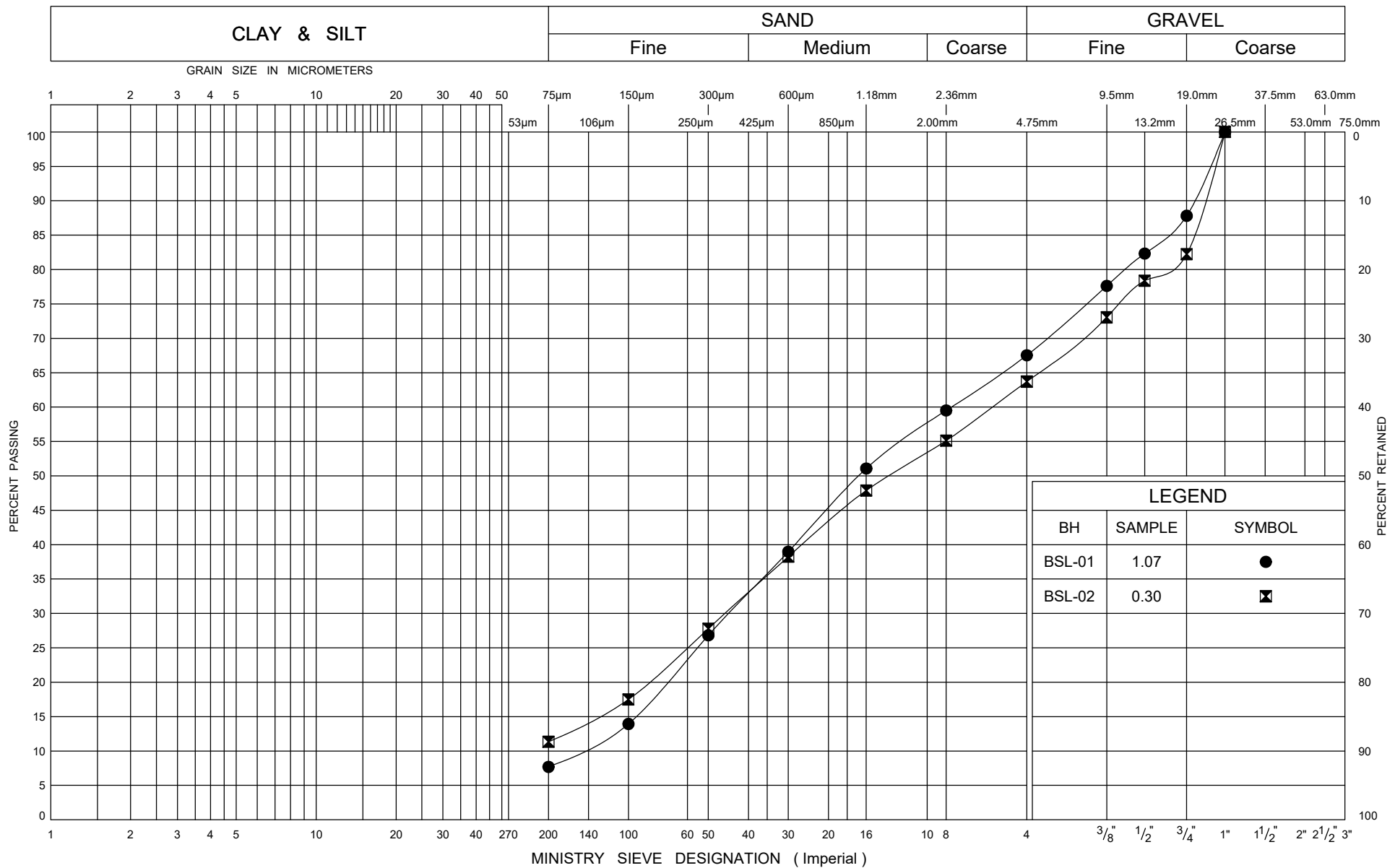
TPS 21-04 Station 20+252 1m RT CL
0- 100 Tps
Zone 16 N 5521241.7 E 215578.3 Elev 334.6 m

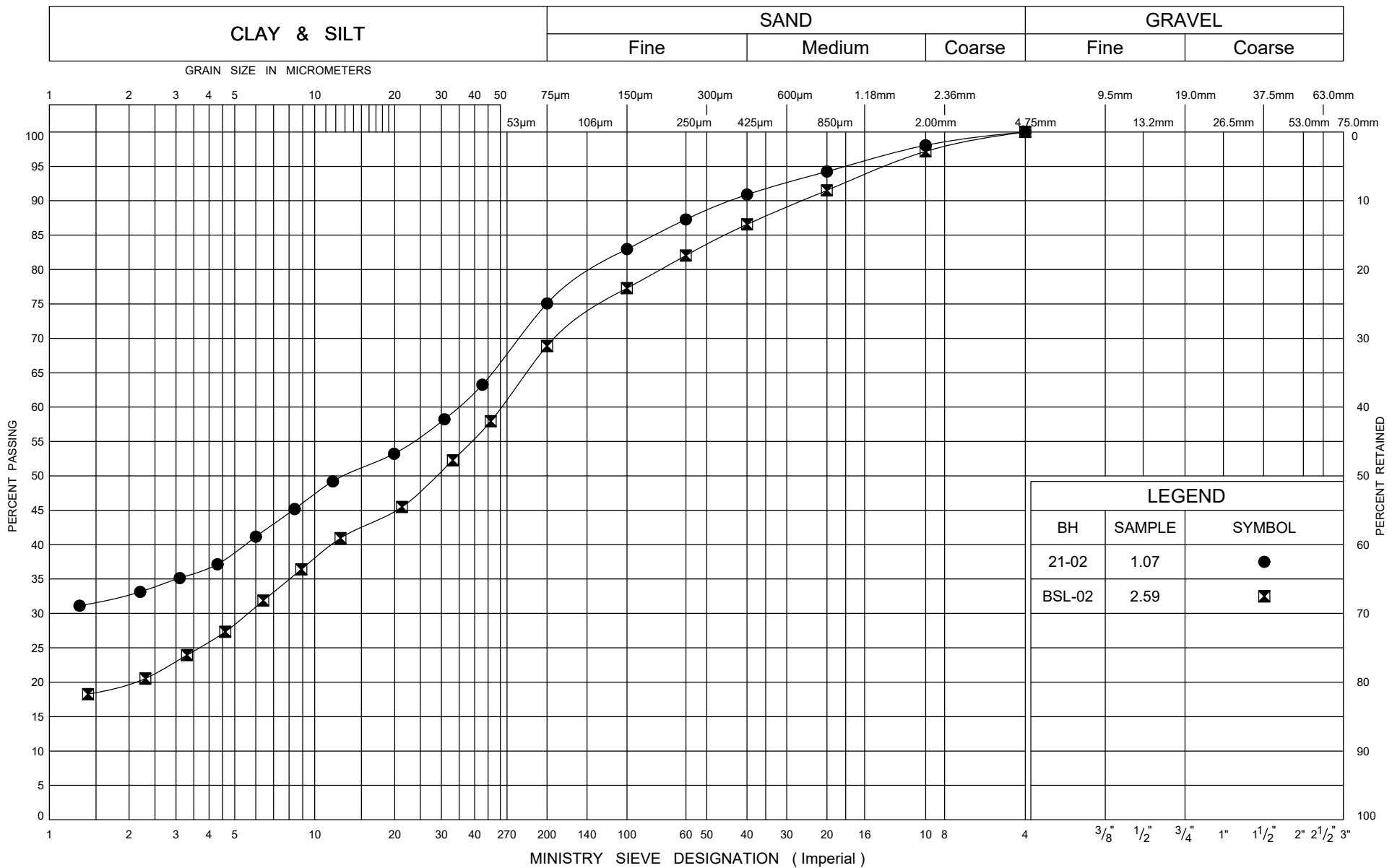
TPS 21-05 Station 20+267 1.5m RT CL
0- 100 Tps
Zone 16 N 5521244 E 215593.7 Elev 335.4 m

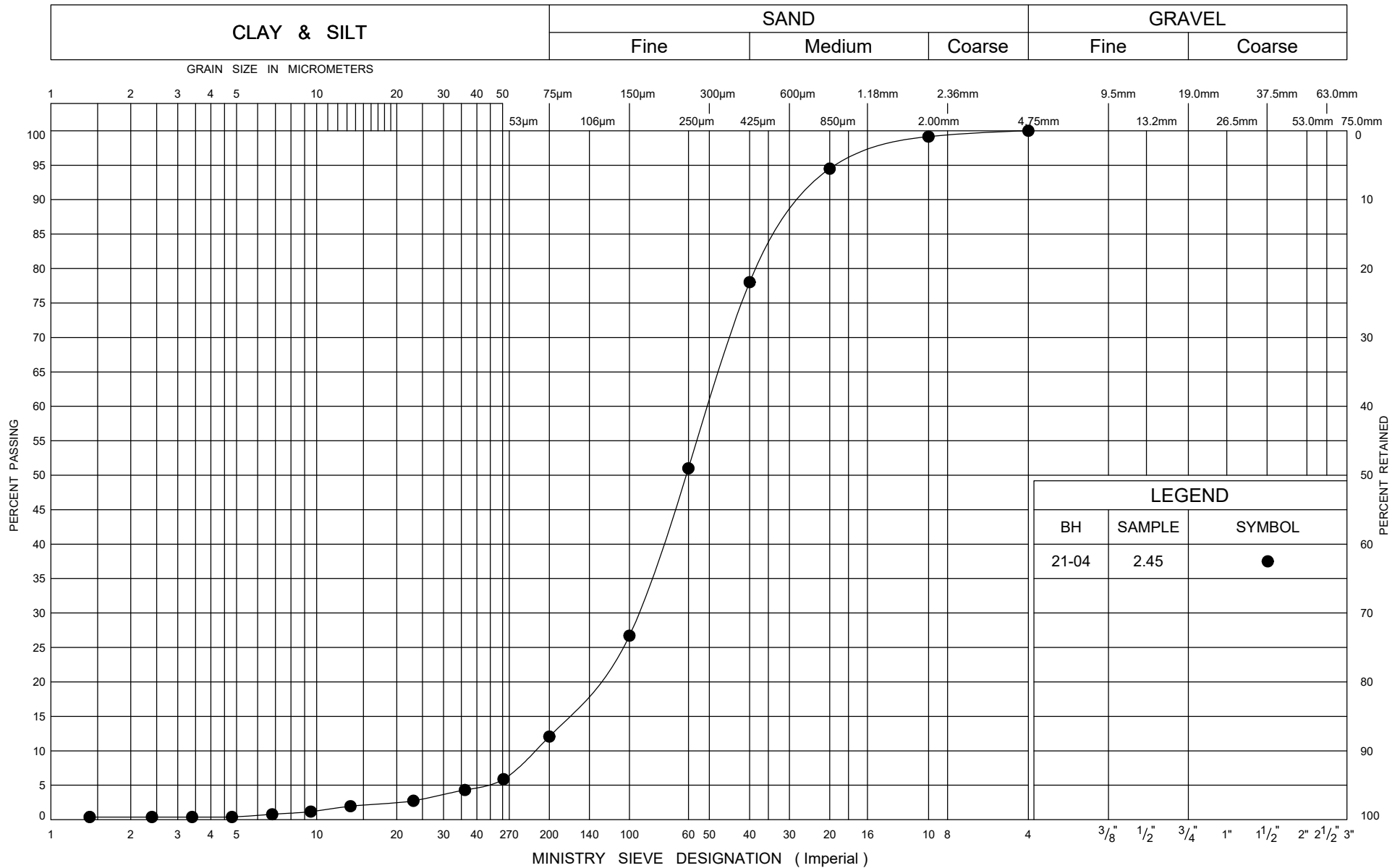


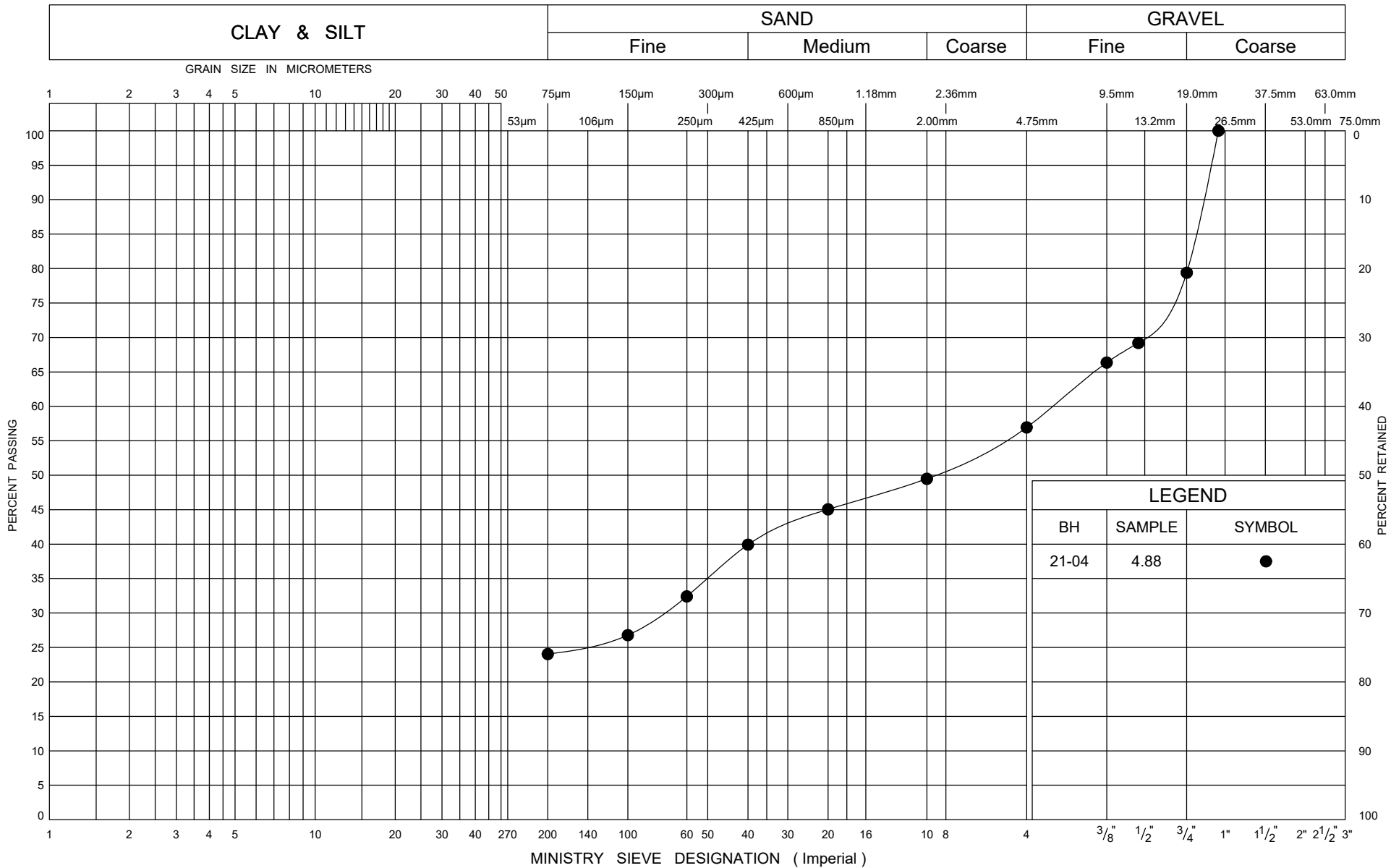
Appendix C

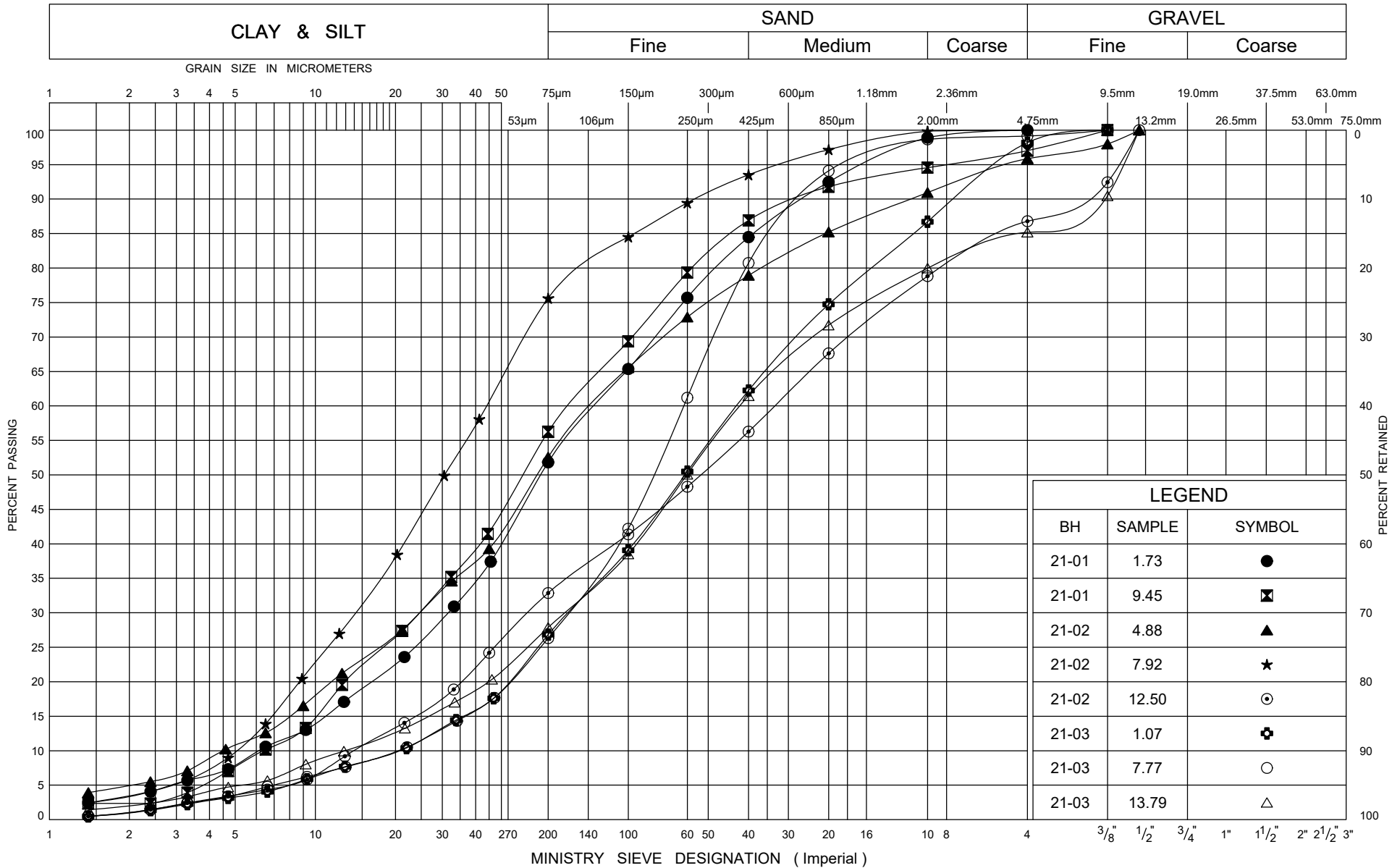
Geotechnical and Analytical Laboratory Test Results

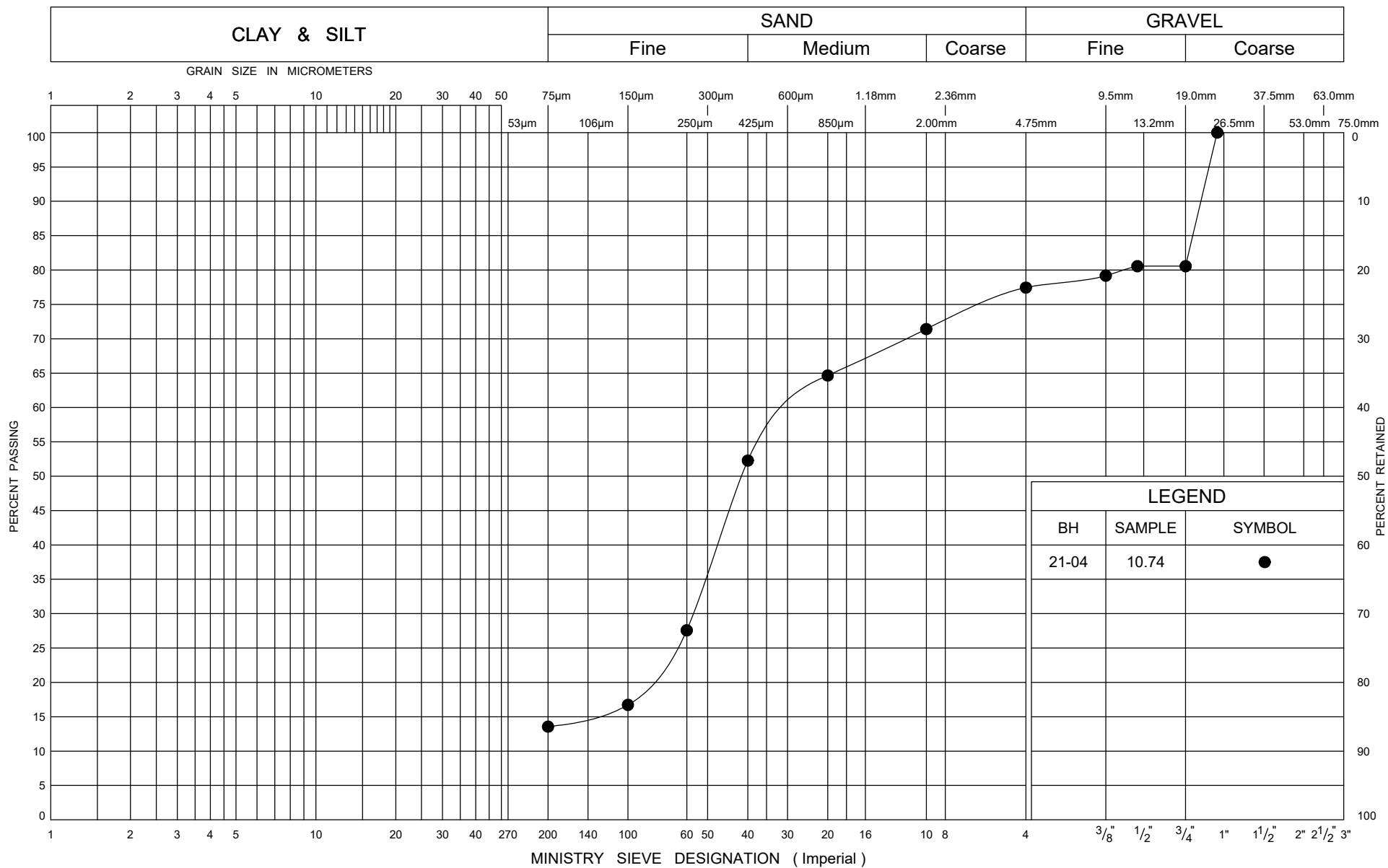


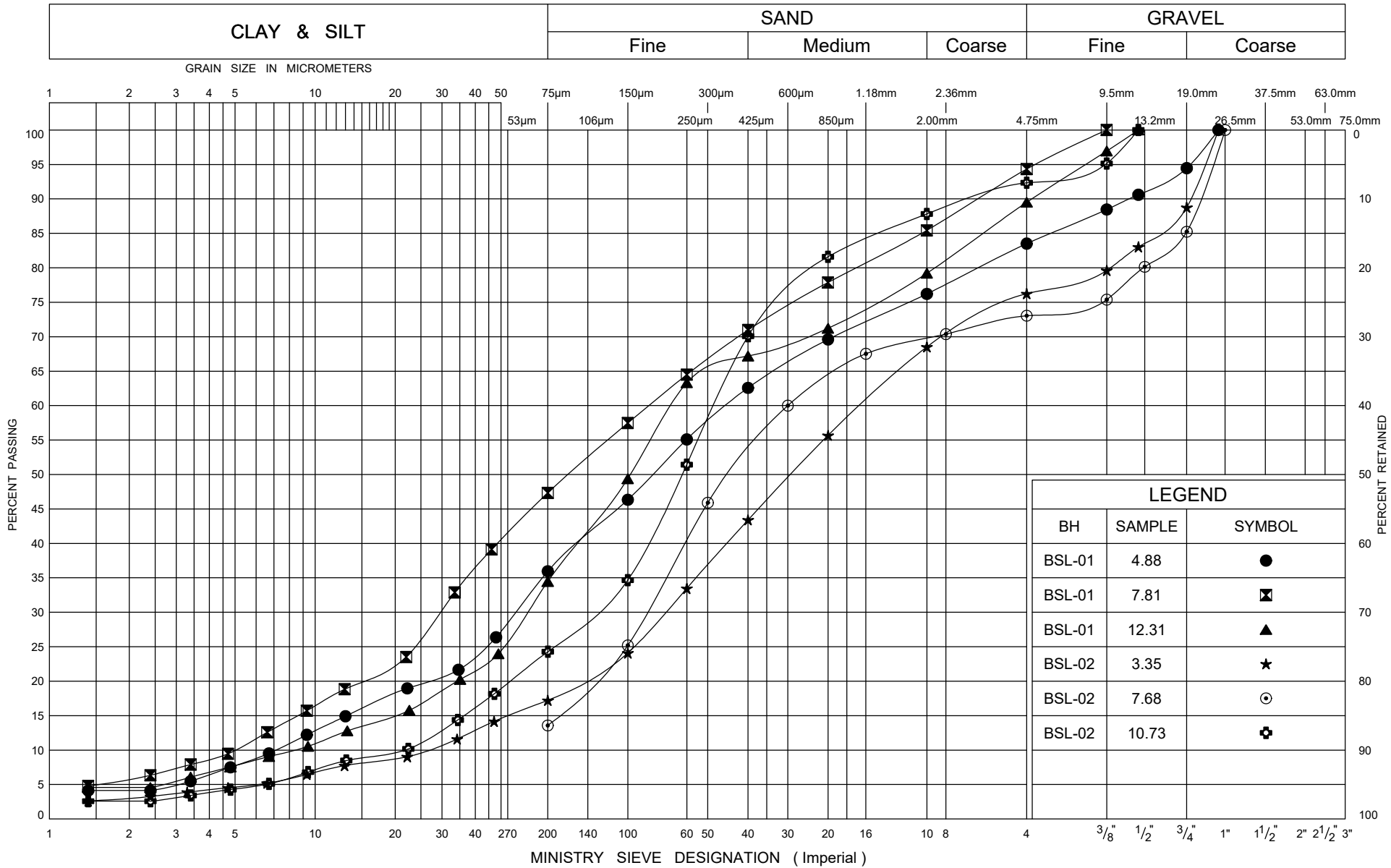


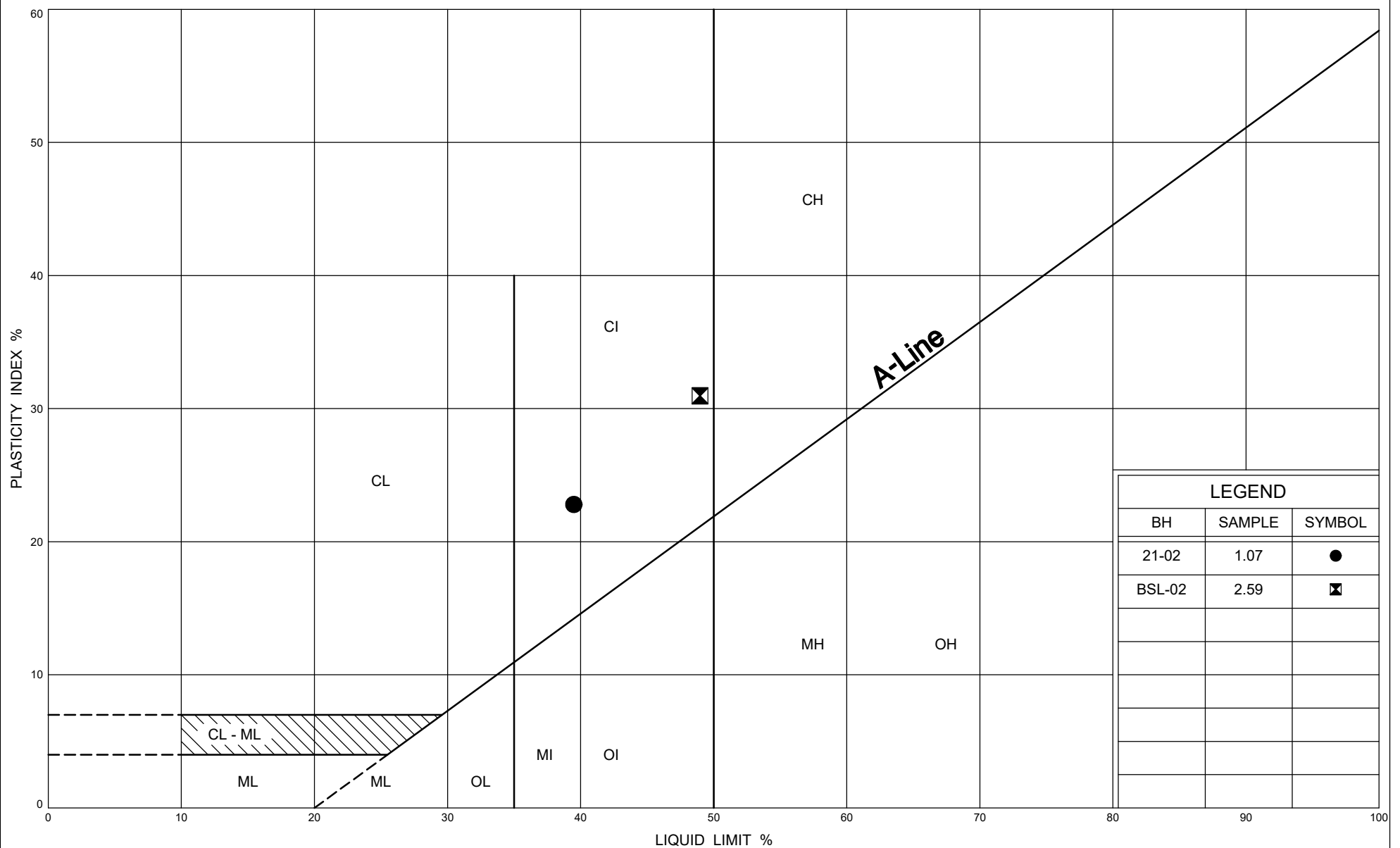












Ministry of
Transportation

PLASTICITY CHART

Silty CLAY

FIG No C8

W P 6124-17-00

Black Sturgeon Lakes Bailey Bridge

First Page

CLIENT DETAILS

Client Thurber Engineering Ltd.

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

Contact Mark Farrant

Telephone 905-829-8666 x 228

Facsimile

Email mfarrant@thurber.ca

Project 19387

Order Number

Samples Soil (2)

LABORATORY DETAILS

Project Specialist Deanna Edwards, B.Sc, C.Chem

Laboratory SGS Canada Inc.

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

Telephone 705-652-2000

Facsimile 705-652-6365

Email deanna.edwards@sgs.com

SGS Reference CA14023-NOV17

Received 11/01/2017

Approved 11/07/2017

Report Number CA14023-NOV17 R1

Date Reported 12/01/2017

COMMENTS

Temperature of Sample upon Receipt: 6 degrees C

Cooling Agent Present: Yes

Custody Seal Present: No

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

SIGNATORIES

Deanna Edwards, B.Sc, C.Chem





FINAL REPORT

CA14023-NOV17 R1

Client: Thurber Engineering Ltd.

Project: 19387

Project Manager: Mark Farrant

Samplers: M F

PACKAGE: - 1.3 Other (ORP) ()

Sample Number	9	10
Sample Name	BSL-1, SS#3 5'-7'	BSL-1, SS#4 7.5'-9.5'
Sample Matrix	Soil	Soil
Sample Date	31/10/2017	31/10/2017

Parameter	Units	RL	Result	Result
1.3 Other (ORP)				
Chloride	µg/g	0.4	2.1	77

PACKAGE: - Corrosivity Index ()

Sample Number	9	10
Sample Name	BSL-1, SS#3 5'-7'	BSL-1, SS#4 7.5'-9.5'
Sample Matrix	Soil	Soil
Sample Date	31/10/2017	31/10/2017

Parameter	Units	RL	Result	Result
Corrosivity Index	none	1	1	1
Soil Redox Potential	mV	-	310	227
Sulphide	%	0.02	< 0.02	< 0.02
pH	no unit	0.05	8.05	7.68
Resistivity (calculated)	ohms.cm	-9999	22700	4480

PACKAGE: - Metals and Inorganics ()

Sample Number	9	10
Sample Name	BSL-1, SS#3 5'-7'	BSL-1, SS#4 7.5'-9.5'
Sample Matrix	Soil	Soil
Sample Date	31/10/2017	31/10/2017

Parameter	Units	RL	Result	Result
Metals and Inorganics				
Sulphate	µg/g	0.4	7.0	10



FINAL REPORT

CA14023-NOV17 R1

Client: Thurber Engineering Ltd.

Project: 19387

Project Manager: Mark Farrant

Samplers: M F

PACKAGE: - UNDEFINED ()

Sample Number	9	10
Sample Name	BSL-1, SS#3 5'-7'	BSL-1, SS#4 7.5'-9.5'
Sample Matrix	Soil	Soil
Sample Date	31/10/2017	31/10/2017

Parameter	Units	RL		Result	Result
UNDEFINED					
Moisture Content	%	0.1		13.8	28.6
Conductivity	uS/cm	2		44	223

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.

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.

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-- End of Analytical Report --

First Page

CLIENT DETAILS

Client Thurber Engineering Ltd.

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

Contact Mark Farrant

Telephone 905-829-8666 x 228

Facsimile

Email mfarrant@thurber.ca

Project 19387

Order Number

Samples Solution (1)

LABORATORY DETAILS

Project Specialist Deanna Edwards, B.Sc, C.Chem

Laboratory SGS Canada Inc.

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

Telephone 705-652-2000

Facsimile 705-652-6365

Email deanna.edwards@sgs.com

SGS Reference CA12231-OCT17

Received 10/05/2017

Approved 10/16/2017

Report Number CA12231-OCT17 R1

Date Reported 12/01/2017

COMMENTS

Temperature of Sample upon Receipt: 19 degrees C

Cooling Agent Present: Yes

Custody Seal Present: Yes

SIGNATORIES

Deanna Edwards, B.Sc, C.Chem





FINAL REPORT

CA12231-OCT17 R1

Client: Thurber Engineering Ltd.

Project: 19387

Project Manager: Mark Farrant

Samplers: Amir F

PACKAGE: - 1.3 Other (ORP) ()

Sample Number 8
Sample Name Black Sturgeon
Lake Bridge
Sample Matrix Solution
Sample Date 28/09/2017

Parameter	Units	RL	Result
1.3 Other (ORP)			
pH	units	0.05	6.79

PACKAGE: - Corrosivity Index ()

Sample Number 8
Sample Name Black Sturgeon
Lake Bridge
Sample Matrix Solution
Sample Date 28/09/2017

Parameter	Units	RL	Result
Corrosivity Index			
Resistivity (calculated)	ohms.cm	-9999	20000

PACKAGE: - Metals and Inorganics ()

Sample Number 8
Sample Name Black Sturgeon
Lake Bridge
Sample Matrix Solution
Sample Date 28/09/2017

Parameter	Units	RL	Result
Metals and Inorganics			
Sulphate	mg/L	0.04	1.2

PACKAGE: - UNDEFINED ()

Sample Number 8
Sample Name Black Sturgeon
Lake Bridge
Sample Matrix Solution



FINAL REPORT

CA12231-OCT17 R1

Client: Thurber Engineering Ltd.
Project: 19387
Project Manager: Mark Farrant
Samplers: Amir F

PACKAGE: - UNDEFINED ()

Sample Number 8
Sample Name Black Sturgeon
Lake Bridge
Sample Matrix Solution
Sample Date 28/09/2017

Parameter	Units	RL	Result	
UNDEFINED				
Conductivity	μS/cm	2		50
Redox Potential	mV	-		303
Chloride	mg/L	0.04		4.1
Sulphide	mg/L	0.006		< 0.006

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.

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.

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Appendix D

Site Photographs



Photo 1: Black Sturgeon Lakes Bridge looking south along Highway 671 (Sept. 2017)



Photo 2: Black Sturgeon Lakes Bridge looking north from south abutment (Sept. 2017)



Photo 3: Black Sturgeon Lakes Bridge looking north at north abutment from south abutment (June 2016)



Photo 4: Black Sturgeon Lakes Bridge looking south at south abutment from north abutment (June 2016)



Photo 5: Black Sturgeon Lakes Bridge north abutment (June 2016)



Photo 6: Black Sturgeon Lakes Bridge south abutment (June 2016)



Photo 7: Looking south along detour alignment north approach (Sept 2021)



Photo 8: Looking north along detour alignment north approach toward granular access pads for Boreholes 21-03 and 21-04 (Sept 2021)



Photo 9: Looking north along detour alignment south approach Oct 2017)



**Photo 10: Looking south along detour alignment south approach toward Borehole 21-02
(Sept 2021)**