



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION AND DESIGN 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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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 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.



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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

8. GENERAL

This report provides an interpretation of the geotechnical data in the factual report, and presents detailed foundation design recommendations for design of the proposed Black Sturgeon Lakes Bailey Bridge replacement on Highway 671, construction of a proposed temporary detour bailey bridge, and construction of a temporary detour embankment. A separate Pavement Design Memorandum by Thurber is also provided to discuss the results and recommendations of a pavement investigation conducted at the site.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of Hatch and 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 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.

Reference has been made to the previous foundation investigation report for replacement of Highway 671 bridge at 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 site is located on Highway 671 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 Preliminary Structural Design Report by MTO indicates that the 25-year design storm water level elevation is approximately 333.2 m.

Based on General Arrangement (GA) drawings provided by MTO and discussions with MTO and Hatch, it is understood that the existing Highway 17 bridge is to be replaced with an approximately 40 m long, 6 m wide, single-span, steel modular bridge in the same alignment and location as the existing bridge. The bridge abutments and approach ramp sleeper slabs are to be supported on concrete spread footings on engineered granular fill pads. A grade raise of approximately 270 mm is proposed at the north bridge approach embankment only.

A temporary detour embankment and detour modular bridge are proposed for construction staging. The centreline of the detour bridge is proposed to be located approximately 10 m east of the existing bridge centreline. The single-span detour bridge is expected to be approximately 46 m long and 6 m wide. The detour bridge abutments and approach ramp sleeper slabs are to be supported on timber spread footings on engineered granular fill pads. Based on cross-sections provided by Hatch, the approximate maximum height of fill for the detour embankment is 1.5 m at the south approach and 3 m at the north approach. The detour embankment transitions to the existing highway at approximately 135 m to the south and 65 m to the north of the detour bridge. The detour embankment is proposed to be constructed of rock fill.

9. STRUCTURE FOUNDATIONS

The subsurface stratigraphy at the site typically consists of gravelly sand embankment fill along the Highway 671 alignment, native deposits of firm to very stiff silty clay, and compact to very dense silty sand to sand, which are further underlain by a thick deposit of very dense silty sand to sandy silt till. Cobbles and boulders are present within the embankment fill and within the till layers. Groundwater level readings of Elevation 331.7 to 332 m were measured in piezometers



installed in the boreholes. The river water level was reported to be at Elevation 331.9 m on July 21, 2017. Wet ground conditions were present along the detour alignment route during the drilling investigation in September 2022.

The previous report by Thurber (Reference 1) included foundation recommendations for different types of bridge foundations, which are not repeated herein, however these recommendations where relevant may be used for detailed design.

9.1 Spread Footings on Engineered Fill Pads (Highway 671 and Detour Bridges)

9.1.1 Founding Level

The replacement Highway 671 bridge and the temporary detour bridge can both be supported on spread footings placed on minimum 1 m thick granular engineered fill pads. Based on the GA drawings, the Highway 671 abutments and the temporary detour bridge abutments will be founded on 1 m thick engineered granular fill pads placed at approximate Elevation 332.5 m. This corresponds to firm to stiff native silty clay, except at the north abutment of the detour bridge. The foundations soils at Elevation 332.5 m at this location consist of very dense silty sand to sandy silt till, based on Borehole 21-03.

The engineered granular fill pads of minimum 1 m thick are recommended to be placed on these native soils at Elevation 332.5 m or lower, but preferably above the groundwater and river water Elevation of approximately 332.0 m.

9.1.2 Engineered Fill Construction

As the bases of the granular pads for both bridges are above the anticipated groundwater level, dewatering will not likely be required during construction of the engineered fill pads. All existing surficial topsoil, peat or other wet or loose organic material must be stripped prior to placing fill for the engineered fill pads. Careful inspection and stripping of these materials will be particularly important at the detour bridge footing locations, where no existing embankment fill is present.

For the Highway 671 bridge, the engineered fill pads should consist of OPSS Granular A or Granular B Type II placed in 150 mm lifts and compacted to 100% of its Standard Proctor Maximum Dry Density (SPMDD) at $\pm 2\%$ of Optimum Moisture Content (OMC). The minimum depth of excavation should accommodate the concrete foundation slab and the thickness of the engineered fill pad below the slab. The dimensions of the base of the excavation should be determined by assuming a granular pad at least 1.0 m wider than the spread footing at the level of the footing base and projecting outward and downward at 1H:1V. The forward slopes of the

foundation pads should be embedded at least 0.5 m below the face of the forward slope, with the edge of footing set-back at a minimum of 1 m behind the crest of the forward slope. This is based on the existing grade of the forward slopes in front of the footings, which are inclined at approximately 10H:1V and should be protected with rock fill. Provision of properly designed erosion protection works will be critical to ensure adequate performance of the foundations / engineered fill pads.

For the detour bridge, since the detour embankment will be constructed of rock fill, the 1 m thick engineered fill pads may instead consist of well graded rock fill with a maximum size of 250 mm. In this case, additional rock fill protection is not required around the engineering fill pads to prevent erosion of exposed granular fill pads. A minimum 75 mm thick layer of compacted 19 mm clear stone should be placed above the rock fill to provide an even founding surface for placement of the footings. The timber footings should be embedded a minimum of 0.3 m below the top of the rock fill foundation pads, with the edge of footing set back at a minimum of 1 m behind the crest of the forward slope and 500 mm behind the crest of the side slopes. The 500 mm rock fill side set-back should be gradually transitioned to the 1 m set-back at the forward slopes. The base of the 1 m thick rock fill pad should be at least 1 m wider than the footing at the level of the footing base and the side slopes inclined at 1.5H:1V. Suggested wording for an NSSP on the construction of the rock fill pads is included in Appendix F.

9.1.3 Axial Geotechnical Resistance and Geotechnical Reaction

The following geotechnical resistances in Tables 9.1 and 9.2 are recommended for design of spread footings placed on engineered fill pads prepared as outlined above with the underside at approximate elevations of 332.5 m or below:

Table 9.1 – Geotechnical Resistances for Highway 671 Permanent Bridge

Geotechnical Resistance (1.25 m Wide Concrete Footing on 1 m Thick Engineered Fill Pad)	South Abutment	North Abutment
Factored Geotechnical Resistance at ULS (kPa)	200	200
Geotechnical Reaction at SLS (kPa) (for up to 25 mm settlement)	135	135

Table 9.2 – Geotechnical Resistances for Temporary Detour Bridge

Geotechnical Resistance (1.2 m Wide Timber Footing on 1 m Thick Engineered Fill Pad)	South Abutment	North Abutment
Factored Geotechnical Resistance at ULS (kPa)	140	140
Geotechnical Reaction at SLS (kPa) (for up to 25 mm settlement)	90	90

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

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

The geotechnical resistance quoted above is for concentric, vertical loads only. In the case of eccentric or inclined loading, the geotechnical resistance should be calculated as indicated in the CHBDC 2019 Clause 6.10.5.3.

The lateral resistance of the concrete footings founded on engineered fill may be computed using an unfactored friction coefficient of 0.6. For timber footings founded on rock fill, an unfactored friction coefficient of 0.45 may be used. These are “ultimate” values and require a degree of sliding movement to occur to fully mobilize the resistance. A resistance factor as per CHBDC 2019 Table 6.2 should be applied to these unfactored values.

9.2 Sleeper Slabs for Approach Ramps (Highway 671 and Detour Bridges)

The GA drawings show that the embankment side of the 3 m long approach ramps will be supported on a 0.9 m wide concrete sleeper slabs for the Highway 671 bridge and 0.955 m wide timber sleeper slabs for the detour bridge. The sleeper slabs are to be placed on at least 1 m thick engineered fill pads. The engineered fill pads below the sleeper slabs may be constructed as per Section 9.1.2, using OPSS Granular A or Granular B Type II fill for the Highway 671 bridge and maximum 250 mm rock fill for the detour bridge.



The engineered fill between the abutment footings and the sleeper slabs for the Highway 671 bridge should be constructed to a 2H:1V slope or flatter and protected with rip rap. For the detour bridge, the rock fill between the abutment footings and sleeper slabs should be constructed to a 1.5H:1V slope. Provided the base of the sleeper slabs are embedded a minimum of 0.3 m below the finished ground in the front and the face of the footings are set back a minimum of 0.5 m behind the crest of the forward slopes, factored geotechnical resistances of 140 kPa at ULS and 90 kPa at SLS are recommended for both bridges.

9.3 Frost Cover

The depth of frost penetration at this site is approximately 2.4 m, as per OPSD 3090.100. Typically, the base of all footings, if employed, must be provided with a minimum of 2.4 m of earth cover as protection against frost action.

Concrete or timber spread footings founded on granular or rock fill engineered fill pads, provided they consist of non-frost susceptible, free draining engineered fill, above the river water level should be provided with a minimum embedment of 0.5 m for the permanent bridge and 0.3 m for the temporary bridge. These footings do not need to be placed below the depth of frost.

10. LATERAL EARTH PRESSURES

Backfill behind the bridge abutments should be placed in accordance with OPSS 902. All backfill should consist of free-draining, non-frost susceptible granular materials such as Granular A or B Type II or Type III conforming to the requirements of OPSS.PROV 1010. Reference should be made to the backfill arrangements stipulated in OPSD 3101.150, as appropriate. Compaction equipment to be used adjacent to the structure should be restricted in accordance with OPSS.PROV 501.

Earth pressures acting on the structures 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 = earth pressure coefficient (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)

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

Table 10.1 – Coefficients of Lateral Earth Pressure (K)

Loading Condition	OPSS Granular A or Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I or Type III $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$	
	Horizontal Backfill	Sloping Backfill (2H:1V)	Horizontal Backfill	Sloping Backfill
Active K_A (Unrestrained Wall)	0.27	0.38*	0.31	0.46*
At-rest K_0 (Restrained Wall)	0.43	-	0.47	-
Passive K_P	3.7	-	3.3	-

* For abutment walls, if required

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

In accordance with Clause 6.12.3 of the CHBDC 2019, a compaction surcharge should be added.

11. EXCAVATION AND GROUNDWATER CONTROL

All excavations should be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the gravelly sand embankment fill, sand fill, silty clay, silty sand to sand, and till soils at this site are classified as Type 3 soils above the water level and Type 4 soils below the water level.

Excavation and backfilling for the bridge construction should be carried out in accordance with OPSS 902. Excavations for the Highway 671 footings will be carried out through the existing gravelly sand fill and extended into the native silty clay. Excavations for the detour bridge footings will be carried out through the surficial deposits, native silty clay and into the silty sand to sandy silt till deposit. It must be noted that obstructions may be encountered within the fill and till deposits such as cobbles and boulders. Suggested wording for an NSSP on obstructions is included in Appendix F.



Construction of the engineered fill pads and the bridge footings should be carried out in the dry. It is anticipated that the bases of all excavations will be maintained above the approximate groundwater and river water level of 332 m. Therefore the need for dewatering is not anticipated. However, any excavations that are below the groundwater or river water level will require dewatering to lower the water level at least 0.5 m below the base of the excavation to permit construction in the dry and facilitate compaction of the backfill materials. Measures should be in place to keep the excavations free from runoff of surface water or seepage of perched groundwater at all times.

Selection of the method of excavation is the responsibility of the Contractor and should be based on the Contractor's experience, equipment and interpretation of the site conditions.

The design of a dewatering system, if utilized, is the responsibility of the Contractor. The Contract Documents must alert the Contractor to this responsibility and to design the system in accordance with SP FOUN0003 which amends OPSS 902. SP FOUN0003 has been included in Appendix F.

In accordance with SP FOUN0003, the dewatering system is to be designed in accordance with OPSS.PROV 517. A preconstruction survey is not required at this site, thus Designer Fill-In ** in SP FOUN0003 should be "N/A".

Dewatering must remain operational and effective until the foundations are constructed. Suggesting wording for an NSSP in this regard is included in Appendix F.

12. SEISMIC CONSIDERATIONS

In accordance with the CHBDC 2019, 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 dense to very dense sand and silt to sand till at the 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 0.039 g as per the National Building Code of Canada (NBCC).

In accordance with Section 6.14.7 of the CHBDC 2019, 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 12.1 may be used:

Table 12.1 – Earth Pressure Coefficients for Earthquake Loading

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

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

** After Woods

The site is underlain by dense to very dense till. In view of the dense till and low potential for seismic activity in the area, liquefaction is not considered to be a concern at this site.

13. SCOUR AND EROSION PROTECTION

Design of the erosion protection measures should consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field.

Typically, rock protection should be provided over all surfaces with which river water is likely to be in contact. In particular, erosion protection must be provided to prevent loss of soils in front of or at the base of the abutment engineered granular fill pads.

A vegetation cover should be established on all other exposed earth surface to protect against surficial erosion, in general accordance with OPSS 804.

14. APPROACH EMBANKMENTS AND FORWARD SLOPES

14.1 Highway 671 Embankments

The existing Highway 671 embankment is approximately 3 m in height at the existing bridge location, with side slopes inclined at 2H:1V or flatter. A 270 mm grade raise is proposed at the north approach embankment only. Settlement due to the minor grade raise on the foundation silty clay is estimated to be less than 25 mm, which is expected to be completed by the end of construction.

Stability analyses conducted for the existing side slopes of Highway 671 indicated Factors of Safety against slope failure of 1.5 for the short and long term (undrained and drained) conditions for the south abutment (See Figures 1 and 2 in Appendix E) and 2.7 (short term) and 1.8 (long



term) for the north abutment (See Figures 3 and 4 in Appendix E). Provided that the embankments are reconstructed at the same slope inclination as the existing embankments, and not steeper than 2H:1V, the restored embankment slopes after bridge replacement are expected to remain stable.

The stability of the forward slopes in front of the replacement bridge abutments was also analysed based on the forward slopes shown on the GA drawings. Figures 5 to 10 in Appendix E show that the forward slopes for the south and north abutments are expected to be stable for the short and long term conditions, with Factors of Safety of 2.2 to 2.6. This includes Figures 7 and 10, which were modelled using the 25 year design storm water level Elevation of 333.2 m.

The stability of the embankment and forward slopes will rely on proper steps being taken to mitigate erosion as described in Section 13.

Embankment restoration after completion of the bridge replacement should be carried out in accordance with OPSS.PROV 206 and OPSS.PROV 209. The embankment material may consist of imported Granular A, Granular B Type II, or Granular B Type III material.

14.2 Detour Embankments

The detour embankments approaching the temporary detour bridge have proposed heights of up to 1.5 m at the south approach and 3 m at the north approach. The detour embankment is proposed to be constructed of rock fill.

The boreholes drilled along the detour route indicate that the embankment will be constructed upon mainly very dense silty sand to sandy silt, with some surficial deposits of firm silty clay at the south approach and compact to very dense silty sand to sand at the north approach. Although it was not encountered in all of the boreholes along the detour route, it is important to note that topsoil or other organics should be expected along the detour alignment. All existing surficial vegetation, topsoil, peat or other wet or loose organic material must be stripped from the areas within the embankment footprint prior to placing fill. Inspection and approval of the foundation subgrade by qualified geotechnical personnel should be conducted.

The foundation settlement under the embankment fill placement is expected to be less than 25 mm, provided all topsoil, peat, organics, and loose/wet soils are stripped from below the embankment footprint. The settlement is expected to be completed by the end of construction.

Stability analyses of the detour embankment fill were conducted for both approaches, assuming the embankments would be constructed using rock fill. At the south approach, Figure 11 indicates



that the 1.5 m high rock fill embankment with side slopes inclined at 1.25H:1V or flatter will be stable, with a Factor of Safety of 1.7. At the north approach, Figure 12 indicates a Factor of Safety of 1.4 for 3 m high rock fill embankment side slopes inclined at 1.25H:1V. Figure 13 indicates that the Factor of Safety increase to at least 1.6 if the side slopes are flattened to 1.5H:1V or flatter.

The stability of the forward slopes in front of the temporary bridge abutments was also analysed. The analyses are based on the detour bridge abutments founded on spread footings on 1 m thick engineered fill pads, constructed of rock fill, sloped at 1.5H:1V, with the footings set back a minimum of 1 m from the crest of the forward slopes. Figures 14 and 15 indicate a Factor of Safety against slope failure of 2.8 for the short term condition and 1.9 for the long term condition at the south abutment. Figure 16 is modelled using the 25 year design storm water level Elevation of 333.2 m, with a Factor of Safety of 1.7. At the north abutment, Figures 17 and 18 indicate Factors of Safety of 1.4 for the long term condition and 1.2 for the 25 year design storm water level Elevation of 333.2 m. As there is no clay at the north approach, the short term condition is not applicable. For a temporary detour bridge, the Factors of Safety of 1.4 for long term and 1.2 for the 25 year design storm are considered to be acceptable.

The temporary detour bridge approach embankments should be constructed in accordance with OPSS.PROV 206 and OPSS.PROV 209 using rock fill conforming to OPSS.PROV 1010 and compacted in accordance with OPSS.PROV 501.

15. CORROSION AND SULPHATE ATTACK POTENTIAL

The results of the corrosivity and sulphate analytical tests conducted on the samples of the embankment fill, native silty clay and river water during the previous investigation were compared to corrosion potential criteria. The California Department of Transportation (Caltrans) Corrosion Guidelines, the Portland Cement Association Cementitious Grouts and Grouting manual, and guidelines from the American Water Works Association (AWWA) were used for comparison. The results indicate the following conditions at the locations tested:

- The potential for sulphate attack on concrete foundations from the surrounding fill, native silty clay or river water is considered to be negligible due to low concentrations of sulphate and chloride in the samples tested. The effect of road deicing salt should also be considering while selecting the class of concrete.
- The potential for soil or water corrosion on metal is considered to be very mild to moderate.



- Appropriate protection measures are recommended if metal structural elements are used. The effect of road deicing salt should be considered while selecting the corrosion protection measures.

16. CONSTRUCTION CONCERNS

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

- Cobbles, boulders and rock protection are exposed on the sides and forward slopes of the existing approach embankments. In addition, cobbles and boulders are present within the underlying till deposits. The Contractor must be prepared to remove or otherwise penetrate these obstructions if encountered during excavation for the bridge footings. Suggested wording for an NSSP on obstructions is included in Appendix F.
- The water level in the river may fluctuate and be at a higher elevation at the time of construction than indicated in the report.
- Stripping of surficial topsoil, peat or other loose/wet organic soils within the footprint of the detour embankment will be required to construct a stable embankment.
- The Contractor's selection of construction equipment and methodology should include assessment of the capability of the existing embankment to support the proposed construction equipment and any temporary structures or fill (i.e., as a pad for crane support). Site conditions may limit the type of equipment suitable for use during construction. The design and safety of any temporary works is the responsibility of the Contractor. Suggested wording for an NSSP on the use of heavy construction equipment is included in Appendix F.

17. CLOSURE

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



Thurber Engineering Ltd.



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

Keli Shi, P.Eng.
Associate, Senior Geotechnical Engineer

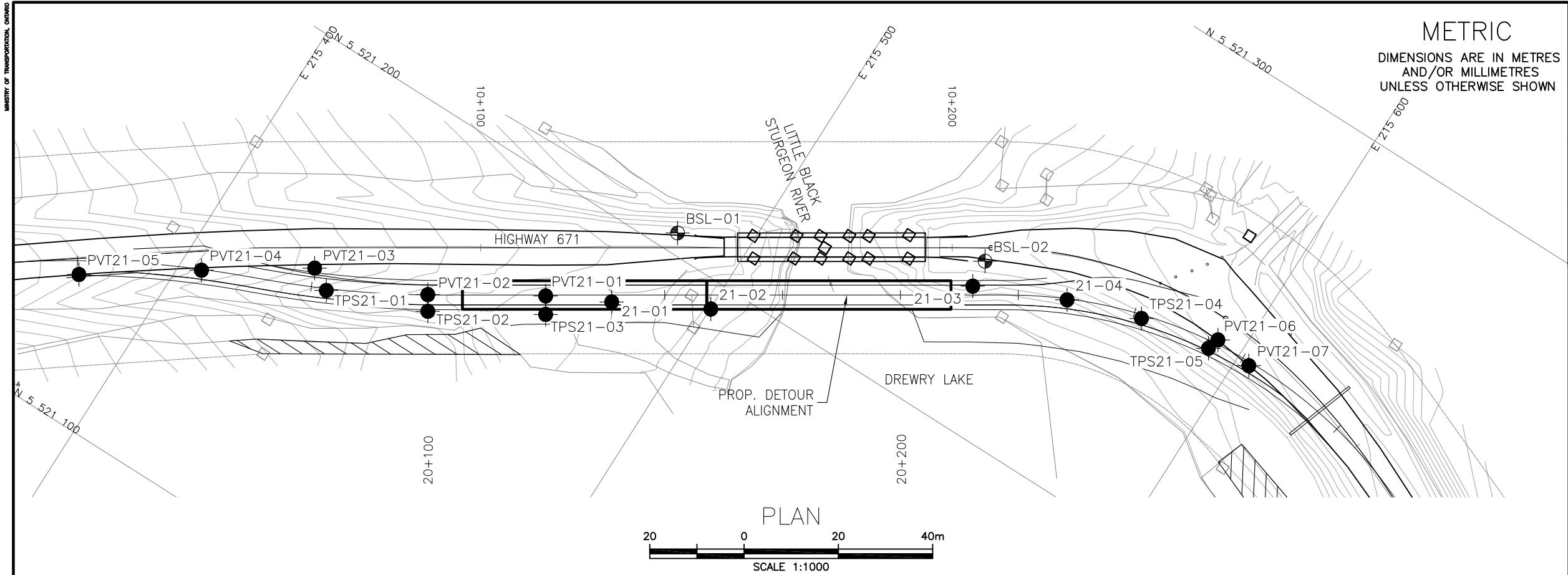


P.K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact



Appendix A

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



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.

KEYPLAN

Latitude: 49.8218° Longitude: -94.2403°

LEGEND

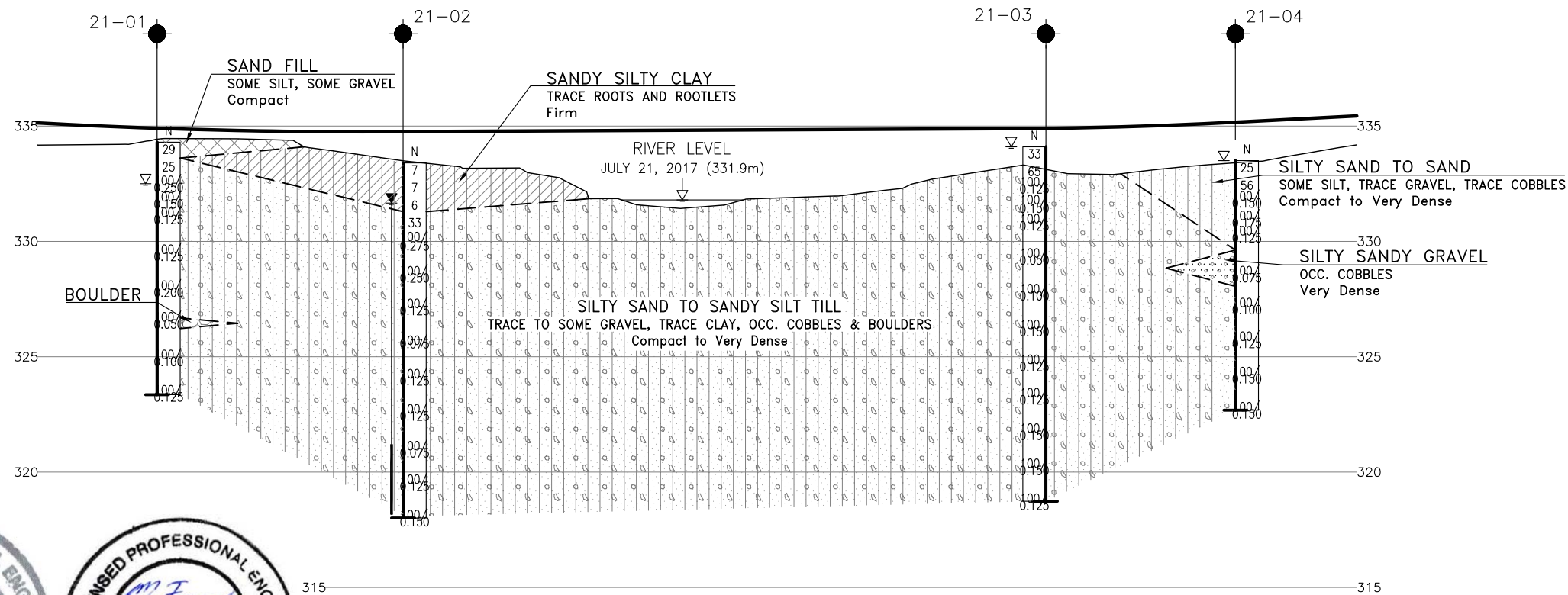
- Borehole (Current Investigation)
- Borehole (Previous Investigation)
- N
- CONE
- PH
- Water Level
- Head Artesian Water
- Piezometer
- 90% Rock Quality Designation (RQD)
- Auger Refusal

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-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83, Zone 16.

GEOCRES No. 52E-74

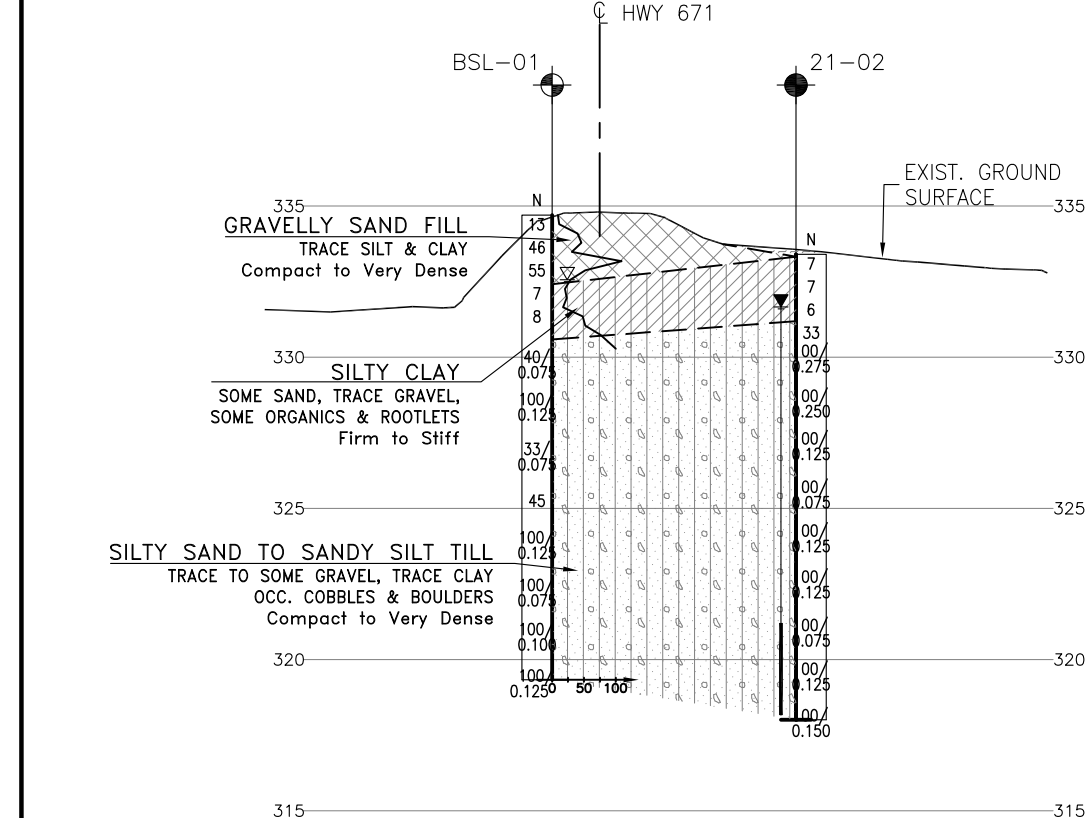
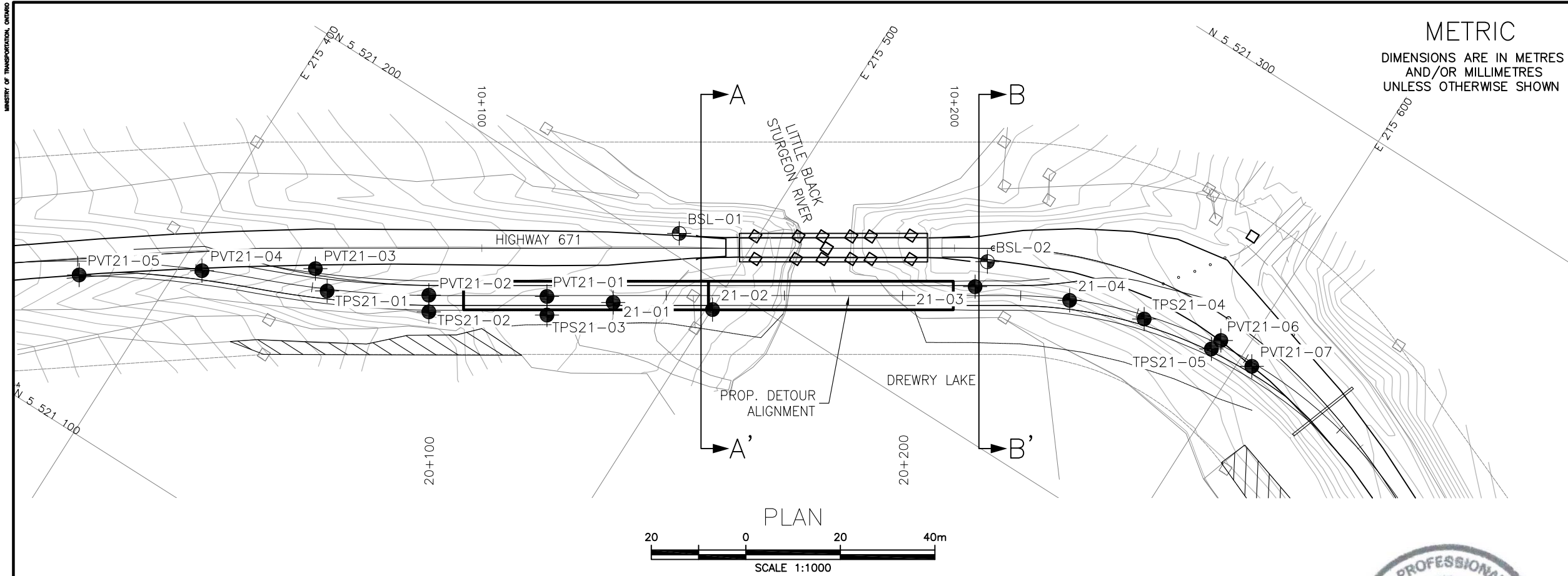


PROFILE ALONG DETOUR ALIGNMENT

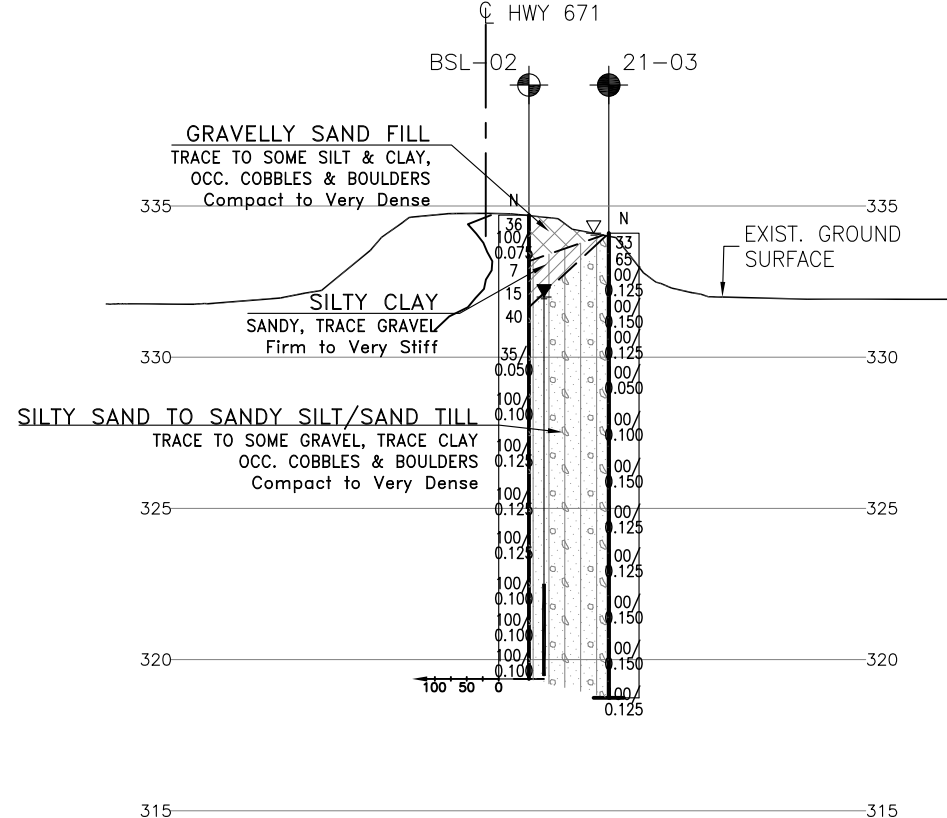
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TPS21-01	336.3	5 521 154.1	215 429.2
TPS21-02	335.3	5 521 161.9	215 449.7
TPS21-03	334.3	5 521 174.7	215 471.2
TPS21-04	334.6	5 521 241.7	215 578.3
TPS21-05	335.4	5 521 244.0	215 593.7



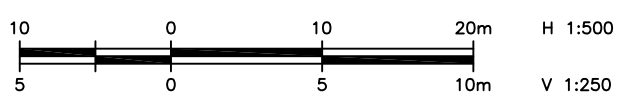
DATE	BY	DESCRIPTION
DESIGN	JA	CHK MEF
DRAWN	BH	CHK JA
LOAD	CODE	SITE
STRUCT	DATE	DWG 1



SECTION ALONG A-A'



SECTION ALONG B-B'



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.

KEYPLAN

LEGEND

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.

GEOCRES No. 52E-74

REVISIONS

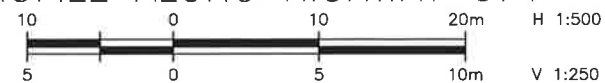
DATE BY DESCRIPTION

DESIGN JA CHK MEF CODE LOAD DATE MAR 2022

DRAWN BH CHK JA SITE STRUCT DWG 2

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

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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
 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			

RECORD OF BOREHOLE No 21-01

1 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				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					
334.3	GROUND SURFACE												
0.0	SAND , some silt, some gravel Compact Brown Moist (FILL)		1	SS	29		334						
333.6													
0.7	Silty SAND to Sandy SILT , trace clay, trace to some gravel Compact to Very Dense Brown to Grey Moist to Wet (TILL)		2	SS	25		333						
			3	SS	100/ 0.250		332						
			4	SS	100/ 0.150		331						
	Occasional cobbles		5	SS	100/ 0.125		330						
			6	SS	100/ 0.125		329						
							328						
	Becoming gravelly		7	SS	100/ 0.200		327						
326.7			8	SS	100/ 0.050		326						
7.6	BOULDER: (450mm diameter)						325						
326.2			9	SS	100/ 0.100								
8.1													

Continued Next Page

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

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			20	40	60	80	100					
323.4	Continued From Previous Page		10	SS	100/		324										
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												

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

RECORD OF BOREHOLE No 21-02

2 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			20	40	60	80	100													
	Continued From Previous Page																								
	Occasional cobbles		10	SS	100/ 0.125																				
			11	SS	100/ 0.075																				
			12	SS	100/ 0.125																				
318.0			13	SS	100/																				
15.4	<p>END OF BOREHOLE AT 15.4m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.</p> <p>WATER LEVEL READINGS</p> <table border="1"> <thead> <tr> <th>DATE</th> <th>DEPTH(m)</th> <th>ELEV.(m)</th> </tr> </thead> <tbody> <tr> <td>2021.09.21</td> <td>1.7</td> <td>331.7</td> </tr> <tr> <td>2021.09.22</td> <td>1.7</td> <td>331.7</td> </tr> </tbody> </table>	DATE	DEPTH(m)	ELEV.(m)	2021.09.21	1.7	331.7	2021.09.22	1.7	331.7				0.150											
DATE	DEPTH(m)	ELEV.(m)																							
2021.09.21	1.7	331.7																							
2021.09.22	1.7	331.7																							

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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



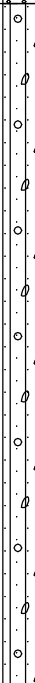
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			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.															

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					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
333.5	GROUND SURFACE							20	40	60	80	100								
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																				
3.9	Silty Sandy GRAVEL , occasional cobbles Very Dense Grey Wet						329							○						
			6	SS	100/ 0.075															
328.1																				
5.4	Silty SAND to SAND , some silt, gravelly, occasional cobbles Very Dense Grey Wet (TILL)						328													
			7	SS	100/ 0.100		327								○					
			8	SS	100/ 0.125		326									○				
							325													
			9	SS	100/ 0.150		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 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			20	40	60	80	100					
322.7	Continued From Previous Page		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



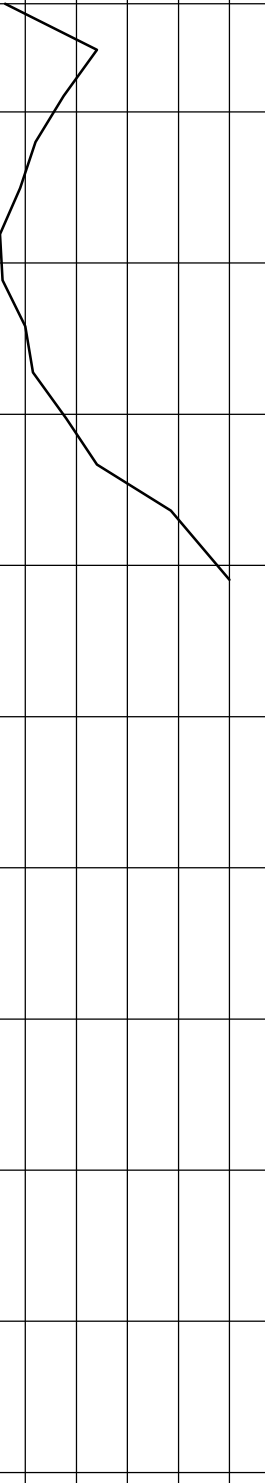

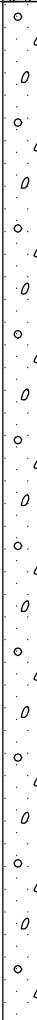
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RECORD OF BOREHOLE No BSL-02

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								
0.0	Gravelly SAND , trace to some silt and clay, occasional cobbles and boulders Dense to Very Dense Brown Moist (FILL)		1	SS	36									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											
			4	SS	15									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										24 59 14 3	
					6	SS	35/ 0.050									
					7	SS	100/ 0.100									
				</												

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%) 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										○					
319.4			13	SS	100/ 0.100	320										○					
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				Split spoon depth from 3000-3275mm
			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 (Compact)	Moist	0- 600	Gry Si(y) Sa Tr Gr Tr Cob (Compact)	Moist
	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

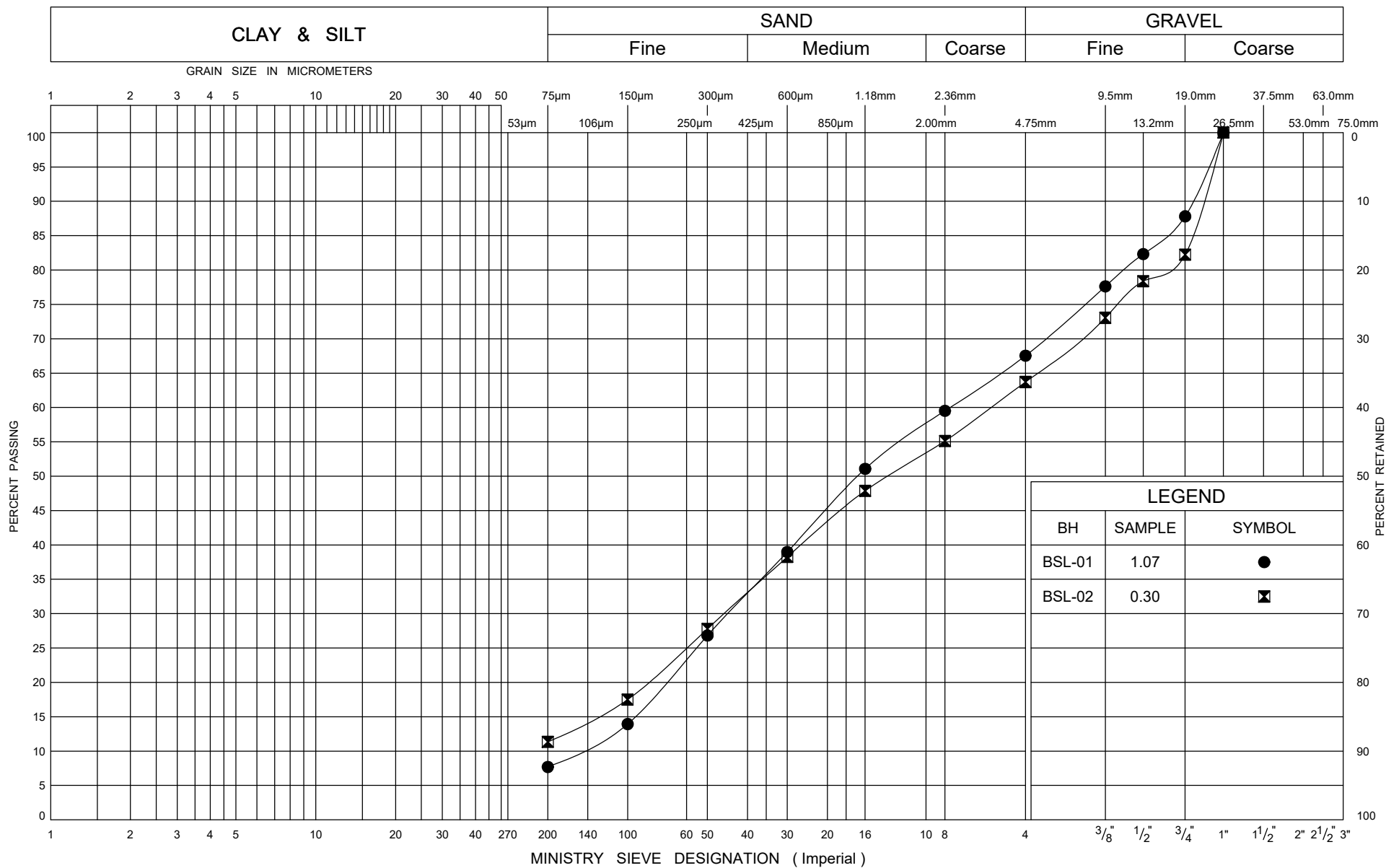
TPS 21-04 Station 20+252 1m RT CL
0- 100 Tps
Zone 16 N 5521241.7 E 215578.3 Elev 334.6 m

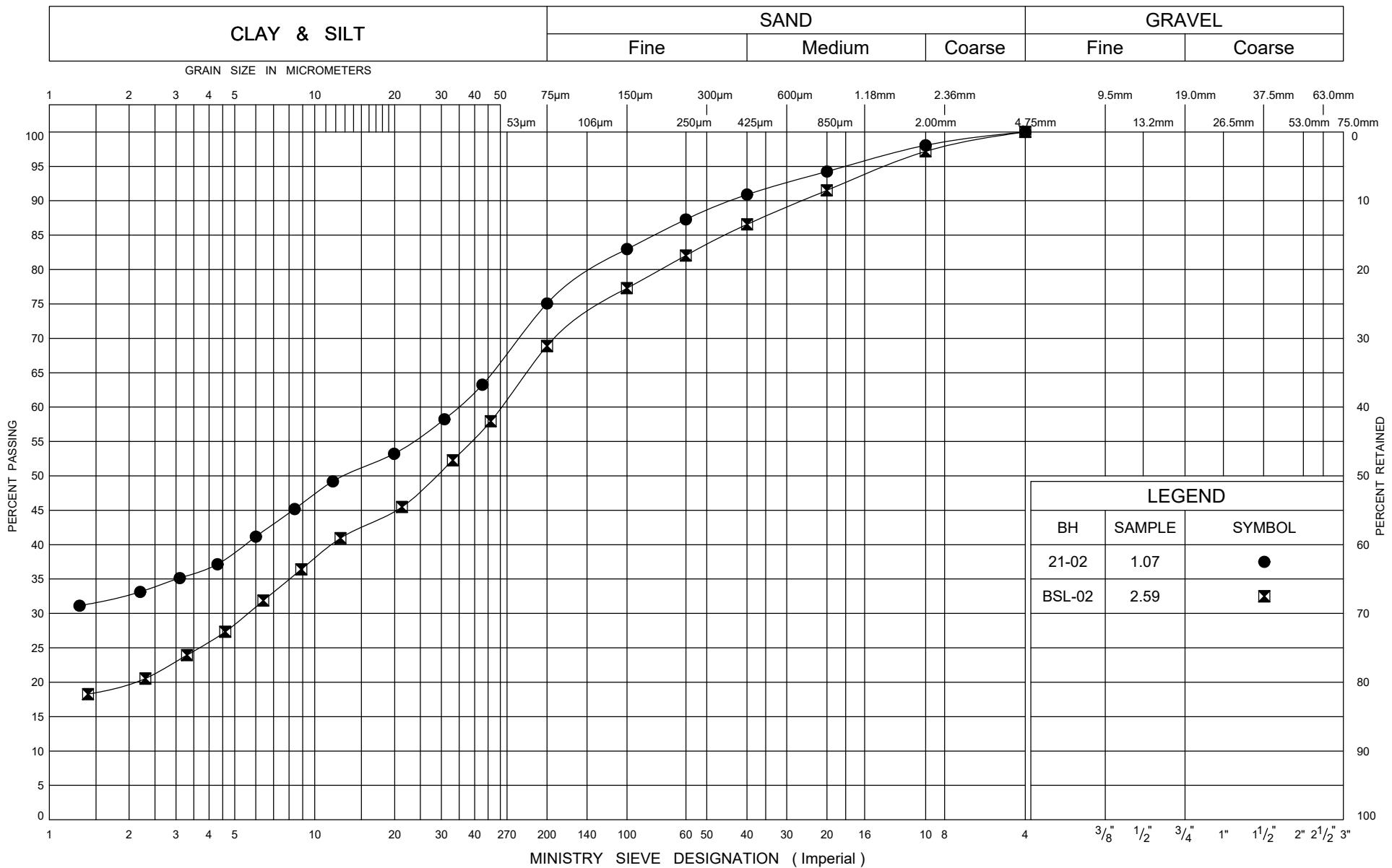
TPS 21-05 Station 20+267 1.5m RT CL
0- 100 Tps
Zone 16 N 5521244 E 215593.7 Elev 335.4 m



Appendix C

Geotechnical and Analytical Laboratory Test Results





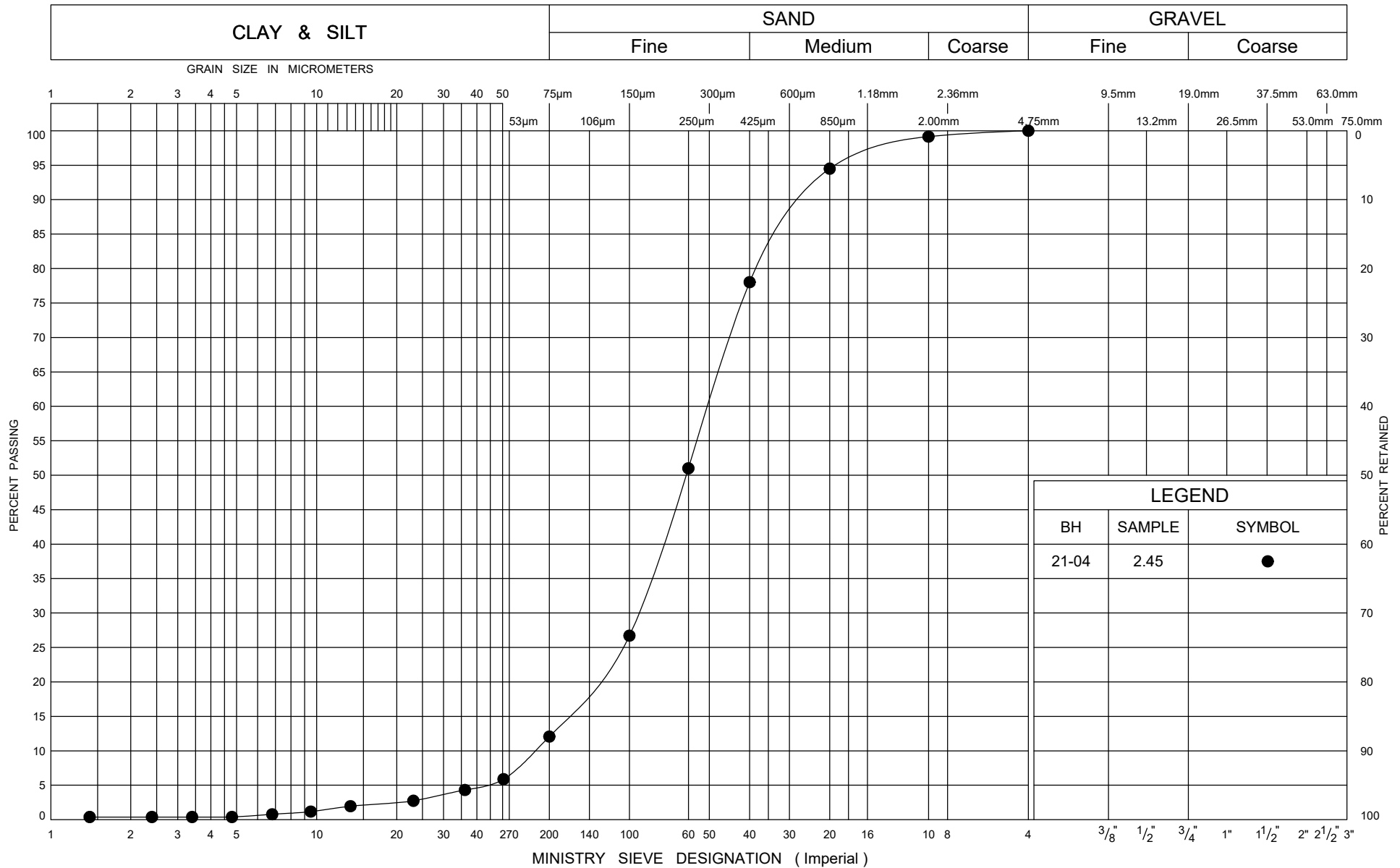
GRAIN SIZE DISTRIBUTION

Silty CLAY

FIG No C2

W P 6124-17-00

Black Sturgeon Lakes Bailey Bridge



Ministry of
Transportation

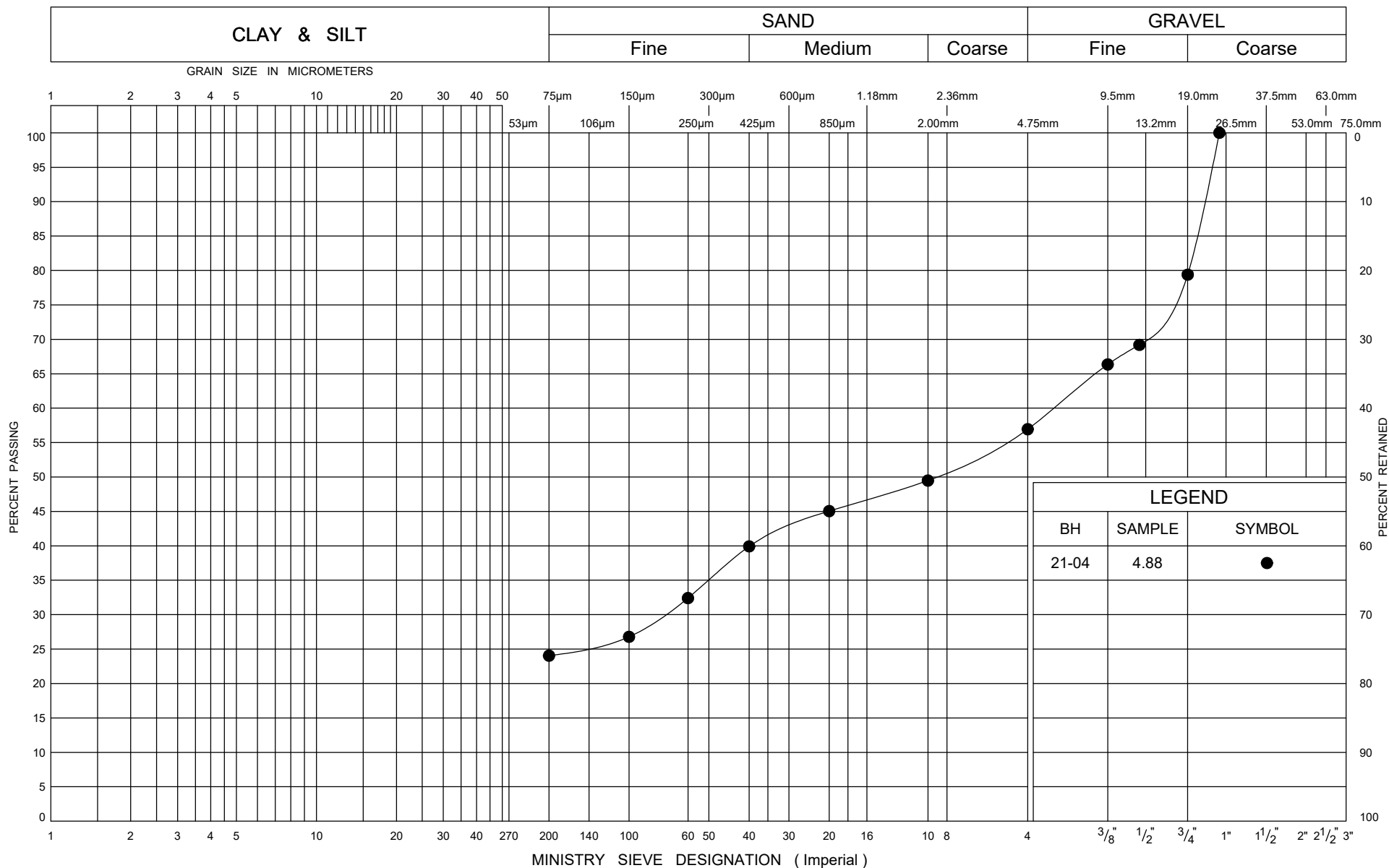
GRAIN SIZE DISTRIBUTION

Silty SAND to SAND

FIG No C3

W P 6124-17-00

Black Sturgeon Lakes Bailey Bridge



Ministry of
Transportation

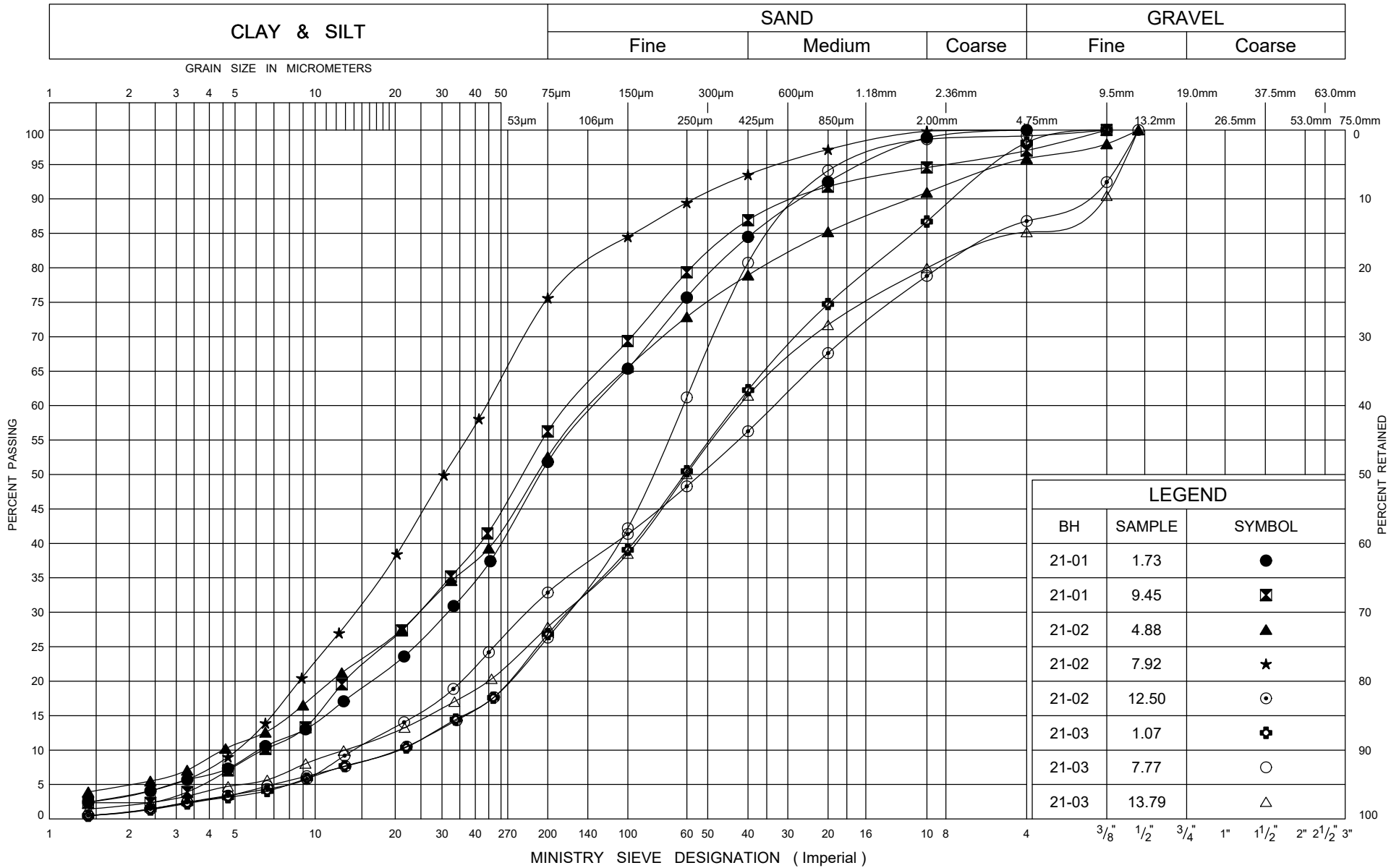
GRAIN SIZE DISTRIBUTION

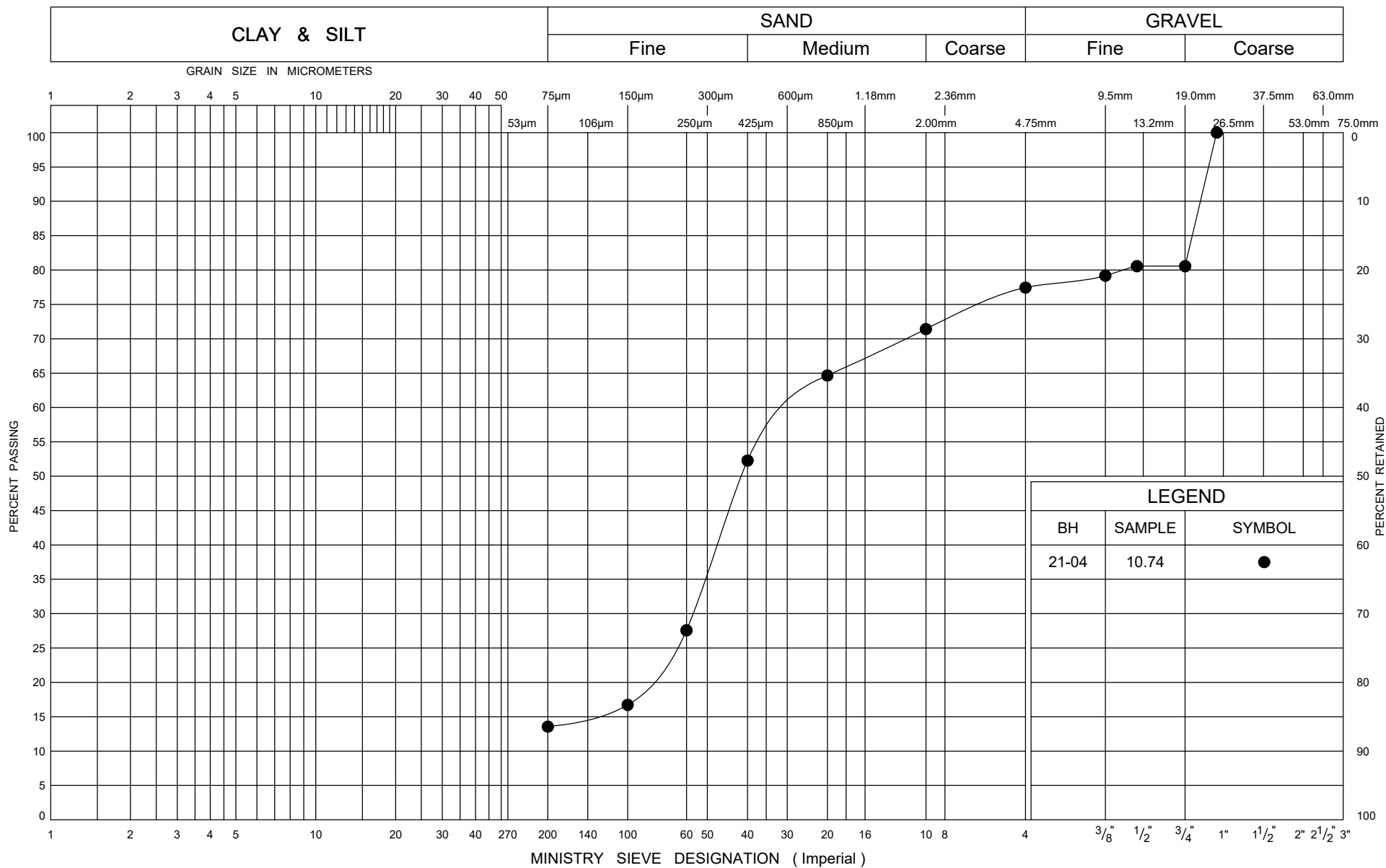
Silty, Sandy GRAVEL

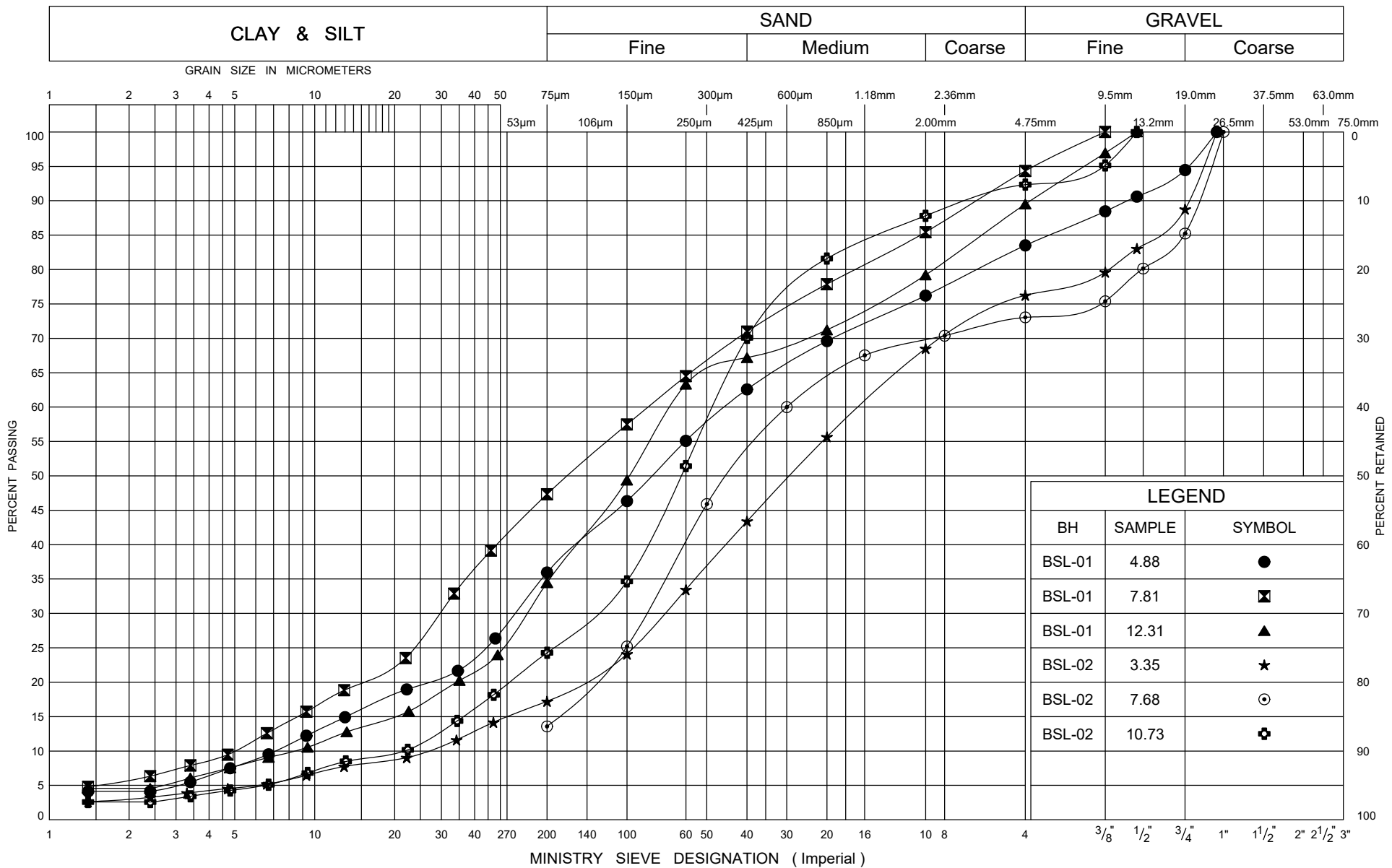
FIG No C4

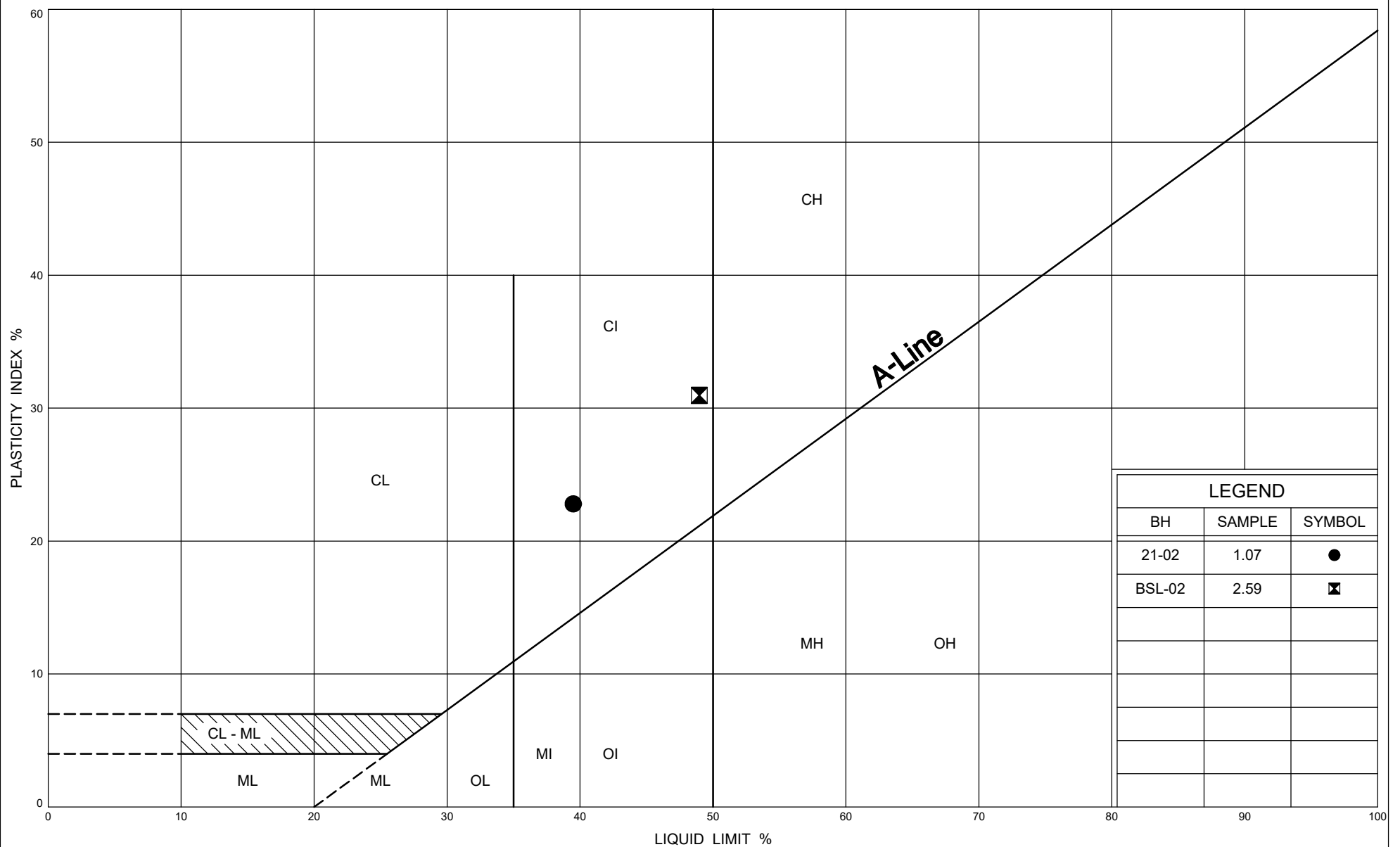
W P 6124-17-00

Black Sturgeon Lakes Bailey Bridge









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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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)**







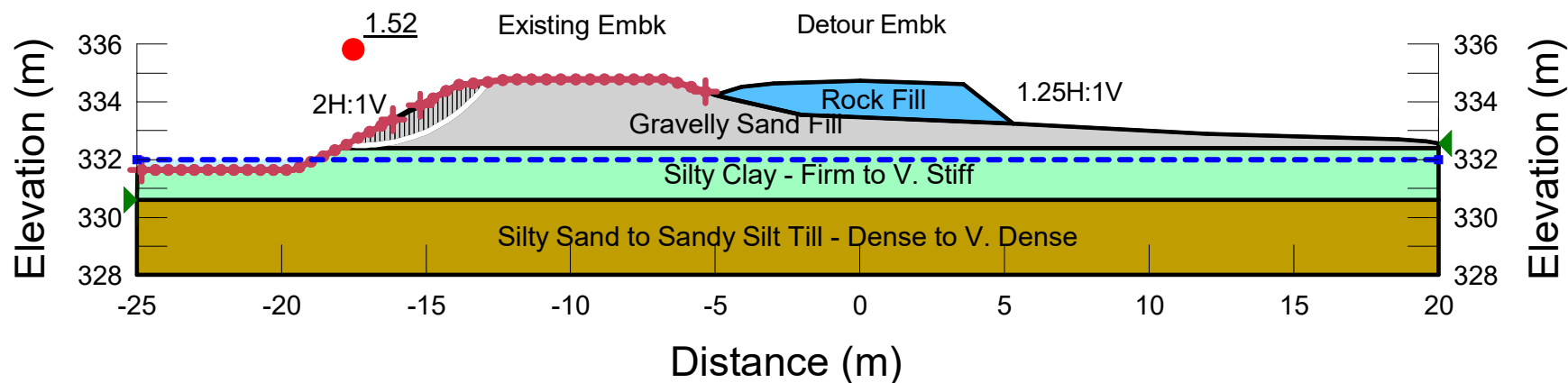
Appendix E

Stability Analysis Figures

BLACK STURGEON LAKES BRIDGE - PERMANENT BRIDGE **SOUTH ABUTMENT - SIDE SLOPE (20+160)** **SHORT TERM CONDITION**





FIGURE 1

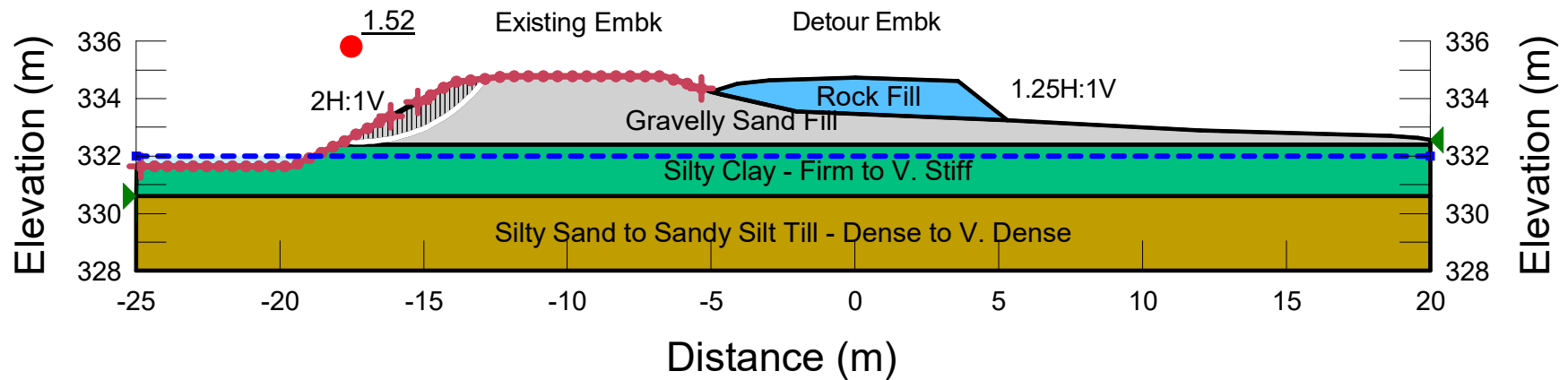
Color	Name	Unit Weight (kN/m ³)	Total Cohesion (kPa)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Gravelly Sand Fill	21		0	32
	Rock Fill	19		0	42
	Silty Clay - Firm to V. Stiff	19	50		
	Silty Sand to Sandy Silt Till - Dense to V. Dense	22		0	32



**BLACK STURGEON LAKES BRIDGE - PERMANENT BRIDGE
SOUTH ABUTMENT - SIDE SLOPE (20+160)
LONG TERM CONDITION**





FIGURE 2

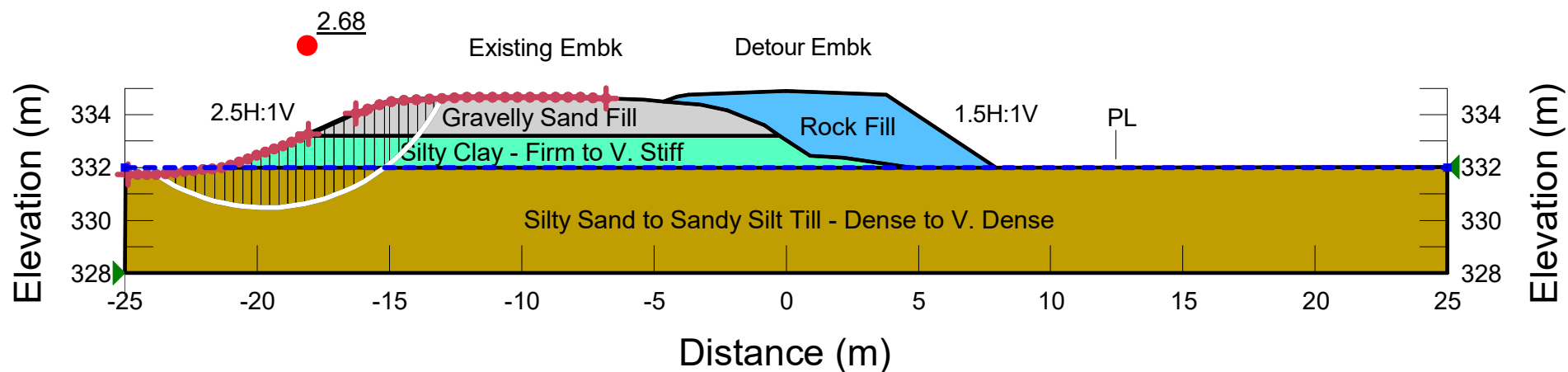
Color	Name	Unit Weight (kN/m ³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Gravelly Sand Fill	21	0	32
	Rock Fill	19	0	42
	Silty Clay - Firm to V. Stiff	19	5	25
	Silty Sand to Sandy Silt Till - Dense to V. Dense	22	0	32



BLACK STURGEON LAKES BRIDGE - PERMANENT BRIDGE **NORTH ABUTMENT - SIDE SLOPE (20+210)** **SHORT TERM CONDITION**





FIGURE 3

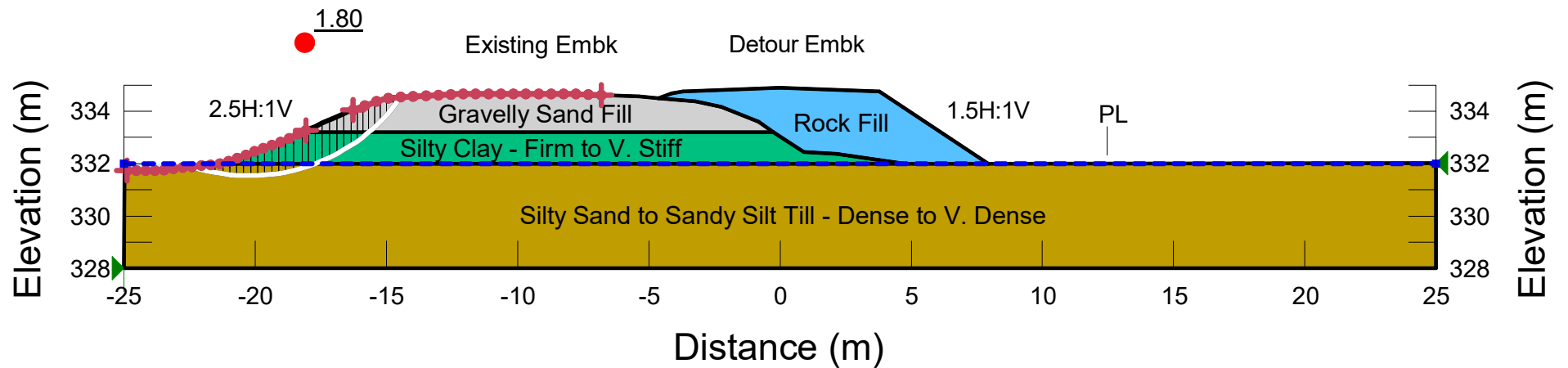
Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Total Cohesion (kPa)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Gravelly Sand Fill	Mohr-Coulomb	21		0	32
	Rock Fill	Mohr-Coulomb	19		0	42
	Silty Clay - Firm to V. Stiff	Undrained (Phi=0)	19	50		
	Silty Sand to Sandy Silt Till - Dense to V. Dense	Mohr-Coulomb	22		0	32



**BLACK STURGEON LAKES BRIDGE - PERMANENT BRIDGE
NORTH ABUTMENT - SIDE SLOPE (20+210)
LONG TERM CONDITION**

FIGURE 4

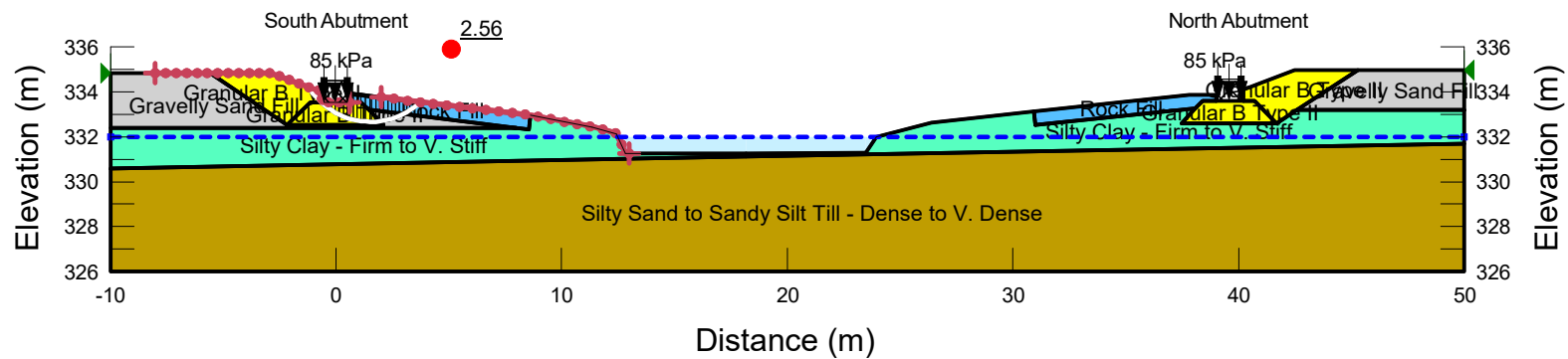
Color	Name	Slope Stability Material Model	Unit Weight (kN/m ³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Gravelly Sand Fill	Mohr-Coulomb	21	0	32
	Rock Fill	Mohr-Coulomb	19	0	42
	Silty Clay - Firm to V. Stiff	Mohr-Coulomb	19	5	25
	Silty Sand to Sandy Silt Till - Dense to V. Dense	Mohr-Coulomb	22	0	32



BLACK STURGEON LAKES BRIDGE - PERMANENT BRIDGE **SOUTH ABUTMENT - FORWARD SLOPE** **SHORT TERM CONDITION**

FIGURE 5

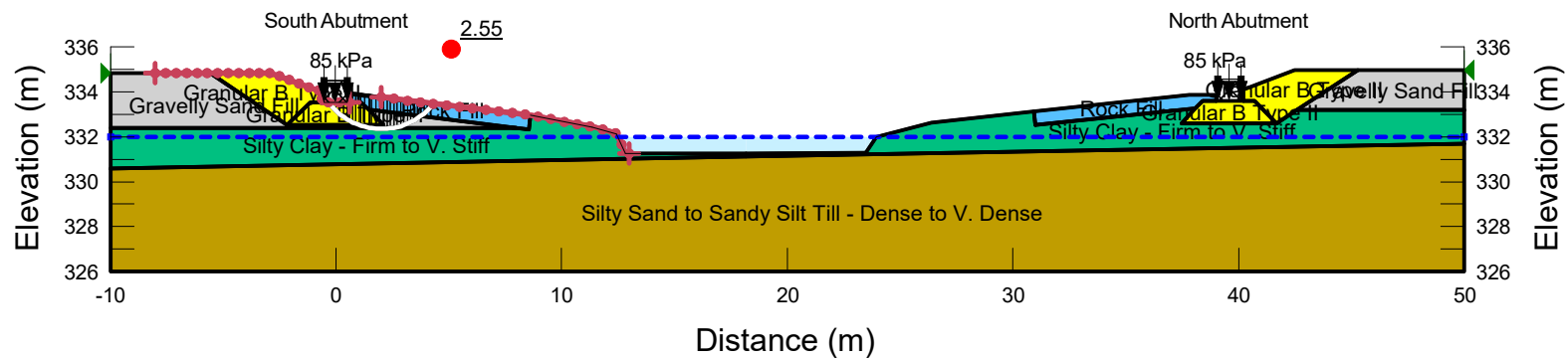
Color	Name	Unit Weight (kN/m³)	Total Cohesion (kPa)	Effective Cohesion (kPa)	Effective Friction Angle (°)
■	Granular B Type II	22		0	35
■	Gravelly Sand Fill	21		0	32
■	Rock Fill	19		0	42
■	Silty Clay - Firm to V. Stiff	19	50		
■	Silty Sand to Sandy Silt Till - Dense to V. Dense	22		0	32



BLACK STURGEON LAKES BRIDGE - PERMANENT BRIDGE **SOUTH ABUTMENT - FORWARD SLOPE** **LONG TERM CONDITION**

FIGURE 6

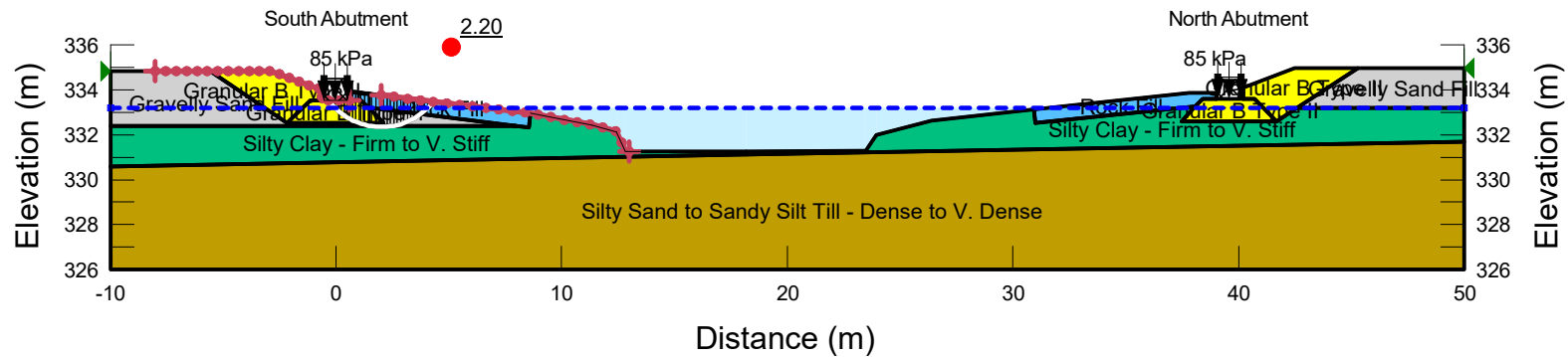
Color	Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Granular B Type II	22	0	35
	Gravelly Sand Fill	21	0	32
	Rock Fill	19	0	42
	Silty Clay - Firm to V. Stiff	19	5	25
	Silty Sand to Sandy Silt Till - Dense to V. Dense	22	0	32



BLACK STURGEON LAKES BRIDGE - PERMANENT BRIDGE **SOUTH ABUTMENT - FORWARD SLOPE** **LONG TERM CONDITION**

FIGURE 7

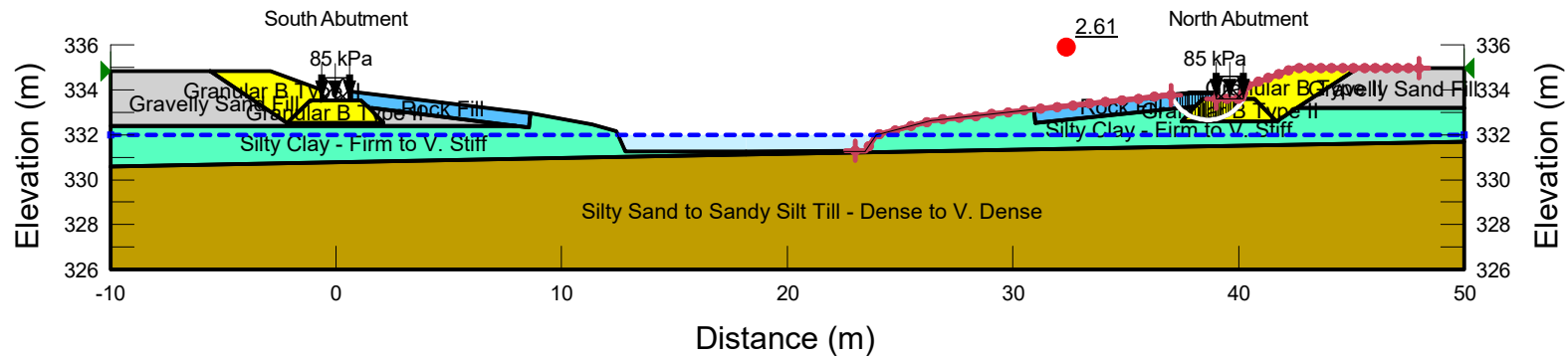
Color	Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
■	Granular B Type II	22	0	35
■	Gravelly Sand Fill	21	0	32
■	Rock Fill	19	0	42
■	Silty Clay - Firm to V. Stiff	19	5	25
■	Silty Sand to Sandy Silt Till - Dense to V. Dense	22	0	32



BLACK STURGEON LAKES BRIDGE - PERMANENT BRIDGE **NORTH ABUTMENT - FORWARD SLOPE** **SHORT TERM CONDITION**

FIGURE 8

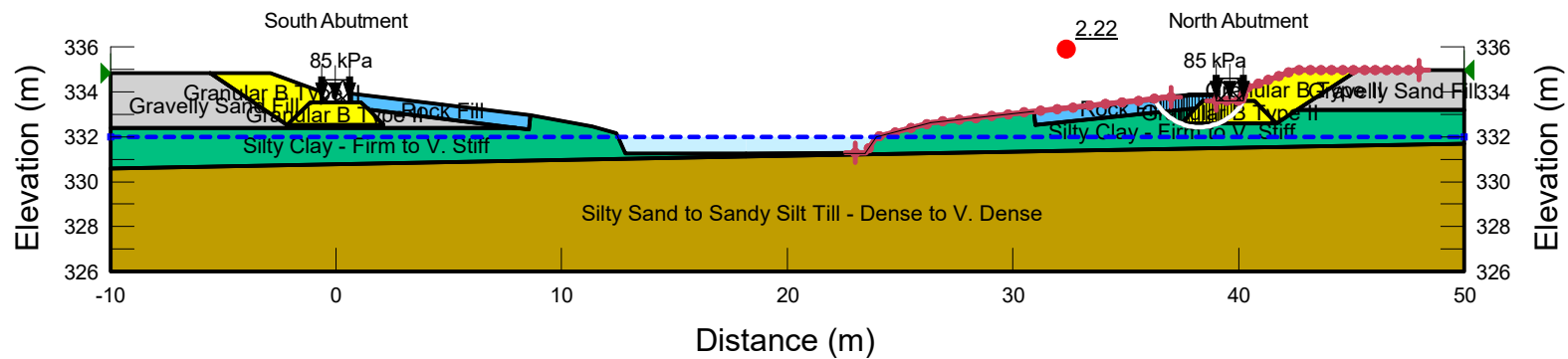
Color	Name	Unit Weight (kN/m³)	Total Cohesion (kPa)	Effective Cohesion (kPa)	Effective Friction Angle (°)
■	Granular B Type II	22		0	35
■	Gravelly Sand Fill	21		0	32
■	Rock Fill	19		0	42
■	Silty Clay - Firm to V. Stiff	19	50		
■	Silty Sand to Sandy Silt Till - Dense to V. Dense	22		0	32



BLACK STURGEON LAKES BRIDGE - PERMANENT BRIDGE **NORTH ABUTMENT - FORWARD SLOPE** **LONG TERM CONDITION**

FIGURE 9

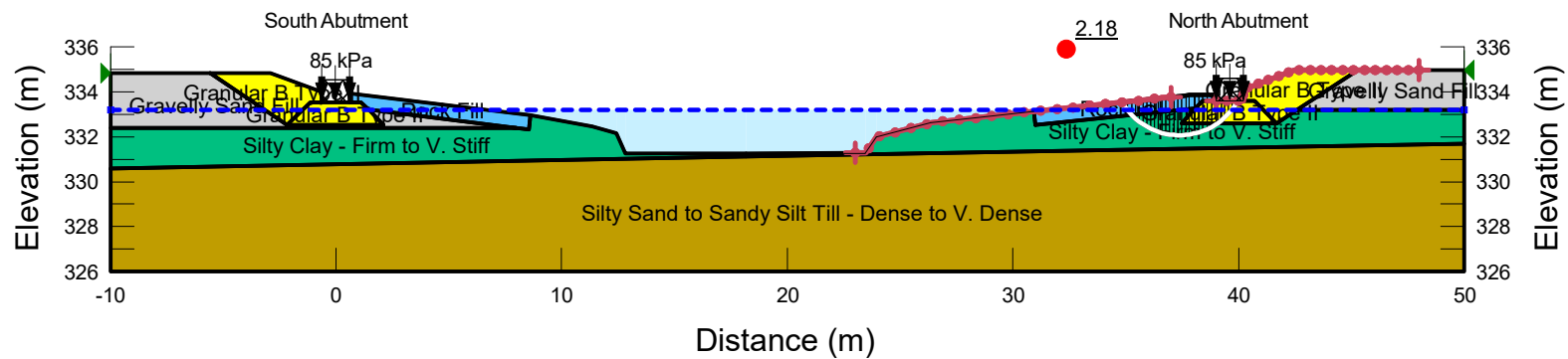
Color	Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
Yellow	Granular B Type II	22	0	35
Grey	Gravelly Sand Fill	21	0	32
Blue	Rock Fill	19	0	42
Green	Silty Clay - Firm to V. Stiff	19	5	25
Brown	Silty Sand to Sandy Silt Till - Dense to V. Dense	22	0	32



BLACK STURGEON LAKES BRIDGE - PERMANENT BRIDGE **NORTH ABUTMENT - FORWARD SLOPE** **LONG TERM CONDITION**





FIGURE 10

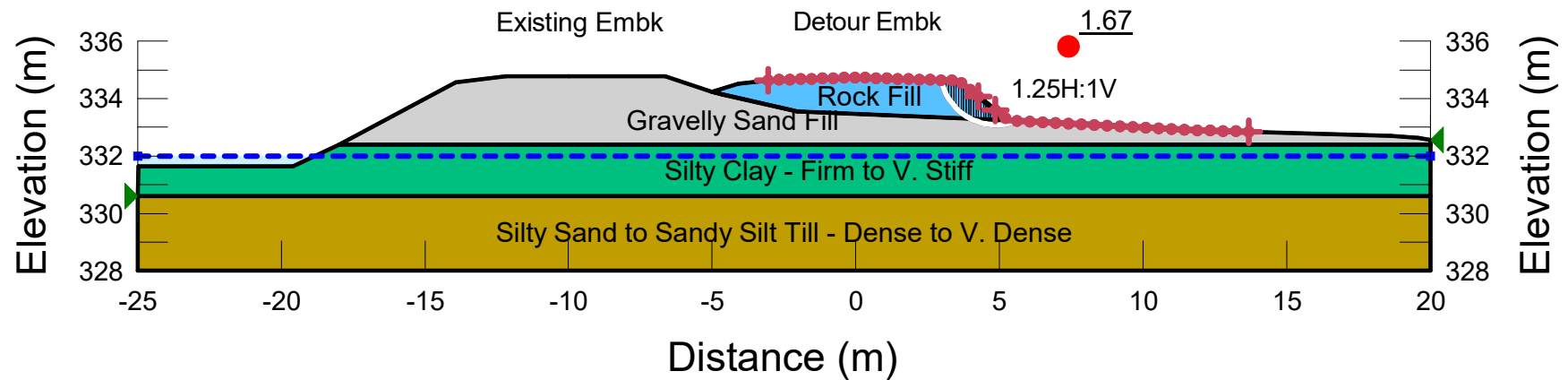
Color	Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
■	Granular B Type II	22	0	35
■	Gravelly Sand Fill	21	0	32
■	Rock Fill	19	0	42
■	Silty Clay - Firm to V. Stiff	19	5	25
■	Silty Sand to Sandy Silt Till - Dense to V. Dense	22	0	32



**BLACK STURGEON LAKES BRIDGE - DETOUR BRIDGE
SOUTH ABUTMENT - SIDE SLOPE (20+160)
LONG TERM CONDITION**

FIGURE 11

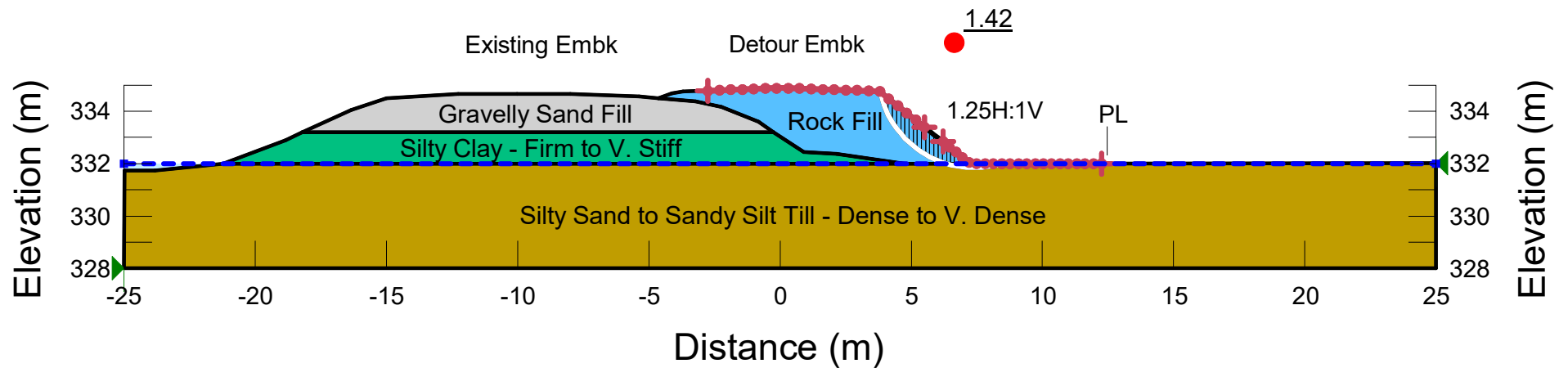
Color	Name	Unit Weight (kN/m ³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Gravelly Sand Fill	21	0	32
	Rock Fill	19	0	42
	Silty Clay - Firm to V. Stiff	19	5	25
	Silty Sand to Sandy Silt Till - Dense to V. Dense	22	0	32



BLACK STURGEON LAKES BRIDGE - DETOUR BRIDGE
NORTH ABUTMENT - SIDE SLOPE (20+210)
LONG TERM CONDITION

FIGURE 12

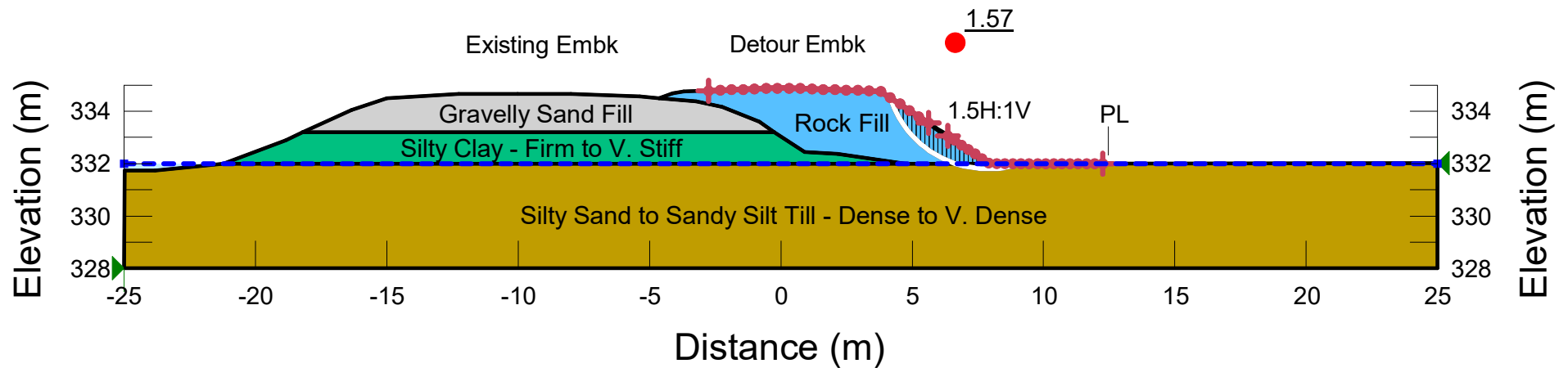
Color	Name	Slope Stability Material Model	Unit Weight (kN/m ³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Gravelly Sand Fill	Mohr-Coulomb	21	0	32
	Rock Fill	Mohr-Coulomb	19	0	42
	Silty Clay - Firm to V. Stiff	Mohr-Coulomb	19	5	25
	Silty Sand to Sandy Silt Till - Dense to V. Dense	Mohr-Coulomb	22	0	32



**BLACK STURGEON LAKES BRIDGE - DETOUR BRIDGE
NORTH ABUTMENT - SIDE SLOPE (20+210)
LONG TERM CONDITION**

FIGURE 13

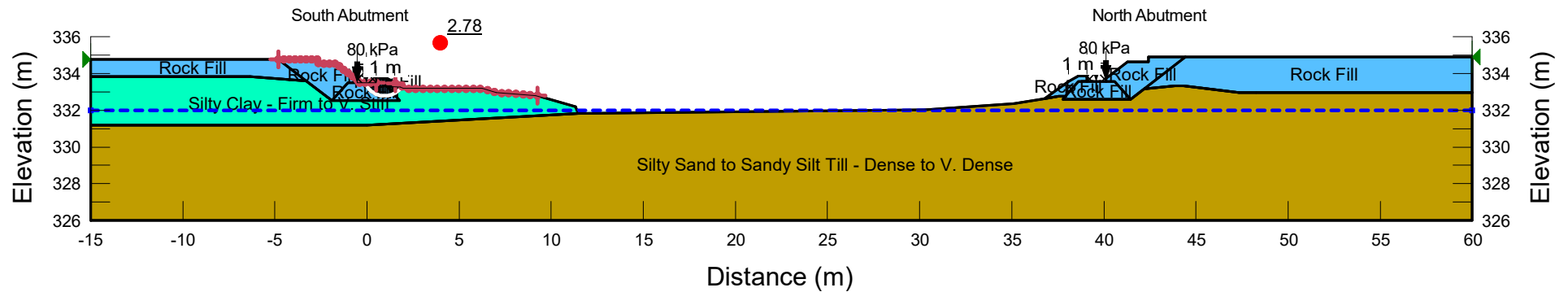
Color	Name	Slope Stability Material Model	Unit Weight (kN/m ³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Gravelly Sand Fill	Mohr-Coulomb	21	0	32
	Rock Fill	Mohr-Coulomb	19	0	42
	Silty Clay - Firm to V. Stiff	Mohr-Coulomb	19	5	25
	Silty Sand to Sandy Silt Till - Dense to V. Dense	Mohr-Coulomb	22	0	32



BLACK STURGEON LAKES BRIDGE - DETOUR BRIDGE **SOUTH ABUTMENT - FORWARD SLOPE** **SHORT TERM CONDITION**

FIGURE 14

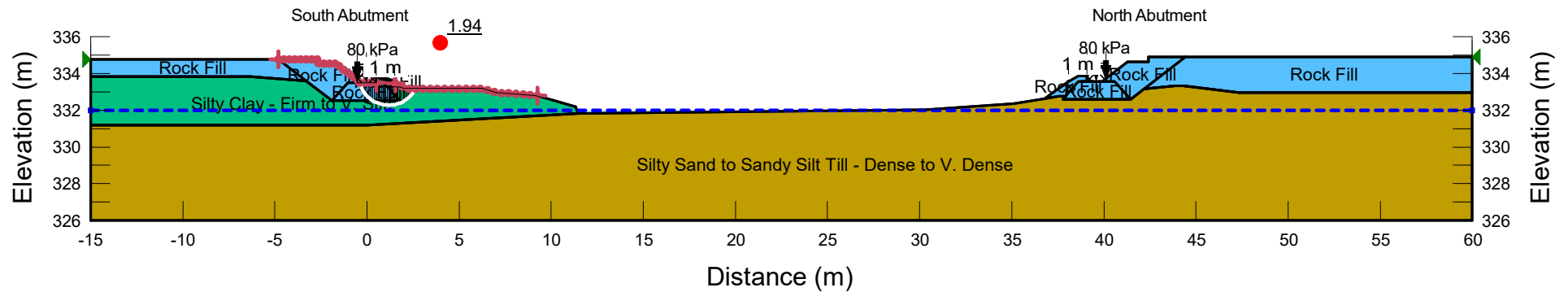
Color	Name	Unit Weight (kN/m³)	Total Cohesion (kPa)	Effective Cohesion (kPa)	Effective Friction Angle (°)
■	Rock Fill	19		0	42
■	Silty Clay - Firm to V. Stiff	19	50		
■	Silty Sand to Sandy Silt Till - Dense to V. Dense	22		0	32



BLACK STURGEON LAKES BRIDGE - DETOUR BRIDGE **SOUTH ABUTMENT - FORWARD SLOPE** **LONG TERM CONDITION**

FIGURE 15

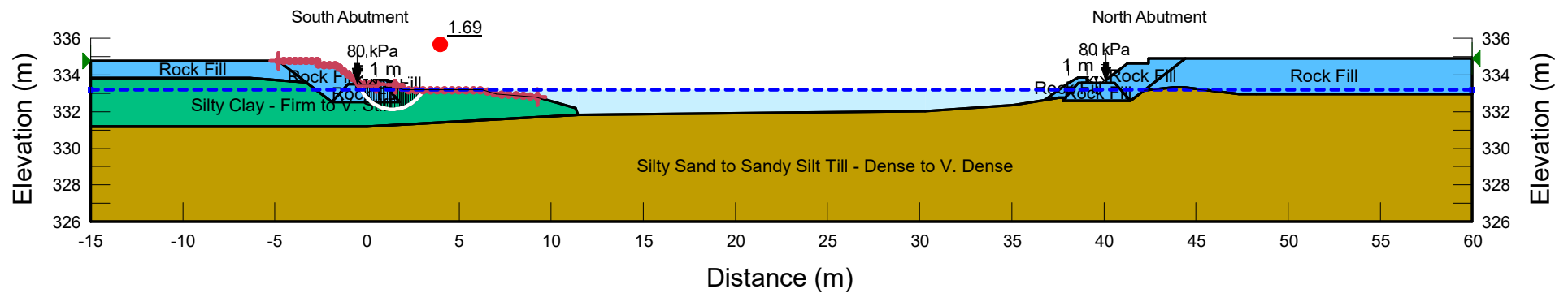
Color	Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
■	Rock Fill	19	0	42
■	Silty Clay - Firm to V. Stiff	19	5	25
■	Silty Sand to Sandy Silt Till - Dense to V. Dense	22	0	32



BLACK STURGEON LAKES BRIDGE - DETOUR BRIDGE **SOUTH ABUTMENT - FORWARD SLOPE** **LONG TERM CONDITION**

FIGURE 16

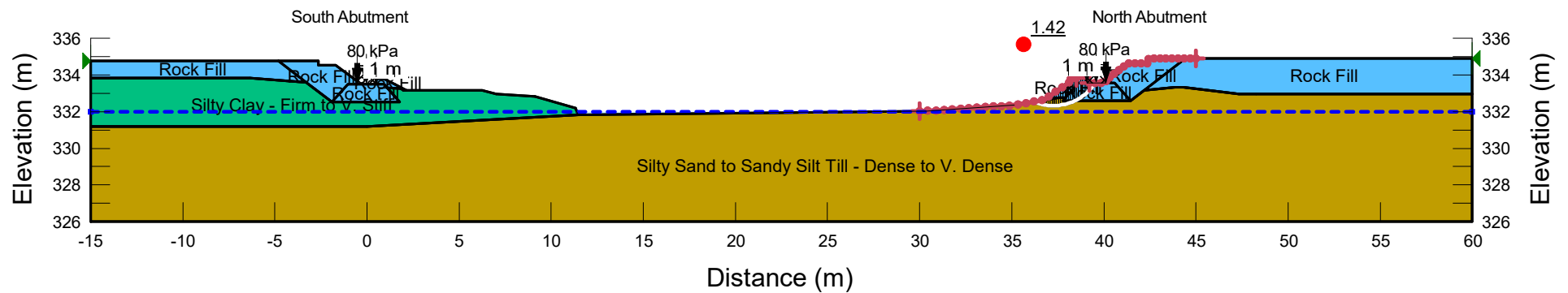
Color	Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
■	Rock Fill	19	0	42
■	Silty Clay - Firm to V. Stiff	19	5	25
■	Silty Sand to Sandy Silt Till - Dense to V. Dense	22	0	32



BLACK STURGEON LAKES BRIDGE - DETOUR BRIDGE **NORTH ABUTMENT - FORWARD SLOPE** **LONG TERM CONDITION**

FIGURE 17

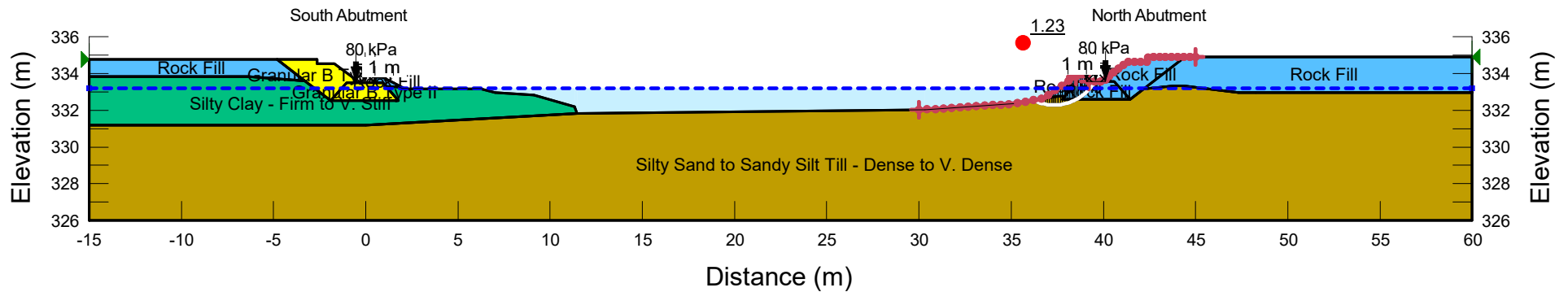
Color	Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
■	Rock Fill	19	0	42
■	Silty Clay - Firm to V. Stiff	19	5	25
■	Silty Sand to Sandy Silt Till - Dense to V. Dense	22	0	32



BLACK STURGEON LAKES BRIDGE - DETOUR BRIDGE **NORTH ABUTMENT - FORWARD SLOPE** **LONG TERM CONDITION**

FIGURE 18

Color	Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Granular B Type II	22	0	35
	Rock Fill	19	0	42
	Silty Clay - Firm to V. Stiff	19	5	25
	Silty Sand to Sandy Silt Till - Dense to V. Dense	22	0	32





Appendix F

List of OPSSs and OPSDs and Suggested Wording for NSSP

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

- OPSS 902 (Construction Specification for Excavating and Backfilling – Structures)
- OPSS PROV 206 (Construction Specification for Grading)
- OPSS PROV 209 (Construction Specification for Embankments over Swamps and Compressible Soils)
- OPSS PROV 501 (Construction Specification for Compacting)
- OPSS PROV 517 (Construction Specification for Dewatering)
- Special Provision No. FOUN0003 to OPSS 902 (Dewatering Structure Excavations)
- OPSS PROV 804 (Construction Specification for Seed and Cover)
- OPSS PROV 1010 (Material Specification for Aggregates – Base, Subbase, Select Subgrade, and Backfill Material)
- OPSD 3090.100 (Foundation Frost Depths for Northern Ontario)
- OPSD 3101.150 (Walls, Abutment, Backfill Minimum Granular Requirement)

2. Suggested text for NSSP on “Compacted Rock Fill Pads below Footings”

For rock fill pads below abutment footings, the rock fill shall be well graded, with a maximum size of 250 mm and containing less than 2% fines. The rock fill shall be freshly produced in a quarry, originating from strong to very strong igneous or metamorphic rock sources, and shall not contain shale or sandstone.

Rock fill pad construction must be carried out in the dry. The rock fill layers shall not exceed 500 mm in thickness prior to compaction. Material in each layer shall be fully compacted before the succeeding layer is placed. Each rock fill layer shall be compacted with a tractor bulldozer, crawler type as specified in the Tractor Bulldozer – Crawler Type for Rock Embankment Construction subsection of OPSS.PROV 206. The minimum number of complete passes shall be six and the maximum number of passes shall be eight. A complete pass shall be defined as 100% coverage of the layer surface.

For the rock fill pads, materials shall be placed in their final position by blading. End dumping or depositing of rock over the end of any layer by hauling equipment is not permitted. Each layer

shall be levelled in place and compacted to minimize voids and bridging of large rock fragments within the rock fill pad.

The top surface of the rock fill pad shall be chinked with rock fragments and spalls to form the subgrade prior to the placement of the levelling pad in order to minimize voids and prevent migration of levelling pad material into the rock fill.

Care shall be taken to avoid large boulders and rock fragments protruding above the rock fill pad surface.

A minimum 75 mm thick layer of compacted 19 mm clear stone should be placed above the rock fill to provide an even founding surface for placement of the footings.

3. Suggested Wording for NSSP on Obstructions

Excavations will encounter obstructions such as rock fill or cobbles and boulders embedded in the fill and native soils. Such obstructions may impede excavation progress. The Contractor shall be prepared to remove, drill through and/or penetrate these obstructions to achieve the design depths.

4. Suggested Wording for NSSP on Dewatering

Effective dewatering shall be designed and provided by the Contractor during structure excavation, footing placement and backfilling to allow the work to proceed in the dry. Excavation below the river and groundwater level will lead to subgrade softening. The dewatering system must be effective to maintain the water level at a minimum depth of 0.5 m below the final subgrade level throughout construction.

The dewatering system is to be designed in accordance with SP FOUN0003 and OPSS.PROV.517. A preconstruction survey is not required, thus Designer Fill-In ** in SP FOUN0003 should be "N/A". Special Provision FOUN0003 is included below.

DEWATERING STRUCTURE EXCAVATIONS - Item No.

Special Provision No. FOUN0003

March 8, 2018

Amendment to OPSS 902, November 2010

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

902.02 REFERENCES

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

Ontario Provincial Standard Specifications, Construction

OPSS 517 Dewatering
OPSS 805 Temporary Erosion and Sediment Control Measures

902.03 DEFINITIONS

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

Automatic Transfer Switch means as defined in OPSS 517.

Cofferdam means as defined in OPSS 539.

Cut-Off Wall means as defined in OPSS 517.

Design Storm Return Period means as defined in OPSS 517.

Dewatering System means as defined in OPSS 517.

Groundwater Control System means as defined in OPSS 517.

Plug means as defined in OPSS 517.

Sediment means as defined in OPSS 517.

Sediment Control Measure means as defined in OPSS 517.

Temporary Flow Passage System means as defined in OPSS 517.

Unwatering means as defined in OPSS 517.

Vegetated Discharge Area means as defined in OPSS 517.

Waterbody means as defined in OPSS 517.

Watercourse means as defined in OPSS 517.

902.04 DESIGN AND SUBMISSION REQUIREMENTS

902.04.01 Design Requirements

902.04.01.01 Dewatering

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

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

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

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

902.04.02 Submission Requirements

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

902.04.02.01 Working Drawings

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

902.04.02.02 Preconstruction Survey

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

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

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

902.04.02.03 Milestone Inspections

Clause 902.04.02.03 of OPSS 902 is deleted in its entirety.

902.07 CONSTRUCTION

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

902.07.04 Dewatering Structure Excavation

902.07.04.01 General

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

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

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

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

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

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

Unwatering shall be carried out as necessary.

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

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

902.07.04.02 Discharge of Water

The discharge of water shall be according to OPSS 517.

902.07.04.03 Monitoring

Monitoring shall be according to OPSS 517.

902.07.04.04 System Amendments

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

902.07.04.05 Removal

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

NOTES TO DESIGNER:

Designer Fill-Ins

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

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

CUSTODIAN: Tony Sangiuliano, MERO - Foundation Group.